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(71) Applicant: **Halliburton Energy Services, Inc.**
Dallas, Texas 75381-9052 (US)

(72) Inventors:
- **Dickson, Rennie L.**
  Carrollton, Texas 75007 (US)
- **Reesing, David L.**
  Irving, Texas 75060 (US)
- **Vinzant, Michael B.**
  Carrollton, Texas 75006 (US)

(74) Representative: **Wain, Christopher Paul et al**
A.A. THORNTON & CO.
Northumberland House
303-306 High Holborn
London WC1V 7LE (GB)

(54) Up-to-set lock mandrel and method of operation thereof

(57) An up-to-set lock mandrel (10) for registering with a locating profile (14) recessed in a sidewall (16) of a well conduit portion (12). The up-to-set lock mandrel (10) comprises a generally cylindrical body (20) and a locating key (22) coupled to the body (20) and biased to be urged from a seeking position toward a no-go position. The locating key (22) has a no-go profile (26) thereon contoured to engage the locating profile (14) when the locating key (22) is in the no-go position, to thereby function as a no-go for the up-to-set lock mandrel (10).

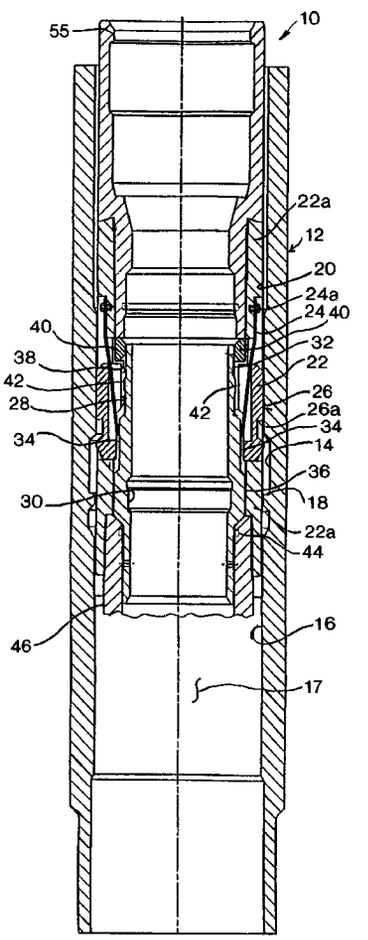

FIG. 1

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Description

The present invention relates generally to well completion apparatus and methods and, more specifically, to an up-to-set-lock mandrel and method of operation thereof.

Lock mandrels for use with wireline equipment and methods are well known in the art, and when so used, they offer substantial cost reductions during well completion and servicing. Presently, the art includes two basic types of lock mandrels. One type is a down-to-set lock mandrel, and the other is an up-to-set lock mandrel; the names are indicative of the directional force required to set the lock mandrel. In other words, in the down-to-set lock, a downward force is used to set the lock mandrel, and in an up-to-set lock, an upward force is used to set the lock mandrel.

One type of down-to-set lock mandrel is disclosed in U.S. Patent No. 4,396,061. This device is directed to a lock mandrel that has a tubular body mandrel adapted to be used with a running tool and well tool to secure the mandrel in the flow conductor. The locking mandrel is lowered below a landing nipple. The running tool and locking mandrel are then lifted back uphole above the landing and locking recesses of the landing nipple and thereafter lowered again toward the landing nipple. The raising of the running tool and the locking mandrel through the nipple causes the locking sleeve to be moved downhole to an intermediate position, which, in turn deploys spring biased dogs against the wall of the flow conductor. The lowering of the running tool and locking mandrel is continued with the dogs dragging along the flow conductor wall. When the dogs arrive at the landing and locking recess of the landing nipple, the dogs are expanded into the landing and locking recesses. Downhole jarring forces are then applied to the locking mandrel to drive a locking sleeve downhole to lock the dogs into position.

One type of an up-to-set lock mandrel is disclosed in U.S. Patent No. 4,545,434. This patent teaches the use of a running tool in a wireline tool string for driving a lock mandrel having a safety valve connected to it into a landing nipple disposed in the flow conductor of a well. The safety valve and lock mandrel are driven downhole into the landing nipple until a fixed no-go ring on the outer surface of the lock mandrel contacts an opposing no-go shoulder in the landing nipple. The locking keys in the lock mandrel are engaged by jarring uphole on the running tool. The running tool is not releasable from the lock mandrel until the safety valve has been pressured open, which activates the running tool, and until the locking sleeve is pulled fully under the locking keys, thus securing the lock in the landing nipple.

Another type of up-to-set lock mandrel is disclosed in U.S. Patent No. 4,962,813. This device comprises a collapsible, slidably engaged no-go ring and locating dogs that are coupled to a locking sleeve to pre-prop locking keys in the annular recesses of a landing nipple prior to applying control line pressure to the safety valve. In the application of this device, the lock mandrel and the safety valve are driven into the landing nipple to the point where the no-go locating dogs contact an inwardly facing annular no-go shoulder. When the no-go locating dogs contact the annular shoulder, the no-go locating dogs and the no-go ring are caused to slide upwardly until an external no-go shoulder on the locking key retainer sleeve stops against the annular no-go shoulder in the landing nipple. The locating dogs and the no-go ring cause the locking sleeve to travel uphole the same distance, which ultimately causes the locking keys to be forced radially outward to partially engage cooperating recesses in the landing nipple.

Yet another up-to-set lock mandrel is disclosed in U.S. Patent No. 5,066,060. The lock mandrel has a shoulder that contacts a no-go of a landing nipple, thereby preventing further downhole travel. Once the shoulder is seated against the no-go, the top sub of a running tool to which the lock mandrel is coupled is jarred downhole to shear a shearing pin. After the shearing pin is sheared, the top sub is jarred uphole to lock the locking keys of the lock mandrel in the annular recesses of the profile of the landing nipple to thereby restrict further axial movement between the lock mandrel and the landing nipple until such time as the locking keys are again withdrawn.

While the locking systems discussed above possess significant advantages when compared to the conventional locking systems previously known, disadvantageous have been encountered with both the down-to-set and up-to-set lock mandrel systems. For instance, in the down-to-set systems, the mandrel lock is set in the downhole direction and released in the uphole direction. As such, the down-to-set lock mandrels can be inadvertently unlocked by pressure exerted by the uphole fluid flow. This pressure can force the lock mandrel and the safety valve coupled to it out of the production tubing. This result is particularly undesirable when the safety valve is coupled to the lock mandrel because the safety system for controlling the well is no longer present in the production tubing. Moreover, the down-to-set lock mandrels typically have complicated mechanical structures that are required to first deploy the locking dogs and then engage them in the locking profile in the nipple or tubing.

While the up-to-set lock mandrels are designed to prevent the lock mandrel and the safety valve from being forced from the well by the fluid flow, they are typically used in conjunction with a no-go on a landing nipple, which is an inside diameter restriction within the interior bore of the landing nipple. In most conventional lock mandrels, the no-go is used to locate and engage the up-to-set lock mandrel. Unfortunately, however, certain disadvantages can arise with the use of such no-goes. For example, if successive landing nipples are located in the well, the interior diameter of the well bore is restricted because the no-go extends into the interior of

the nipple's bore. Further, if other no-goes are used within the same well, the interior diameter can become more restricted with each successive landing nipple. Thus, larger equipment cannot be used downhole if so desired.

In yet another example, many existing wells do not have landing nipples with no-go shoulders. In such instances, conventional up-to-set lock mandrels cannot be used in these wells. Consequently their use is thus restricted to only those wells where either the specific landing nipples are inserted or, by chance, they are already present in the well. However, in many existing wells, particularly older wells, landing nipples with no-go shoulders are not present.

In view of the foregoing, it is highly advantageous to have an up-to-set lock mandrel that is easily activated, such as a lock mandrel with a key having a locating profile with a no-go shoulder thereon. The lock mandrel key could be used to engage a recessed locating profile, to thereby function as a no-go for the up-to-set lock mandrel. Such a device could be used in existing wells that do not have landing nipples with no-goes, and moreover, landing nipples with no-goes would not be necessary in new wells because the up-to-set lock mandrel could be activated via the recessed locating profiles in the production tubing. As such, the inside diameter of a well having multiple landing nipples would not have to be restricted by each successive no-go shoulder that is located further downhole. This no-go shoulder free well bore would provide a well with a larger inside diameter so that larger downhole tools could be used below the deepest landing nipple, if so desired or required.

Additionally, the prior art devices comprise complicated locking devices that require more difficult operating procedures to deploy the dogs and engage them in the locking profile. Consequently, these devices can be prematurely locked into position. Thus, it would also be advantageous to have a device that automatically engages the locating keys when the appropriate locating profile. Furthermore, it would be highly advantageous to have a lock mandrel that is an up-to-set lock mandrel such that inadvertent unlocking due to well flow does not occur. The present invention provides such a device and addresses the disadvantages associated with the prior art devices.

To address the above-discussed deficiencies in the prior art, it is a primary object of the present invention to provide an up-to-set lock mandrel for registering with a locating profile recessed in an interior sidewall of a well conduit portion. Preferably, the well conduit is a landing nipple that is made up either within a production tubing string or within the well casing. The well conduit is desirably free of an interior diameter reducing no-go shoulder proximate the locating profile, thereby providing a well conduit that does not have a restricted inside diameter proximate the locating profile. Preferably, the lock mandrel includes a locating key with a no-go profile that preferably includes a square shoulder contoured to engage a corresponding square shoulder of the locating profile.

According to one aspect of the invention there is provided an up-to-set lock mandrel for registering with a locating profile recessed in an interior sidewall of a well conduit portion, comprising: a generally cylindrical body; and a locating key coupled to said body and biased to be urged from a seeking position toward a no-go position, said locating key having a no-go profile thereon contoured to engage said locating profile when said locating key is in said no-go position, to thereby function as a no-go for said mandrel, said locating key being lockable in a set position.

Preferably, the locating key is coupled to the body to allow radial translation of the locating key with respect to the body as said up-to-set lock mandrel and said locating key traverse the sidewall of the well conduit. More particularly, the locating key is preferably coupled to the body to allow radial translation of the locating key with respect to the body as (1) the lock mandrel is run downhole and the locating key contacts the interior sidewall of the well conduit and (2) the locating key moves between the seeking position and the no-go position.

This unique combination of elements provides distinct advantages over the prior art. Since the locating key functions as a no-go for the lock mandrel, there is no need for providing a no-go in the nipple that restricts the inner diameter of the well conduit. Thus, larger tools can be used in downhole operations below the nipple. Further, since the locating key is always in the seeking position, the up-to-set lock mandrel cannot be inadvertently or prematurely set because the locating key engages only the locating profile that matches the contour of the locating key's no-go profile. When the locating key engages the locating profile, the up-to-set lock mandrel can be locked in place to maintain the locating key in the set position.

Preferably, the no-go profile includes a square shoulder contoured to engage a corresponding square shoulder of said locating profile.

In a preferred embodiment, the lock mandrel further includes a locking mechanism located proximate the locating key. The locking mechanism is displaceable with respect to the body between a running position wherein the locating key is maintained in the seeking position and a set position wherein the locking sleeve maintains the locating key in the no-go position. Preferably, an uphole force is applied to the locking mechanism to move it from the seeking position to the set position.

In one aspect of this embodiment, the locking mechanism is preferably a locking sleeve having a detent with an increased outer diameter; that is, the detent, or annular boss, protrudes beyond the diameter of the adjacent sections of the locking sleeve. The up-to-set lock mandrel further comprises a locking ring captured between the body and the locking sleeve. The annular boss traverses the locking ring as the locking sleeve is moved from the running position to the set position, to

thereby maintain the locking sleeve in the set position. Alternatively, the locking sleeve has a recessed portion with a decreased outer diameter. The up-to-set lock mandrel further comprises a locking ring captured between the body and the locking sleeve. The locking ring is received in the recessed portion as the locking sleeve is moved from the running position to the set position, to thereby maintain the locking sleeve in the set position.

In another aspect of this embodiment, the locking mechanism is located radially inward of the locating key and the up-to-set lock mandrel further comprises a running tool profile on an inner surface of the locking mechanism. The running tool profile allows a running tool to engage the locking mechanism to move the locking mechanism between the running position and the set position.

In another aspect of the present invention, the well conduit may have a plurality of locating profiles recessed in the sidewall with each of the locating profiles having a unique configuration or shape. In such instances, the no-go profile of the locating key can be configured to engage a selective one of the plurality of the unique locating profiles. This provides a simple yet efficient up-to-set lock mandrel that allows selective engagement with different locating profiles within the same well conduit. Thus, the no-go profile of the locating key can be contoured for engagement with a specific locating profile, thereby allowing the lock mandrel to bypass other locating profiles that may be above that specific locating profile within the well conduit.

In yet another aspect of the present invention, there is provided a downhole well system, comprising a downhole nipple having a locating profile recessed in an interior sidewall of the nipple casing disposed within the well and an up-to-set lock mandrel for registering with the locating profile. The production downhole nipple is preferably free of a no-go shoulder proximate the locating profile. In a preferred embodiment, the up-to-set lock mandrel includes a generally cylindrical body and a locating key coupled to the body and biased to be urged from a seeking position toward a no-go position. The locating key has a no-go profile thereon contoured to engage the locating profile when the locating key is in the no-go position and to function as a no-go for the up-to-set lock mandrel. Preferably, the no-go profile includes a square shoulder contoured to engage a corresponding square shoulder of the locating profile. The preferred embodiment of the up-to-set lock mandrel further includes a locking mechanism located proximate the locating key. The locking mechanism is displaceable with respect to the body between a running position wherein the locating key is maintained in the seeking position, and a set position wherein the locking sleeve maintains the locating key in the no-go position. This aspect of the present invention may further include a flow control device coupled to the body to prevent a force applied to the flow control device by a production fluid within the production tubing from displacing the up-to-set lock mandrel within the production tubing.

In one embodiment of this aspect of the invention, the locking mechanism is preferably a locking sleeve having a detent with an increased outer diameter; that is, the detent, or annular boss, protrudes beyond the diameter of the adjacent sections of the locking sleeve. The up-to-set lock mandrel further comprises a locking ring captured between the body and the locking sleeve. The annular boss traverses the locking ring as the locking sleeve is moved from the running position to the set position, to thereby maintain the locking sleeve in the set position. Alternatively, the locking sleeve has a recessed portion with a decreased outer diameter. The up-to-set lock mandrel further comprises a locking ring captured between the body and the locking sleeve. The locking ring is received in the recessed portion as the locking sleeve is moved from the running position to the set position, to thereby maintain the locking sleeve in the set position.

In another embodiment of this aspect of the invention, the locking mechanism is located radially inward of the locating key and the up-to-set lock mandrel further comprises a running tool profile on an inner surface of the locking mechanism. The running tool profile allows a running tool to engage the locking mechanism to move the locking mechanism between the running position and the set position.

In another preferred embodiment, the well conduit has a plurality of locating profiles recessed in the sidewall, and the up-to-set lock mandrel further comprises a plurality of locating keys coupled to the body at positions radially about the body, each of the plurality of locating keys contoured to engage a selective one of the plurality of locating profiles. Alternatively, the well conduit may have a plurality of locating profiles recessed in the sidewall. In such instances the no-go profile on the locating key can be contoured to allow the lock mandrel to engage a selective one of the plurality of the locating profiles.

According to another aspect of the invention, there is provided a method of operating an up-to-set lock mandrel within a well conduit portion having a locating profile recessed in an interior sidewall of said well conduit portion, said method comprising the steps of: moving a generally cylindrical body within said well conduit portion; urging a locating key coupled to said body from a seeking position toward a no-go position, said locating key having a no-go profile thereon contoured to engage said locating profile when said locating key is in said no-go position; and locking said locating key in a set position using an upward force.

The step of locking preferably includes the step of displacing a locking mechanism located proximate said locating key between: a running position wherein said locating key is maintained in said seeking position, and a set position wherein said locking mechanism maintains said locating key in said set position.

The well conduit portion is preferably free of an in-

terior diameter reducing no-go shoulder proximate said locating profile.

In one embodiment, the locking mechanism is a locking sleeve having an annular boss of increased outer diameter and said up-to-set lock mandrel further comprises a locking ring captured between said body and said locking sleeve, and the method further comprises the step of traversing said annular boss across said locking ring as said locking sleeve is moved from said running position to said set position, to thereby maintain said locking sleeve in said set position.

In another embodiment, the locking mechanism is a locking sleeve having a recessed portion with a decreased outer diameter and said up-to-set lock mandrel further comprises a locking ring captured between said body and said locking sleeve, and the method further comprises the step of positioning said locking ring in said recessed portion as said locking sleeve is moved from said running position to said set position, to thereby maintain said locking sleeve in said set position.

The step of displacing preferably includes the step of applying an uphole force to said locking sleeve to position said locking sleeve and maintain said locking key in said set position.

The locking mechanism may be located radially inward of said locating key, said up-to-set lock mandrel may further comprise a running tool profile on an inner surface of said locking mechanism. The step of displacing may further comprise the step of engaging said running tool profile of said locking mechanism with a running tool to move said locking mechanism between said running position and said set position.

The method preferably further includes the step of positioning said locating key in a selected one of a plurality of locating profiles recessed in said interior sidewall, said locating key being contoured to engage a selective one of said plurality of locating profiles; preferably it is the no-go profile of the locating key that is contoured to engage a selective one of said plurality of locating profiles.

The well conduit portion is preferably free of an interior diameter reducing no-go shoulder proximate said locating profile.

The locating key is preferably coupled to said body to allow radial translation of said locating key relative to said body as said up-to-set lock mandrel and said locating key traverse the interior sidewall of said well conduit.

The well conduit may have a plurality of locating profiles recessed in said sidewall, said no-go profile being contoured to engage a selective one of said plurality of locating profiles.

Preferably the no-go profile includes a square shoulder contoured to engage a corresponding square shoulder of said locating profile.

Reference is now made to the accompanying drawings, in which:

FIG. 1 illustrates a cross-sectional view of an embodiment of a lock mandrel of the present invention within the well conduit with the locating keys having a no-go profile in the seeking position;

FIG. 2 illustrates a cross-sectional view of the lock mandrel of FIG. 1 with the locating keys' no-go profile engaged with a locating profile of the well conduit;

FIG. 3 illustrates a cross-sectional view of the lock mandrel of FIG. 1 with the locking sleeve moved uphole and held in place by a snap ring to thereby sustain the locating keys in the set position;

FIG. 4 illustrates a cross-sectional view of the lock mandrel of FIG. 1 with the locking sleeve moved back downhole to thereby allow the locating keys to move inwardly to disengage from the set position; and

FIG. 5 illustrates a cross-sectional view of another embodiment of the lock mandrel of FIG. 1 wherein the locating key has a plurality of shoulders, including at least one no-go shoulder.

Referring initially to FIG. 1, there is illustrated, in a preferred embodiment thereof, a cross-sectional view of a up-to-set lock mandrel 10 of the present invention within a portion of a well conduit 12. The well conduit 12 may include casing, tubing, well heads, trees, risers, liners; or downhole accessories, including landing nipples, packers, valves, sleeves, mandrels, hangers, and seal bore extensions; or any combination of these devices used with respect to a well. As such, it should be understood that any given well may have multiple conduits therein. For instance, as is well known in the art, a well may include casing, production tubing, and a packer, with the packer made up within the tubing string, and the tubing string being positioned within and concentric to the casing. The up-to-set lock mandrel 10 is set by application of an uphole force. The application of an uphole force to set the up-to-set lock mandrel 10 is particularly advantageous when the up-to-set lock mandrel 10 is coupled to a flow control device, such as a safety valve, a plug, an injection valve, a choke, a pressure-temperature recording device, a testing tool or a standing valve, just to name a few. The reason that the up-to-set lock mandrel 10 is advantageous is that: since an up-to-set lock mandrel is set by the application of an uphole force, a counter downhole force is typically required to unlock the up-to-set lock mandrel. As such, the requirement of the downhole force prevents the up-to-set lock mandrel 10 from being inadvertently removed from the well conduit 12 by the uphole directional force created by the fluid flow within the well conduit 12. However, it will be appreciated that the up-to-set lock mandrel 10 may have a number of applications and can be used with a variety of downhole tools, including those mentioned above.

The portion of well conduit 12 has a locating profile 14 recessed or indented in an interior sidewall 16 of the well conduit 12. The locating profile 14 may be posi-

tioned anywhere along the length of the well conduit 12 where a no-go is desired, and there may be a plurality of such profiles. As used herein, a no-go is a point below which a tool with a predetermined diameter cannot be moved. As illustrated, the interior sidewall 16 is next to the passageway 17 of the well conduit 12. Since the locating profile 14 is recessed or indented in the interior sidewall 16, it does not protrude into the interior passageway 17 of the well conduit 12, and thus, does not restrict the interior diameter passageway 17, as does a convention no-go shoulder. In conventional settings, no-go shoulders are shoulders that extend into the interior passageway of the well conduit to provide a stop point for a tool. To pass any tool below the no-go shoulder, it must, therefore, have an outer diameter that is less than the diameter of the well conduit passageway as restricted by the no-go shoulder. Because the up-to-set lock mandrel 10 cooperatively engages the recessed locating profile 14 to function as a no-go for the up-to-set lock mandrel 10, a conventional no-go, which restricts the diameter of well conduit's passageway 17, is not necessary. The present invention, therefore, provides a distinct advantage over the prior art because the present invention can be operated in a well conduit 12 that does not have a conventional no-go shoulder anywhere along its length.

The locating profile 14 may be any type of recessed profile, however, in preferred cases, the locating profile 14 is an "X®" or "R®" type of profile. The locating profile 14 may include a square shoulder 18 or the profile may have varying degrees of slope. Preferably, the varying degrees of slope may range from about 45° to about 120° from the longitudinal axis of the well flow conduit 12, and the slope is such that it effectively functions as a no-go when the up-to-set lock mandrel 10 engages the locating profile 14. It should be noted that the profiles designated as X® and R® are well known and understood by those skilled in the art. As previously mentioned, the well conduit 12 may be various tools. However, the well conduit 12 is preferably a nipple either within a production tubing string or within the well casing. Furthermore, the well conduit 12 is preferably free of a no-go shoulder proximate the locating profile 14, thereby providing a well conduit 12 that does not have a restricted passageway 17 proximate the locating profile 14. As such, the present invention is ideally suited to be used in a well conduit 12 that does not have a conventional no-go shoulder anywhere along its length.

Continuing to refer to FIG. 1, the up-to-set lock mandrel 10 preferably comprises a generally cylindrical body 20 and a locating key 22 coupled to the body 20. A locating key 22 is biased to be urged from a seeking position toward a no-go position. Preferably, the locating key 22 is held in position with respect to the body 20 by a key retainer 22a and is coupled to the body 20 to allow radial translation relative thereto as the locating key moves between the seeking position and the no-go position. Radial translation means that the locating key 22 moves in a radial direction with respect to the body 20. As illustrated, the locating key 22 is in a seeking position, which is its normal operating position as it is passed downhole through the well conduit 12. As such, the locating key 22 is in constant contact with the sidewall 16 as it is being lowered through the well conduit 12. This allows the locating key 22 to automatically engage the matching locating profile 14 when the locating key 22 encounters the locating profile 14. This can be advantageous because the locating key 22 cannot be prematurely or inadvertently deployed. The locating key 22 may be biased in any manner known to those skilled in the art, however, it is preferably biased by a spring 24 that is coupled to the locking mandrel 10 by a screw 24a. In a preferred embodiment, there are at least two locating keys 22 that are positioned radially around the body 20. The locating key 22 has a no-go profile 26 thereon contoured to engage the locating profile 14 when the locating key 22 is in the no-go position. Preferably, the no-go profile 26 includes a square shoulder 26a that is contoured to engage the square shoulder 18 of the locating profile 14. However, the no-go profile 26 may also have the same varying degrees of slope that cooperatively correspond to the slope of the locating profile 14 as previously mentioned above. Whatever, the degree of slope, however, the no-go profile 26 engages the locating key 22 to thus uniquely function as a no-go for the up-to-set lock mandrel 10; that is, the no-go profile 26 prevents the up-to-set lock mandrel 10 from moving any further downhole when the no-go profile 26 engages the locating profile 14. This unique aspect offers the distinct advantage of providing a lock mandrel that does not need to be set in a conventional landing nipple having a no-go shoulder that restricts the interior diameter or the passageway 17 of the well conduit 12.

In a more preferred embodiment, the up-to-set lock mandrel 10 further includes a locking mechanism 28, located proximate the locating key 22. The locking mechanism 28 is displaceable with respect to the body 20 between (1) a running position, wherein the locating key 22 is maintained in the seeking position, and (2) a set position, wherein the locking mechanism 28 maintains the locating key 22 in the set position. The locking mechanism 28 may be displaced by a sliding action, a rotating action, or an expanding action, such as that used in a collapsible sleeve. The locking mechanism 28 may be any type of locking mechanism known to those skilled in the art such as a locking sleeve or expander sleeve, including a piston actuated collapsible sleeve. In a preferred embodiment, however, the locking mechanism 28 is a locking sleeve and is located radially inward of the locating key 22.

In those embodiments where the locking mechanism 28 is a locking sleeve, the up-to-set lock mandrel 10 may further comprise a running tool profile 30 formed on an inner surface of the locking mechanism next to the passageway 17. The running tool profile 30 allows a running tool to engage the locking mechanism 28 to

move it between the running position and the set position. In such embodiments, the locking mechanism 28 preferably includes a shifting profile 32 that has a beveled running portion 34 and a beveled setting portion 36 that extend outwardly past the running portion 34 and toward the locating key 22. The shifting profile 32 and the locating key 22 are separated by a locating key pocket 38 in which the locating key 22 may be at least partially retracted so that the locating key 22 can traverse irregularities on the interior sidewall 16 in the well conduit 12. Thus, the locating key 22 is coupled to the body 20 to allow radial translation of the locating key 22 relative to the body 20 as the locating key 22 transverses the interior sidewall 16 of the well conduit 12.

In a preferred embodiment, a lock retainer ring 40, which is preferably a snap ring or "C" ring, cooperatively works with the locking mechanism 28 to maintain the locating key 22 in the set position. Preferably, the locking mechanism 28 includes a detent or annular boss 42 formed on the outer surface of the locking mechanism 28, wherein the annular boss 42 has an increased outer diameter. While the annular boss 42 is illustrated, it will be appreciated that alternative embodiments may include a recessed portion 43 (See FIG. 2) having a decreased outer diameter, as opposed to the raised annular boss 42. In such embodiments, the locking retainer ring 40 may contact or collapse into the recessed portion 43 as the locking mechanism 28 is moved from the seeking position to the set position. Once the locking mechanism 28 is in the set position, it maintains the locating key 22 in the set position.

Referring now to the more preferred embodiment, since the annular boss 42 extends outwardly, a certain amount of force is required to traverse the annular boss 42 across the lock retainer ring 40. When the locking mechanism 28 is in the seeking position, the lock retainer ring 40 is positioned uphole from the annular boss 42, as illustrated in FIG. 1. Conversely, when the locking mechanism 28 is in the set position, the lock retainer ring 40 is positioned downhole from the annular boss 42, as illustrated in FIG. 3. The cooperation of the lock retainer ring 40 and the annular boss 42 provide a preferred mechanism through which the locking mechanism 28 maintains the locating key 22 in the set position. Of course, it will be appreciated by those skilled in the art that other locking mechanisms may be used as well to accomplish the same result.

The locking mechanism 28 may also have vibration dampers 44, such as "o" rings, positioned on its opposite ends. In certain applications, it is desirable to couple a conventional flow control device 46 to the up-to-set lock mandrel 10. The flow control device 46 may be one of the types listed above that are well known in the art. One such device is a safety valve that is described in detail in the references that are incorporated herein by reference. Therefore, only a partial schematic of the flow control device 46 is shown.

Turning now to FIG. 2, the lock mandrel of FIG. 1 is shown with the locating key 22 engaged with the locating profile 14 of the well conduit and in the no-go position. However, the locating key 22 is not yet set in the set position as illustrated by the fact that the recessed portion 43 is positioned downhole from the lock retainer ring 40. Even though the locating key 22 is not set, the no-go profile 26 of the locating key 22 is firmly engaged with the locating profile 14 of the well conduit 12. With the no-go profile 26 so engaged, the up-to-set lock mandrel 10 cannot be moved downhole any further.

Referring now to FIG. 3, the up-to-set lock mandrel 10 of FIG. 1 is shown with the locking mechanism 28 moved uphole and held in place by the lock retainer ring 40 to thereby maintain the locating keys 22 in the set position. In this figure, sufficient uphole force was exerted on the locking mechanism 28 to traverse the detent or annular boss 42 across the lock retainer ring 40, thereby capturing the retainer ring 40 between the annular boss 42 and the beveled running profile 34. Additionally, the beveled setting profile 36 is firmly engaged against the locating key 22. The capturing of the lock retainer ring 40 causes the locking mechanism 28 to maintain the locating key 22 in the set position. When the locking mechanism 28 is in the set position, the up-to-set lock mandrel 10 cannot be moved either uphole or downhole because the lock mechanism 28 prevents the locating key 22 from disengaging from the locating profile 14.

Turning now briefly to FIG. 4, there is illustrated the lock mandrel of FIG. 1 with the locking mechanism 28 moved back downhole to thereby allow the locating keys 22 to move inwardly and disengage from the set position. In this figure, sufficient downhole force was exerted on the locking mechanism 28 to traverse the annular boss 42 back across the lock retainer ring 40, thereby releasing the retainer ring 40 from its previous captured position as shown in FIG. 3. As illustrated in FIG. 4, annular boss 42 is again downhole from the lock retainer ring 40. Additionally, the beveled setting profile 36 has been shifted downhole and is no longer engaged against the locating key 22, thereby allowing the locating key 22 to move inwardly and release from the no-go position. The no-go profile 26 is contoured such that the beveled faces that comprise the no-go profile 26 allow the up-to-set lock mandrel 10 to disengage from the locating profile 14 and be moved uphole only but the no-go profile prevents the up-to-set lock mandrel 10 from being moved downhole any further.

Turning now to FIG. 5, there is illustrated a plurality of locating key 22 having a plurality of shoulders 26a and 26b associated therewith. The well conduit 12 may have a plurality of locating profiles 14 and 54 recessed in its sidewall 16. In such instance, the locating key 22 can be configured to have a no-go profile 26 that is contoured to engage a selective one of the plurality of the locating profiles 14 and 54. Thus, the no-go profile 26 can be contoured for engagement with a specific locating profile 14, thereby allowing the no-go profile 26 to

bypass the other locating profile 54 that is located above that specific locating profile 14 within the well conduit 12.

With the invention having been described, a preferred method of its operation with reference to FIGs. 1-4 will now be discussed. Prior to the insertion of the up-to-set lock mandrel 10 in the well conduit 12, a conventional flow control device 46 can be coupled to the downhole end of up-to-set lock mandrel 10 if so desired. As the up-to-set lock mandrel 10 is positioned in the well conduit 12, the locating keys 22 are urged outwardly to a seeking position against the sidewall 16 as the up-to-set lock mandrel 10 is moved downhole. If the locating keys 22 encounter an irregularity in the sidewall 16 of the well conduit 12, the locating keys 22 can retract radially into the locating key pocket 38 slightly to allow them to bypass the irregularity. When the locating keys 22 reach the locating profile 14 that is recessed in the sidewall 16, the locating key 22 is urged into the locating profile 14, and the no-go profile 26 engages the locating profile 14, which stops the downhole movement of the up-to-set lock mandrel 10.

A conventional running tool is then used to engage the running tool profile 30 on the interior sidewall of the locking mechanism 28, and an uphole force is exerted against the locking mechanism 28 via the running tool. An uphole force sufficient to slide the annular boss 42 across the lock retainer ring 40 is exerted such that the lock retainer ring 40 is positioned between the annular boss 42 and the beveled running profile 34 of the locking mechanism 28. As the locking mechanism 28 is moved uphole, the beveled setting profile 36 engages the locating key 22 and maintains the locating key 22 in the set position. The locking mechanism 28 is held in this set position by the lock retainer ring 40, which is captured between the annular boss 42 and the beveled running profile 34. When so positioned, the lock retainer ring prevents the locking mechanism 28 from shifting downhole to the running position. Once operations are complete or if the up-to-set lock mandrel 10 needs to be removed from the well conduit 12, a conventional pulling tool is used to exert a downhole force on the locking mechanism 28 sufficient to cause the annular boss 42 to traverse the lock retainer ring 40 and thereby position the annular boss 42 downhole from the lock retainer ring 40. As a result of this shifting action, the beveled setting profile 36 is shifted downhole from the locating key 22, which allows the locating key 22 to be urged inward into the locating key pocket 38 when the lock mandrel is lifted out of the nipple. The conventional pulling tool lifts the lock mandrel by engaging the fish neck 55 of the lock mandrel. The no-go profile 26 is then allowed to disengage from the locating profile 14. The up-to-set lock mandrel 10 can then be removed from the well conduit 12.

From the above discussion, it is apparent that the present invention provides a lock mandrel for registering with the locating profile in a well conduit. The well conduit is preferably either a nipple within the production tubing or a nipple within the well casing. The well conduit is free of a no-go shoulder proximate the locating profile. Thus, the well conduit does not have a restricted inside diameter proximate the locating profile. The no-go profile preferably includes a square shoulder contoured to engage a corresponding square shoulder of the locating profile. In a preferred embodiment, the lock mandrel is an up-to-set lock mandrel that comprises a generally cylindrical body and a locating key coupled to the body and biased to be urged from a seeking position toward a no-go position. The locating key has a no-go profile thereon contoured to engage the locating profile when the locating key is in the no-go position, to thereby function as a no-go for the up-to-set lock mandrel. Preferably, the locating key is coupled to the body to allow radial translation of the locating key relative to the body as the locating key (1) contacts the interior side wall of the well conduit as the lock mandrel is run in the well and (2) moves between the seeking position and the no-go position. The lock mandrel further includes a locking mechanism located adjacent the locating key and displaceable with respect to the body between a running position wherein the locating key is maintained in the seeking position and a set position, wherein the locking sleeve sustains the locating key in the set position.

Although the present invention and its advantages have been described in detail, those skilled in the art should understand that they can make various changes, substitutions and alterations within the scope of the appended claims.

Claims

1. An up-to-set lock mandrel (10) for registering with a locating profile (14) recessed in an interior sidewall (16) of a well conduit portion (12), comprising: a generally cylindrical body (20); and a locating key (22) coupled to said body (20) and biased to be urged from a seeking position toward a no-go position, said locating key (22) having a no-go profile (26) thereon contoured to engage said locating profile (14) when said locating key (22) is in said no-go position, to thereby function as a no-go for said mandrel, said locating key (22) being lockable in a set position.

2. An up-to-set lock mandrel according to Claim 1, further comprising a locking mechanism (28) located proximate said locating key (22) and displaceable with respect to said body (20) between: a running position wherein said locating key (22) is maintained in said seeking position against said interior sidewall (16), and a set position wherein said locking mechanism (28) maintains said locating key (22) in said set position.

3. An up-to-set lock mandrel according to Claim 1 or

2, wherein said well conduit portion (12) is free of an interior diameter reducing no-go shoulder proximate said locating profile (14).

4. An up-to-set lock mandrel according to Claim 1,2 or 3, wherein said locking mechanism (28) is a locking sleeve having an annular boss (42) of increased outer diameter, said up-to-set lock mandrel further comprising a locking ring (40) captured between said body (20) and said locking sleeve, wherein said annular boss (42) traverses said locking ring (40) as said locking sleeve is moved from said running position to said set position, to thereby maintain said locking sleeve in said set position.

5. A method of operating an up-to-set lock mandrel (10) within a well conduit portion (12) having a locating profile (14) recessed in an interior sidewall (16) of said well conduit portion (12), said method comprising the steps of: moving a generally cylindrical body (20) within said well conduit portion (12); urging a locating key (22) coupled to said body (20) from a seeking position toward a no-go position, said locating key (22) having a no-go profile (26) thereon contoured to engage said locating profile (14) when said locating key (22) is in said no-go position; and locking said locating key (22) in a set position using an upward force.

6. A method according to claim 5, wherein the step of locking includes the step of displacing a locking mechanism (28) located proximate said locating key (22) between: a running position wherein said locating key (22) is maintained in said seeking position, and a set position wherein said locking mechanism (28) maintains said locking key (22) in said set position.

7. A method according in Claim 5 or 6, wherein said well conduit portion (12) is free of an interior diameter reducing no-go shoulder proximate said locating profile (14).

8. A downhole well system, comprising: a downhole nipple (12) having a locating profile (14) recessed in an interior sidewall (16) of said nipple (12); an up-to-set lock mandrel (10) for registering with said nipple (12), including, a generally cylindrical body (20), a locating key (22) coupled to said body (20) and biased to be urged from a seeking position toward a no-go position, said locating key (22) having a no-go profile (26) thereon contoured to engage said locating profile (14) when said locating key (22) is in said no-go position and to function as a no-go for said mandrel (10), and a locking mechanism (28) located proximate said locating key (22) and displaceable with respect to said body (20) between a running position wherein said locating key (22) is maintained in said seeking position, and a set position wherein an uphole force on said locking mechanism (28) positions said locking mechanism (28) to sustain said locating key (22) in said set position; and a flow control device coupled to said body.

9. A downhole well systgem according to claim 8, wherein said downhole nipple (12) is free of an interior diameter reducing no-go shoulder proximate said locating profile.

10. A downhole well system according to claim 8 or 9, wherein said locking mechanism (28) is a locking sleeve having an annular boss (42) of increased outer diameter, said up-to-set lock mandrel (10) further comprising a locking ring (40) captured between said body (20) and said locking sleeve, wherein said annular boss (42) traverses said locking ring (40) as said locking sleeve is moved from said running position to said set position, to thereby maintain said locking sleeve in said set position.

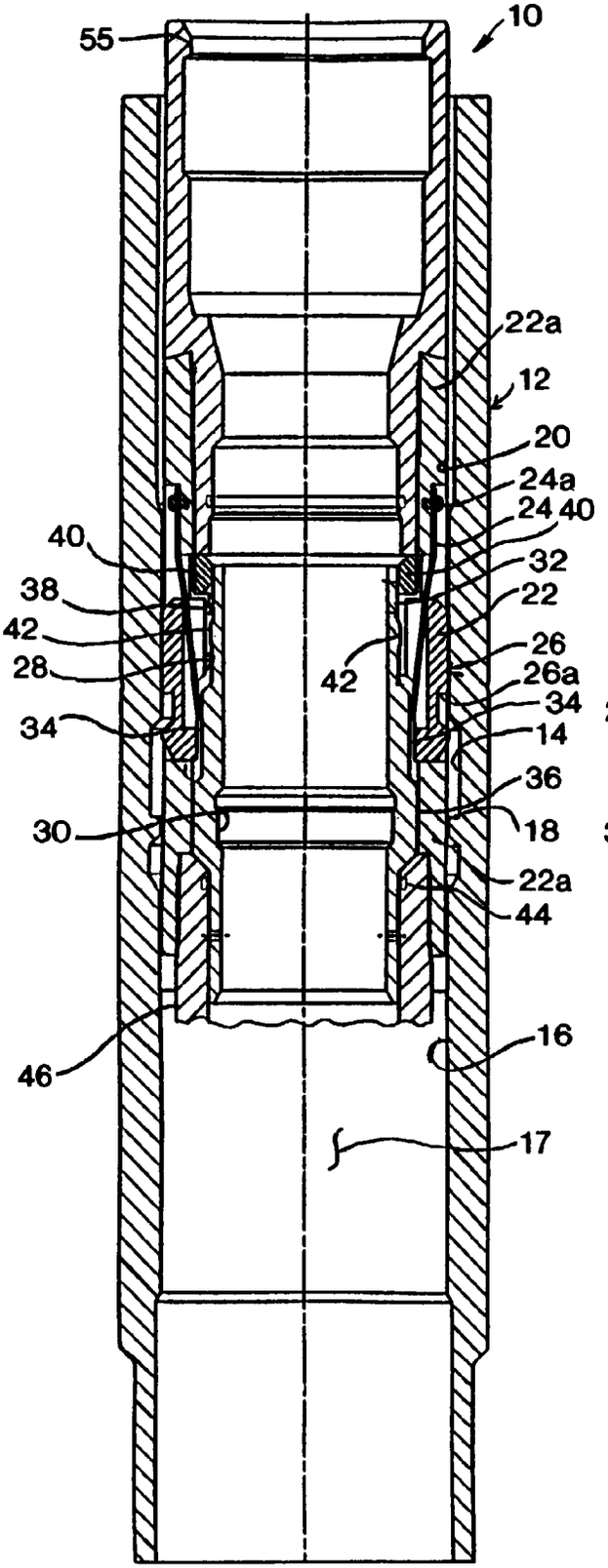
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FIG. 1

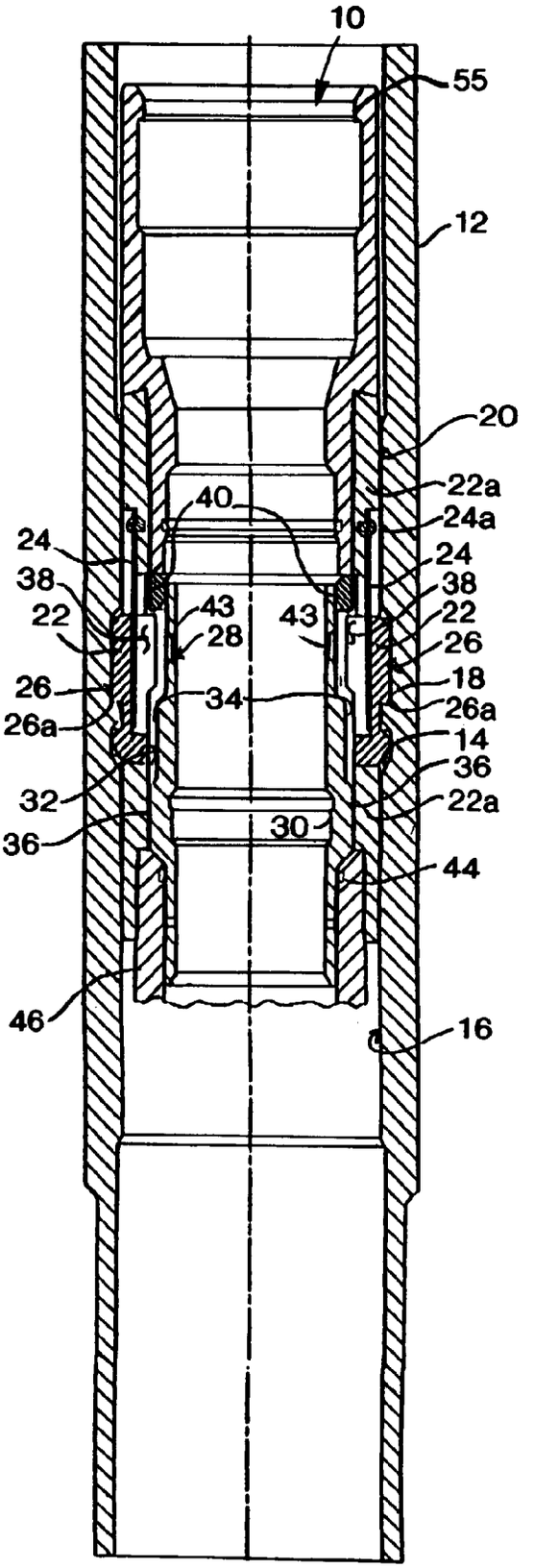
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FIG. 2

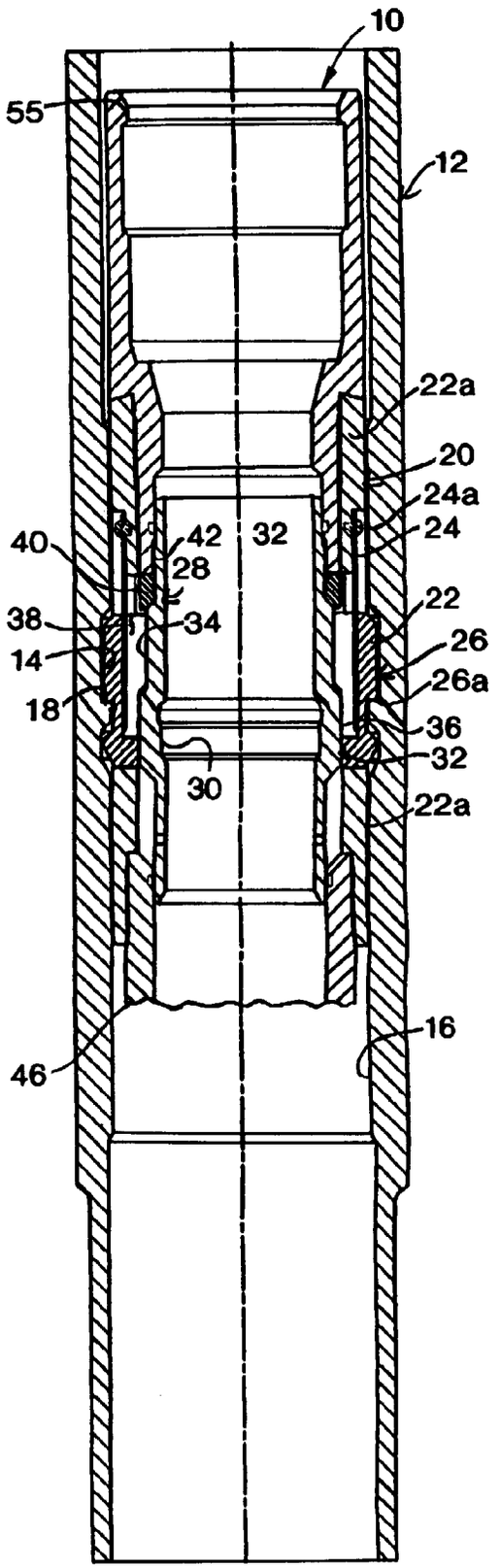
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FIG. 3

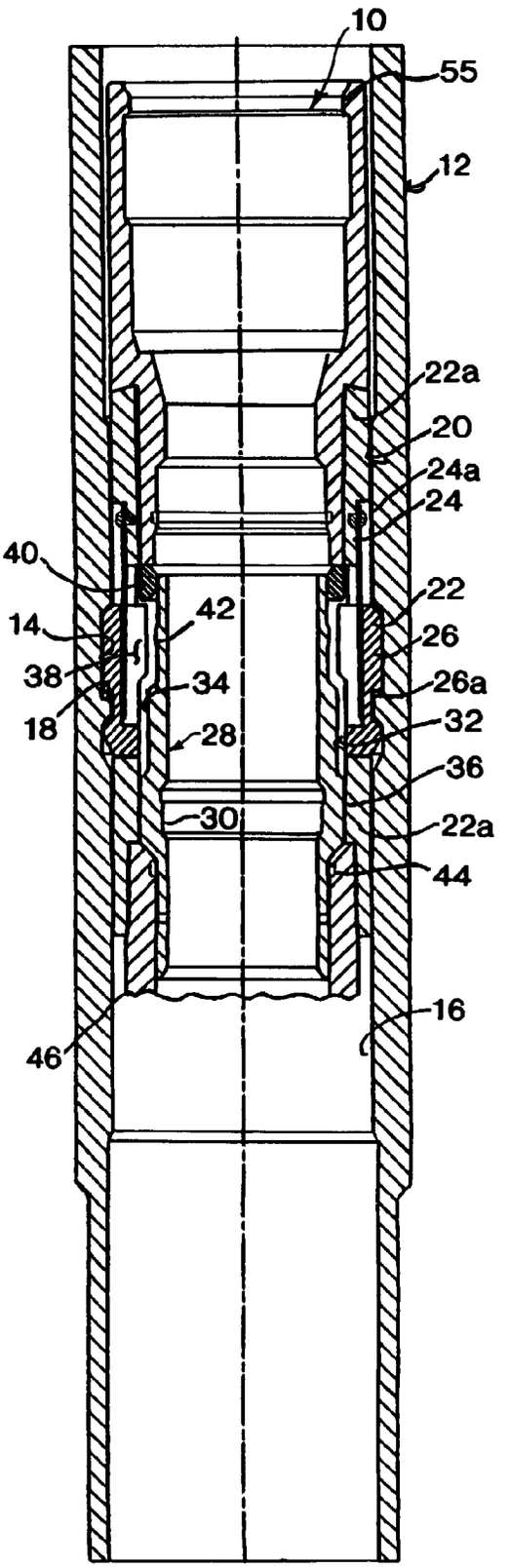
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FIG. 4

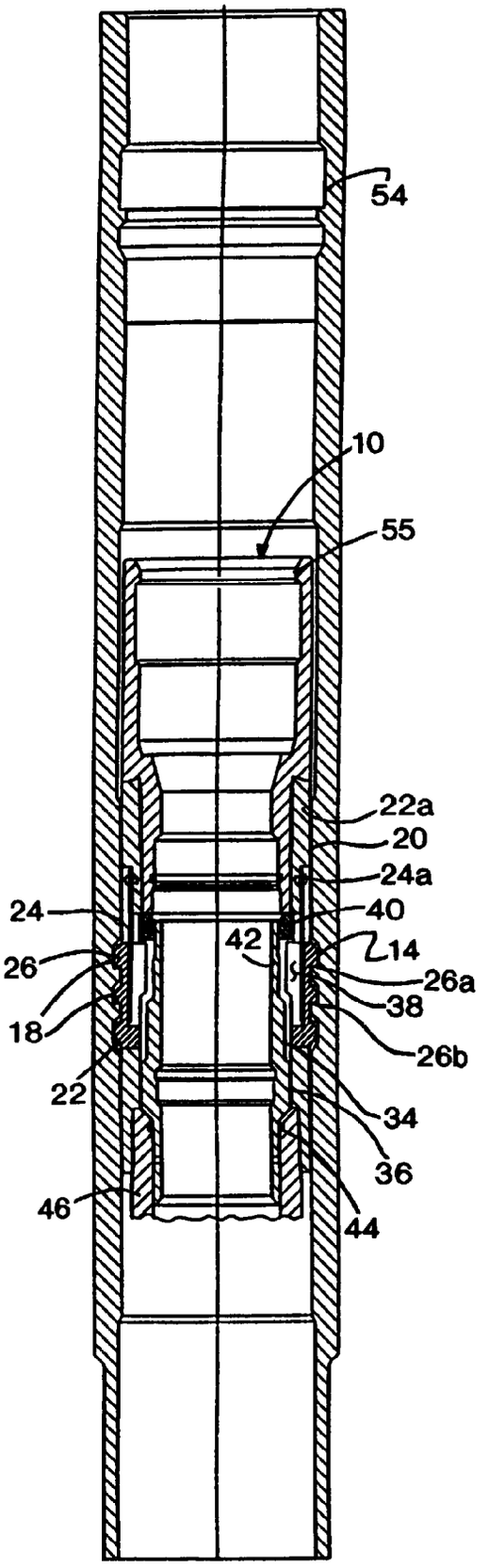

FIG. 5