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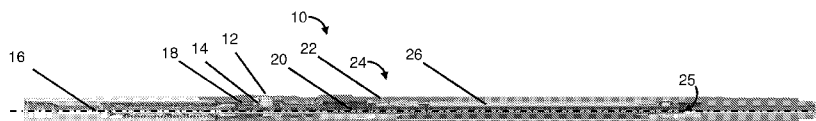


Fig. 2

(57) Abstract: A downhole apparatus (10) that is selectively reconfigurable between a first configuration and a second configuration. The downhole apparatus comprises an actuator (24) for controlling the reconfiguration between the first and second configurations. The actuator comprises a rotationally-activatable device (26), the rotationally-activatable device being substantially unaffected by gravitational orientation such that the apparatus is suitable for use in at least one of: a deviated bore, and a horizontal bore.



DOWNHOLE APPARATUS

FIELD

Embodiments described herein relate generally to a downhole apparatus, and associated methods; and in particular, but not exclusively, to a downhole tool actuator
5 for cycling between actuator positions; and to a downhole generator.

BACKGROUND

In the oil and gas industry, downhole tools are used to perform various operations during exploration, production, maintenance or decommissioning or the like.
10 The tools often form part of a tool string that travels downhole, such as a drill string for drilling a bore in an underground formation. Typically the downhole tools perform different functions during different stages of downhole operations. For example, downhole tools are often transported to and from a particular location in a bore and only activated for use at the particular location for a specific interval, such as to perform
15 a local operation such as packing or reaming or perforating, or the like. Downhole tools are run in downhole on strings, such as drill strings, work strings, coil tubing strings, or the like. Many downhole operations require the actuation of equipment in downhole locations at specific phases and/or positions of downhole operations.

It is often unsuitable to transport the downhole tools in an active configuration.
20 For example, there are numerous downhole tools that feature radially extendable members. Blades or cutters such as on an underreamer are radially extendable to allow the underreamer to pass through a restriction or a casing with the blades in a relatively compact radial configuration. When the underreamer passes out of the end of the casing in a bore, the blades are extended to allow the bore to be drilled to a
25 diameter greater than the internal diameter of the casing. Likewise, tools with particular ports or flow paths may be unsuitable for running in with active configurations whereby flow may be undesirably routed.

During an underreaming operation the blades can be subjected to high radial forces so, to ensure effective cutting, the blades are radially supported in the extended
30 configuration. Upon completion of an underreaming operation, the blades are retracted to allow the toolstring including the underreamer to be retrieved from the bore. Failure to retract the blades, or to retain the blades in a retracted configuration during retrieval of the underreamer, causes the blades to contact the existing casing. A blade retraction

failure of the underreamer makes it difficult, sometimes impossible, to retrieve the underreamer and can also cause damage to the casing or other equipment in the bore.

Actuation or deactuation of tools, including under-reamers, downhole is achieved through various means. For example, downhole actuation may occur at a predetermined location such as a depth or relative to other downhole apparatus or features, such as when a tool being run-in reaches a previously-positioned tool or feature. Other forms of downhole actuation involve remote actuation, such as from surface. Forms of remote actuation from surface include the use of drop-balls or darts transported by fluid in a bore, pressure pulses or variations in properties of a fluid transported in a bore, hydraulic control by hydraulic lines, or signals sent by other means from surface, such as electric or light (e.g. via fibre-optic).

For some downhole operations, electrical power may be required. For example, measurement equipment or particular downhole devices may require an electrical supply to operate. Accordingly, electrical lines may be run from a surface electricity power source to downhole locations; or batteries that have been charged at surface may be incorporated into a toolstring for running in to a downhole location. Alternatively, electricity may be generated downhole, such as with a fluid-powered downhole generator.

SUMMARY

According to a first aspect there are provided at least some embodiments of a downhole apparatus.

The downhole apparatus may be reconfigurable between at least a first and a second configuration.

The downhole apparatus may be reconfigurable between at least a first and a second configuration according to a rotational parameter.

The rotational parameter may comprise a rotational velocity parameter. The rotational parameter may comprise a centrifugal force. The rotational velocity parameter may be at least associated with a rotation of the downhole apparatus.

The downhole apparatus may be reconfigurable between at least a first and a second configuration according to a fluid parameter.

The downhole apparatus may be selectively reconfigurable between the first and second configurations according to a combination of both the fluid parameter and the rotational parameter. The combination of both the fluid parameter and the rotational parameter may be predetermined. The downhole apparatus may be selectively

reconfigurable between the first and second configurations only according to the combination of both the fluid parameter and the rotational parameter. For example, the downhole apparatus may be selectively reconfigured only when both the fluid parameter and the rotational parameter correspond to respective predetermined parameter values.

The downhole apparatus may comprise a downhole actuator. The downhole apparatus may comprise a selective downhole actuator. The actuator may control the reconfiguration of the downhole apparatus between the first and second configurations.

The actuator may comprise a rotationally-activated device. Additionally or alternatively, the actuator may comprise a fluid-activated device.

The rotationally-activated device may be activatable in response to the rotational parameter. The rotationally-activated device may comprise a centrifugally-operated device. The rotationally-operated device may comprise at least one portion that is laterally movable. The rotationally-operated device may comprise at least one portion that is laterally movable in response to the rotational parameter. The lateral movement may comprise a radial movement. The lateral movement may comprise a movement with at least a vector component transverse or perpendicular to a longitudinal direction.

The rotationally-activated device may comprise a lock, the lock being selectively activatable and optionally deactivatable in response to the rotational parameter. The lock may be for selectively locking the fluid-activated device. The lock may be for selectively locking the fluid-activated device to prevent reconfiguration to the second configuration. The lock may be for selectively locking the fluid-activated device in the first configuration. In at least some embodiments, the lock may be for selectively locking the fluid-activated device in both the first and second configurations.

The rotationally-activated device may comprise a mass. The mass may comprise the portion that is laterally movable. The mass may comprise a mass member, such as a solid, non-hollow member. The mass may be a longitudinally-extending mass, extending in or along a longitudinal direction of the apparatus, such as parallel to a bore axis or axis of a toolstring or the like. The mass may be longitudinally elongated. The mass may comprise a length dimension in the longitudinal direction of the apparatus that is considerably greater than a width dimension of the mass (e.g. the width being transverse or radial to the longitudinal direction or axis). The length of the mass may be a factor or a multiple greater than the width. For example, the mass length may be twice, thrice, five times, ten times, or more the mass width.

The mass may be pivotably laterally movable. The mass may be pivotably laterally movable about a pivot axis parallel to the axis of rotation. Alternatively, the mass be pivotably laterally movable about a pivot axis transverse, such as perpendicular to the axis of rotation.

5 The mass may be biased. The mass may be biased inwards, such as towards the axis of rotation. The mass may be biased in a lateral direction. The mass may be biased against movement resulting from rotational movement (such as rotation of the apparatus). The mass may be biased against a centrifugal force. The mass may be biased against a centrifugal force below a threshold. The mass may be biased against
10 a centrifugal force below a threshold such that the mass does not move laterally until the centrifugal force reaches or exceeds the threshold.

 The mass may be mechanically biased. The mass may be biased by a spring force. The mass may be biased by one or more of: a resilient element, a torsion spring, a compression spring, a helical spring, a Belleville spring, an elastic member, a tension
15 spring, a coil spring, or the like.

 Additionally or alternatively the mass may be biased by a fluid force, such as by a hydraulic fluid force, such as associated with a fluid flow and/or a static fluid pressure (e.g. within a substantially closed chamber or passage).

 The fluid-activated device may be activatable in response to a fluid parameter.
20 The fluid-activated device may comprise a longitudinally movable device. The fluid-activated device may comprise a piston. The apparatus may be configured such that a longitudinal movement of the fluid-activated device is prevented in the first configuration. The apparatus may be configured such that any longitudinal movement of the fluid-activated device is prevented in the first configuration. The apparatus may
25 be configured such that substantially no longitudinal movement of the fluid-activated device is permitted in the first configuration. The apparatus may prevent a longitudinal extension of the fluid-activated device in the first configuration. The apparatus may prevent any longitudinal extension of the fluid-activated device in the first configuration. The apparatus may comprise or at least allow a longitudinal movement of the fluid-
30 activated device in the second configuration. The apparatus may allow a longitudinal extension and/or retraction of the fluid-activated device in the second configuration. The rotationally-activated device may control or define allowance of longitudinal movement of the fluid-activated device.

The fluid-actuated device and the rotationally-activated device may be operatively associated with each other such that the operation or activation of at least one of said devices is at least partially dependent upon the operation or activation of the other said device. For example, the fluid-activated device may not be activatable before, until or only after the rotationally-activatable device has been or is activated. The fluid-activated device may only be activated, or activation of the fluid-activated device may only be initiated, whilst the rotationally-activated device is activated. The fluid-actuated device and the rotationally-activated device may be operatively associated such that the operation or activation of each device is at least partially dependent upon the operation or activation of the other device. For example, the rotationally-activated device may only be activatable whilst the fluid-activated device is not activated; and the fluid-activated device may only be activatable whilst the rotationally-activated device is activated.

At least one of the rotationally-activated device and the fluid-activated device may be operatively associated with an actuatable portion of the downhole apparatus. For example, the fluid-activated device may be operatively associated with a member for laterally extending one or more portions of the apparatus. The fluid-activated device may be operatively associated with a cam member for laterally extending one or more members (and optionally for laterally retracting the one or more members). Where the downhole apparatus may be a reamer or under-reamer, the one or more laterally-extendable members may comprise one or more cutters or cutter blocks.

The combination of both the fluid parameter and the rotational parameter may comprise a sequential combination. The downhole apparatus may be reconfigurable according to a predetermined sequence of a variation in the rotational parameter and a variation in the fluid parameter. The downhole apparatus may be reconfigurable according to a predetermined sequence comprising one or more sequential variations in both the rotational parameter and the fluid parameter. The downhole apparatus may be reconfigurable only in accordance with the predetermined sequence. For example, the predetermined sequence may require first predetermined values of both of the rotational and fluid parameters followed by a variation in one of the rotational or fluid parameters to a second predetermined value. The predetermined sequence may require the first predetermined values of both of the rotational and fluid parameters to be followed by a variation in only one of the rotational or fluid parameters to a second predetermined value. The predetermined sequence may require the first predetermined

values of both of the rotational and fluid parameters to be followed by a variation in only one of the rotational or fluid parameters to a second predetermined value.

The predetermined sequence for reconfiguring the apparatus from the first configuration to the second configuration may comprise the following sequential steps:

- 5 (i) providing for or setting both the rotational and fluid parameters at the first predetermined values;
- (ii) varying one of the rotational and fluid parameters from the first predetermined value to a second value.

10 The predetermined sequence may comprise the additional step (iii) after, such as directly after, step (ii):

- (iii) varying the other one of the rotational and fluid parameters from the first predetermined value to a second value, the other of the rotational and fluid parameters being the parameter that was not previously varied during step (ii).

15 Step (ii) may additionally comprise maintaining the other of the rotational and fluid parameters at the first predetermined value. Step (ii) may comprise varying a particular one of the rotational and fluid parameters. Step (ii) may comprise varying only one of the rotational and fluid parameters.

20 Step (iii) may additionally comprise maintaining the one of the rotational and fluid parameters at the second value of step (ii).

The apparatus may be reconfigurable from the second configuration to the first configuration according to a continuation or further predetermined sequence.

25 The apparatus may be reconfigurable from the second configuration to the first configuration by one or more of: varying the rotational parameter from the second value; and/or varying the fluid parameter from the second value. The apparatus may require only one of the rotational parameter and the fluid parameter to be varied from the second value in order to reconfigure the apparatus from the second configuration to the first configuration. The apparatus may be reconfigurable from the second configuration to the first configuration by varying either the rotational parameter or the fluid parameter from the second value. Alternatively, the apparatus may be reconfigurable from the second configuration to the first configuration by varying a particular one of the rotational parameter or the fluid parameter from the second value. Further alternatively, in at least some embodiments, the apparatus may be reconfigurable from the second configuration to the first configuration by varying both
35 the rotational parameter and the fluid parameter from the second value.

The/each second predetermined value may be separated from the/each respective first predetermined value by a respective threshold.

For reconfiguration from the second configuration to the first configuration, the parameter/s to be varied from the second value may be varied from the second value
5 to the first value.

The apparatus may be reconfigurable from the second configuration to the first configuration by substantially reversing steps (i) and (ii). The apparatus may only be reconfigurable from the second configuration to the first configuration by substantially reversing steps (i) and (ii). The apparatus may be reconfigured from the second
10 configuration to the first configuration by varying the one of the rotational and fluid parameters of step (ii) from the second value to the first predetermined value.

In at least some embodiments, the apparatus may be reconfigurable from the second configuration to the first configuration by substantially reversing steps (ii) and (iii). The apparatus may only be reconfigurable from the second configuration to the
15 first configuration by substantially reversing steps (ii) and (iii). The apparatus may be reconfigured from the second configuration to the first configuration by varying the other one of the rotational and fluid parameters of step (iii) from the second value to the first predetermined value.

In at least some embodiments, the apparatus may be reconfigurable from the second configuration to the first configuration by either substantially reversing steps (ii) and (iii) or reversing steps (i) and (ii). The apparatus may be reconfigured from the
20 second configuration to the first configuration by varying either of the rotational and fluid parameters from the second value to the first predetermined value.

In at least some embodiments, the apparatus may be reconfigurable from the second configuration to the first configuration by substantially reversing steps (i), (ii) and (iii). The apparatus may only be reconfigurable from the second configuration to the first configuration by substantially reversing steps (i), (ii) and (iii). The apparatus
25 may only be reconfigured from the second configuration to the first configuration by varying both of the rotational and fluid parameters from the second values to the first predetermined values.
30

The apparatus may effectively be locked in the first configuration. The apparatus may effectively be locked in the first configuration by maintaining the rotational parameter at the first predetermined rotational value. The apparatus may effectively be locked in the first configuration by varying the fluid parameter to the
35 second predetermined value whilst the rotational parameter is at the first

predetermined value, such as below the threshold. The apparatus may effectively be locked in the first configuration by setting the fluid parameter to the second predetermined fluid value whilst the rotational parameter is at the first predetermined rotational value, such as below the threshold. The apparatus may effectively be locked in the first configuration by maintaining the fluid parameter at the second predetermined fluid value whilst the rotational parameter is at the first predetermined rotational value, such as below the threshold. The apparatus may effectively be locked in the first configuration by setting the fluid parameter to the second predetermined fluid value before the rotational parameter is varied from the first predetermined rotational value to the second predetermined rotational value, such as above the threshold. To unlock the apparatus from the locked first configuration may require the fluid parameter to be set to the first predetermined fluid value, such as below the threshold.

In at least some embodiments, the apparatus may effectively be locked in the second configuration by setting the rotational parameter to the first predetermined rotational value whilst the apparatus is in the second configuration. The apparatus may effectively be locked in the second configuration by setting the rotational parameter to the first predetermined rotational value whilst the fluid parameter is at the second predetermined value, such as above the threshold. The apparatus may effectively be locked in the second configuration by first setting the rotational parameter to the first predetermined rotational value whilst the fluid parameter is in the second configuration, before the fluid parameter is varied from the second predetermined fluid value to the first predetermined fluid value. To unlock the apparatus from the locked second configuration may require the rotational parameter to be set to the second predetermined rotational value, such as above the threshold. To unlock the apparatus from the locked second configuration may require the fluid parameter to be set to the second predetermined fluid value and then the rotational parameter to be set to the second predetermined rotational value. To unlock the apparatus from the locked second configuration may require the fluid parameter to be set to the second predetermined fluid value and then the rotational parameter to be set to the second predetermined rotational value.

The rotational parameter may comprise a rotational velocity parameter. The rotational parameter may comprise a centrifugal force. The rotational parameter may be associated with a rotational velocity of at least a portion of the rotationally-activatable device relative to a longitudinal axis, such as of the downhole apparatus. The rotational velocity of the portion of the rotationally-activatable device may be

related to a rotational velocity of the downhole apparatus. For example, the downhole apparatus may be rotatable, such as by a downhole motor and/or from surface (e.g. as part of a toolstring, such as a drill string or the like).

The rotational velocity of the portion may be absolute. The rotational velocity of the portion may be relative, such as relative to a formation adjacent the downhole apparatus, or the bore within which the apparatus is located. The rotational velocity of the portion of the rotationally-activatable device may be related to a rotational velocity of the downhole apparatus. The rotational velocity of the portion of the rotationally-activatable device may be related to a rotational velocity of the downhole apparatus. The rotational velocity of the portion may be in a same rotational direction as the rotational direction of the downhole apparatus. The rotational velocity of the portion may be the same as the rotational velocity of the downhole apparatus. Alternatively, the rotational velocity of the portion of the rotationally-activated device may be different from the rotational velocity of the downhole apparatus. For example, the rotational velocity of the portion of the rotationally-activated device may be greater than the rotational velocity of the downhole apparatus. The rotational velocity of the portion of the rotationally-activatable device may be proportional to the rotational velocity of the downhole apparatus.

The apparatus may comprise a transmission arrangement.

The portion of the rotationally-activatable device may be rotatable via the transmission arrangement. The transmission arrangement may comprise a ratio for converting relative rotational movements. The transmission arrangement may comprise a gearing. The transmission arrangement may transmit relative movement (e.g. rotation) to the portion of the rotationally-activated device, such as between the downhole apparatus and the portion of the rotationally-activated device. The transmission arrangement may be directly connected to the rotation of the downhole apparatus. Alternatively, the transmission arrangement may be indirectly connected to the rotation of the downhole apparatus. For example, the transmission arrangement may comprise one or more borewall-contacting members for contacting an inner surface of a bore within which the downhole apparatus is located, the transmission arrangement being powered or driven by movement relative to the borewall. The transmission arrangement may comprise a plurality of borewall-contacting members arranged around a circumference of the apparatus, such as three borewall-contacting members evenly distributed around the circumference. The borewall-contacting member may comprise a roller configured to rollingly engage or grip the borewall such

that the roller is rotated about its axis by relative movement with the borewall. The roller may have any axis of rotation parallel to the axis of rotation of the downhole apparatus. The roller's axis of rotation may be offset from the downhole apparatus' axis of rotation. The roller may have a diameter that is proportionally smaller than the diameter of the downhole apparatus such that for each revolution of the downhole apparatus results in more than one revolution of the roller. The transmission arrangement may comprise a gearing to transmit the rotation of the /each roller to the portion of the rotationally-activated device. The transmission may ensure that the portion of the rotationally-activated device (that rotates about the axis of rotation of the downhole apparatus) rotates in the same direction as the downhole apparatus (e.g. clockwise or counter-clockwise as appropriate), which may be opposite to a direction of rotation of the roller/s.

In at least some embodiments, providing a transmission arrangement may allow rotation of the portion of the rotationally-activated device at a higher rotational velocity such that a greater centrifugal force may be generated for a given mass at a given rotational velocity of the downhole tool (e.g. compared to embodiments with the same given mass and for the same given rotational velocity of the downhole apparatus where the portion of the rotationally-activated device rotates at the same velocity as the downhole apparatus). Accordingly, centrifugal activation of the rotationally-activated member may be achieved at a lower or relatively low rotational velocity of the downhole apparatus; and/or a greater centrifugal force may be generated at a same rotational velocity of the downhole apparatus.

The fluid parameter may comprise a fluid flow parameter. The fluid flow parameter may comprise a fluid flow rate. The fluid parameter may comprise a fluid pressure. The fluid parameter may comprise a fluid pressure differential. The fluid parameter may comprise a fluid pressure differential present or generated across or within the fluid-activated device, such as by a fluid flow rate across or through a restriction.

The value/s of the fluid parameter and/or the rotational parameter the may comprise a range/s. The value may comprise a threshold. For example, the first predetermined value of the fluid parameter may comprise a range of fluid flow or pressure below a fluid parameter threshold and the second value of the fluid parameter may comprise a range of fluid flow or pressure above the fluid parameter threshold.

The fluid comprising the fluid parameter may be selected from one or more of: a wellbore fluid; a production fluid; a drilling fluid; an injection fluid; a mud, such as a drilling mud; or the like.

The apparatus may comprise a passage for the flow of the fluid therethrough.

5 The passage may comprise a longitudinal passage, for longitudinal flow of the fluid (e.g. for fluid flow uphole or downhole). The passage may comprise an axial passage. The passage may comprise a throughbore. The apparatus may comprise a passage for the flow of fluid therethrough in the first and/or second configurations. The apparatus may be configured to allow the flow of fluid therethrough in the first and/or second
10 configurations; and in at least some embodiments, allowing the flow of fluid therethrough in all configurations.

The downhole apparatus may be repeatedly, such as endlessly, reconfigurable between the first and second configurations. The downhole apparatus may be reconfigurable from the first configuration to the second configuration and from the
15 second configuration to the first configuration. The downhole apparatus may be cyclable between the first and second configurations. The downhole apparatus may be repeatedly cyclable between the first and second configurations. The downhole apparatus may be endlessly cyclable between the first and second configurations. The downhole apparatus may be endlessly cyclable between the first and second
20 configurations according to a predetermined sequence or sequences of variation of the fluid and/or rotational parameters.

One of the first and second configurations may correspond to an active configuration, and the other of the first and second configurations may correspond to an inactive configuration. One of the first and second configurations may correspond to
25 a default configuration (e.g. the first configuration may be a default, inactive configuration).

The downhole apparatus may be for use in vertical and/or deviated and/or horizontal bores. The downhole apparatus may be adapted for use in vertical and/or deviated and/or horizontal bores. The downhole apparatus may be configured for use
30 in vertical and/or deviated and/or horizontal bores. The downhole apparatus may comprise a high-angle downhole apparatus, for use in deviated bores.

The downhole apparatus may be substantially unaffected by gravitational orientation. The downhole apparatus may be operational irrespective of gravitational orientation. The downhole apparatus may be similarly or identically operational
35 irrespective of gravitational orientation. For example, the downhole apparatus may

function substantially identically in a vertical orientation and in a horizontal orientation. The downhole apparatus may be suitable for use in various gravitational orientations of bores, such as horizontal and vertical and all angles of deviation therebetween.

5 The downhole apparatus may be suitable for operation in all gravitational orientations. The downhole apparatus may be adapted for operation in all gravitational orientations. The downhole apparatus may be configured for operation in all gravitational orientations.

10 The downhole apparatus may be suitable for use in bores of varying gravitational orientation, such as bores that vary between horizontal and vertical or angles of deviation therebetween (e.g. a bore that starts vertical, then deviates through an angle towards horizontal, such as when the bore nears a well or reservoir or particular formation). The downhole apparatus may be configured for use in various gravitational orientations of bores, such as horizontal and vertical and angles of deviation therebetween. The downhole apparatus may be configured for use in bores
15 of varying gravitational orientation. The downhole apparatus may be adapted for use in various gravitational orientations of bores, such as horizontal and vertical and angles of deviation therebetween. The downhole apparatus may be adapted for use in bores of varying gravitational orientation.

20 The rotationally-activatable device may be substantially unaffected by gravitational orientation. The rotationally-activatable device may be configured for use irrespective of gravitational orientation. For example, the rotationally-activatable device may be balanced to counteract gravitational effects. The rotationally-activated device may be balanced about its axis of rotation. The axis of rotation may be defined by the rotational movement that activates the rotationally-activated device. The axis of rotation
25 may coincide with an axis of rotation of the downhole apparatus and/or the longitudinal axis of the downhole apparatus or toolstring and/or the longitudinal axis of the bore, such as a wellbore, in which the apparatus is located. The rotationally-activated device may be symmetrical, such as rotationally symmetrical about its axis of rotation. The rotationally-activated device may be mass-balanced.

30 The mass of the rotationally-activated device may be arranged about the axis of rotation. The mass of the rotationally-activated device may be balanced about the axis of rotation such that the rotationally-activated device may be operated substantially independently of gravitational orientation of the downhole apparatus. For example, the mass may be balanced such that, when located in a non-vertical bore, there is no

tendency for the mass to adopt a single orientation with a single particular circumferential point of the mass located on the low side.

The mass may comprise a plurality of mass members arranged about the axis of rotation. For example, the mass may comprise a plurality (e.g. three) mass members evenly distributed about the axis of rotation. Each mass member may comprise a segment, such as a segment or partial segment when viewed in cross-section or end-profile parallel to the axis of rotation.

The mass members may be linked so as to be movable together or in unison. The mass members may be linked so as to only be movable together or in unison. The mass members may be linked so as to be laterally movable in unison in response to the centrifugal force.

In at least some embodiments, linking the mass members to only be laterally movable in unison in response to the centrifugal force may ensure that the mass members respond to the centrifugal force to move laterally independently of the gravitational orientation of the downhole apparatus or independently of the rotational orientation of the downhole apparatus in a non-vertical bore.

Each mass member may be pivotably laterally movable. Each mass member may be pivotably laterally movable about its own pivot axis parallel to the axis of rotation. Accordingly, each mass member may pivot outwards in response to the centrifugal force reaching the threshold; and each mass member may pivot inwards when or if the centrifugal force drops below the threshold.

The pivotal movements of the mass members may be linked by a linkage arrangement. The pivotal movements of the mass members may be linked such that each mass member pivots by a similar amount or number of degrees when the mass members pivot in unison. The linkage arrangement may comprise a gear, such as a ring gear.

Each mass member may be biased inwards, such as towards the axis of rotation, by a biasing member associated with each mass member. Each mass member may be biased against pivoting outwards. For example, each mass member may be associated with a torsion bar, the torsion bar biasing each mass member towards an inner position. Each torsion bar may define a pivoting hinge for each associated mass member. The torsion bars may be arranged parallel to the axis of rotation.

The downhole apparatus may comprise one or more of: a reamer, underreamer, stabilizer, BHA, drill-bit assembly, scraper, valve, bypass tool, percussion tool, agitator, or the like.

5 The apparatus may be controlled, such as from surface, purely by controlling rotation and/or the fluid parameter; such as without any requirement for drop-balls, darts, tags or the like or signal lines or electromagnetically-transmitted signals, such as from surface.

10 The downhole apparatus may be suitable for use in bores of different diameters. The downhole apparatus may be configurable for use in bores of different diameters. For example, the downhole apparatus may comprise compliant pads or the like in an outer diameter for accommodating bores of larger diameter than a minimum diameter for accommodating the downhole apparatus.

15 According to a further aspect there are provided at least some methods of reconfiguring a downhole apparatus between at least a first and a second configuration.

20 The method of reconfiguring a downhole apparatus between at least a first and a second configuration, the method may comprise providing: a downhole apparatus comprising an actuator for controlling the reconfiguration between the first and second configurations, wherein the actuator comprises a rotationally-activatable device, the rotationally-activatable device being substantially unaffected by gravitational orientation such that the apparatus is suitable for use in at least one of: a deviated bore, and a horizontal bore; and rotationally activating the rotationally-activatable device of an actuator to control the reconfiguration between the first and second configurations.

25 The method may comprise reconfiguring the downhole apparatus according to a rotational parameter and/or a fluid parameter.

30 The method may comprise reconfiguring the downhole apparatus according to a predetermined sequence of a variation in the rotational parameter and a variation in the fluid parameter. The downhole apparatus may be reconfigured according to a predetermined sequence comprising one or more sequential variations in both the rotational parameter and the fluid parameter. The downhole apparatus may be reconfigured only in accordance with the predetermined sequence. For example, the predetermined sequence may require first predetermined values of both of the rotational and fluid parameters followed by a variation in one of the rotational or fluid parameters to a second predetermined value. The predetermined sequence may
35 require the first predetermined values of both of the rotational and fluid parameters to

be followed by a variation in only one of the rotational or fluid parameters to a second predetermined value. The predetermined sequence may require the first predetermined values of both of the rotational and fluid parameters to be followed by a variation in only one of the rotational or fluid parameters to a second predetermined value.

5 The predetermined sequence for reconfiguring the apparatus from the first configuration to the second configuration may comprise the following sequential steps:

(i) providing for or setting both the rotational and fluid parameters at the first predetermined values;

10 (ii) varying one of the rotational and fluid parameters from the first predetermined value to a second value.

The predetermined sequence may comprise the additional step (iii) after, such as directly after, step (ii):

15 (iii) varying the other one of the rotational and fluid parameters from the first predetermined value to a second value, the other of the rotational and fluid parameters being the parameter that was not previously varied during step (ii).

20 Step (ii) may additionally comprise maintaining the other of the rotational and fluid parameters at the first predetermined value. Step (ii) may comprise varying a particular one of the rotational and fluid parameters. Step (ii) may comprise varying only one of the rotational and fluid parameters.

Step (iii) may additionally comprise maintaining the one of the rotational and fluid parameters at the second value of step (ii).

25 The method may comprise reconfiguring the apparatus from the second configuration to the first configuration according to a continuation or further predetermined sequence.

30 The method may comprise reconfiguring the apparatus from the second configuration to the first configuration by one or more of: varying the rotational parameter from the second value; and/or varying the fluid parameter from the second value. The apparatus may require only one of the rotational parameter and the fluid parameter to be varied from the second value in order to reconfigure the apparatus from the second configuration to the first configuration. The method may comprise reconfiguring the apparatus from the second configuration to the first configuration by varying either the rotational parameter or the fluid parameter from the second value. Alternatively, the method may comprise reconfiguring the apparatus from the second configuration to the first configuration by varying a particular one of the rotational

35

parameter or the fluid parameter from the second value. Further alternatively, in at least some embodiments, the method may comprise reconfiguring the apparatus from the second configuration to the first configuration by varying both the rotational parameter and the fluid parameter from the second value.

5 For reconfiguration from the second configuration to the first configuration, the parameter/s to be varied from the second value may be varied from the second value to the first value.

10 The method may comprise reconfiguring the apparatus from the second configuration to the first configuration by substantially reversing steps (i) and (ii). The apparatus may only be reconfigured from the second configuration to the first configuration by substantially reversing steps (i) and (ii). The method may comprise reconfiguring the apparatus from the second configuration to the first configuration by varying the one of the rotational and fluid parameters of step (ii) from the second value to the first predetermined value.

15 In at least some embodiments, the method may comprise reconfiguring the apparatus from the second configuration to the first configuration by substantially reversing steps (ii) and (iii). The apparatus may only be reconfigured from the second configuration to the first configuration by substantially reversing steps (ii) and (iii). The method may comprise reconfiguring the apparatus from the second configuration to the first configuration by varying the other one of the rotational and fluid parameters of step (iii) from the second value to the first predetermined value.

20 In at least some embodiments, the apparatus may be reconfigured from the second configuration to the first configuration by either substantially reversing steps (ii) and (iii) or reversing steps (i) and (ii). The apparatus may be reconfigured from the second configuration to the first configuration by varying either of the rotational and fluid parameters from the second value to the first predetermined value.

25 In at least some embodiments, the method may comprise reconfiguring the apparatus from the second configuration to the first configuration by substantially reversing steps (i), (ii) and (iii). The apparatus may only be reconfigured from the second configuration to the first configuration by substantially reversing steps (i), (ii) and (iii). The apparatus may only be reconfigured from the second configuration to the first configuration by varying both of the rotational and fluid parameters from the second values to the first predetermined values.

30 According to a further aspect there are provided at least some embodiments of a downhole locking device. The downhole locking device may be centrifugally-

operated. The downhole locking device may comprise one or more features of the rotationally-activated device of any other aspect.

According to a further aspect there are provided at least some embodiments of a downhole actuator. The downhole actuator may be centrifugally-operated. The
5 downhole actuator may comprise one or more features of the rotationally-activated device of any other aspect.

According to a further aspect there are provided at least some embodiments of a downhole centrifuge. The downhole centrifuge may comprise one or more features of the rotationally-activated device of any other aspect.

10 According to a further aspect there are provided at least some embodiments of a downhole power generator. The downhole power generator may comprise one or more features of the rotationally-activated device of any other aspect.

The portion of the rotationally-activated device may comprise a first portion of a generator, such as a coil or a magnet, for cooperation with a second portion of the
15 generator, such as the other of a coil or a magnet.

According to a further aspect there are provided at least some embodiments of a downhole transmission arrangement for transmitting relative rotational movement downhole, such as between a bore and a downhole apparatus or toolstring. For example, the transmission may transmit rotation between a borewall (e.g. of a lined,
20 cased or unlined wellbore ball) and a portion of a toolstring within the bore. The downhole power transmission may comprise one or more features of the rotationally-activated device of any other aspect, such as one or more features of the transmission arrangement of the first aspect.

The invention includes one or more corresponding aspects, embodiments or
25 features in isolation or in various combinations whether or not specifically stated (including claimed) in that combination or in isolation. For example, it will readily be appreciated that features recited as optional with respect to the first aspect may be additionally applicable with respect to the other aspects without the need to explicitly and unnecessarily list those various combinations and permutations here (e.g. the
30 downhole apparatus of one aspect may comprise features of any other aspect; and the downhole apparatus of one aspect may comprise corresponding features of a downhole actuator of another aspect - and vice versa). Optional features as recited in respect of a method may be additionally applicable to an apparatus; and vice versa. For example, an apparatus may be configured to perform any of the steps or functions

of a method; and a method may comprise any step for which an apparatus is configured, adapted, suitable or performs.

In addition, corresponding means for performing one or more of the discussed functions are also within the present disclosure.

5 It will be appreciated that one or more embodiments/aspects may be useful in downhole actuation.

The above summary is intended to be merely exemplary and non-limiting.

As used herein, the term “comprise” is intended to include at least: “consist of”; “consist essentially of”; “include”; and “be”. For example, it will be appreciated that
10 where the apparatus may “comprise an actuator”, the apparatus may “include an actuator” (and optionally other element/s); the apparatus “may be an actuator”; or the apparatus may “consist of an actuator”; etc. For brevity and clarity not all of the permutations of each recitation of “comprise” have been specifically stated. Similarly,
15 as used herein with reference to a direction or orientation, it will be appreciated that “downhole” and “uphole” do not necessarily relate to vertical directions or arrangements, such as when applied in deviated, non-vertical or horizontal bores. For example, “downhole” may mean any direction towards a reservoir or bore destination; and “uphole” may mean any direction leading to surface or wellhead.

20 BRIEF DESCRIPTION OF THE DRAWINGS

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

Figure 1 shows a schematic representation of a toolstring comprising a downhole apparatus;

25 Figure 2 shows a cross-sectional side representation of a portion of a downhole string incorporating a first embodiment of the downhole apparatus;

Figure 3 shows a further cross-sectional side representation of the portion of the downhole string incorporating the first embodiment of the downhole apparatus of Figure 2 in a first configuration;

30 Figure 4 shows a cross-sectional side representation of a portion the downhole apparatus of Figure 2 in the first configuration;

Figure 5 shows a perspective view of the portion shown in Figure 4;

Figure 6 shows a partially-transparent view of a detail of the portion of Figure 5;

Figure 7 shows an additional view of a detail of the portion of Figure 5;

Figure 8 shows a cross-sectional side representation of a portion of the downhole apparatus of Figure 2 in the first configuration;

Figure 9 shows a detail of the cross-sectional side representation of the portion of the downhole apparatus of Figure 8 in the first configuration;

5 Figure 10 shows a cross-sectional end or plan view of the downhole apparatus of Figure 2 in the first configuration;

Figure 11 shows a cross-sectional end or plan view of the downhole apparatus of Figure 2 in a second configuration;

10 Figure 12 shows a detail of the cross-sectional side representation of the portion of the downhole apparatus of Figure 8 generally similar to Figure 9, but in the second configuration;

Figure 13 shows a cross-sectional side representation of the portion of the downhole string incorporating the first embodiment of the downhole apparatus of Figure 2 generally similar to Figure 3, but in the second configuration;

15 Figure 14 schematically shows a flow chart depicting operational sequences of the apparatus of Figures 2 to 13;

Figure 15 shows a schematic perspective view of a portion of a transmission, such as for use with the apparatus of Figure 2;

Figure 16 shows a partially-transparent view of Figure 15;

20 Figure 17 shows a detail view of Figure 16;

Figure 18 shows a schematic representation of a further toolstring comprising an embodiment of a selective downhole actuator; and

Figure 19 shows a schematic representation of a yet further toolstring comprising an embodiment of a selective downhole actuator;

25 Figure 20 shows a detail of a cross-sectional side representation of a portion of a downhole apparatus of a further embodiment of a selective downhole actuator in the second configuration, generally similar to Figure 12, but with a different second portion of an inter-engaging coupling arrangement; and

30 Figure 21 shows the detail of the cross-sectional side representation of the portion of the downhole apparatus of Figure 20 locked in the second configuration.

DETAILED DESCRIPTION OF THE DRAWINGS

Reference is first made to Figure 1, which shows a schematic representation of a downhole tool string 2 in accordance with a first embodiment of the present invention.

35 Here, the tool string comprises a downhole apparatus 10, here in the form of an

actuator, located in a BHA, adjacent an under-reamer 5, above a drill-bit 4. However, it will be appreciated that in other embodiments (not shown), the selective downhole actuator is located at any position in the tool string. It will also be appreciated that in other tool string embodiments (not shown) additional or alternative tools, including for selective downhole actuation, are selected from one or more of: a reamer; a drill-tool; a valve; a scraping tool; a percussion tool; an agitator; a bypass tool; or the like (not shown). Examples of under-reamers are described in applicant's International (PCT) Application Publication No.s WO 2004/097163 and WO 2010/116152, the disclosures of which are incorporated herein by reference. Here the string 2 is shown in Figure 1 without a means of rotation. However, it will be appreciated that rotation may be from surface (e.g. by a rotary table or the like); or in other embodiments, rotation may be by other means, such as via a downhole motor.

Figure 2 shows a cross-sectional side representation of a portion of a downhole string 2 incorporating a first embodiment of the downhole apparatus 10. Here, the downhole apparatus comprises an underreamer, with cutters 12 mounted on cutter blocks 14, arranged circumferentially around a longitudinal axis 16 of the downhole apparatus 10. It will be appreciated that the apparatus 10 may be run into a bore (not shown) on the string 2. The cutters 12 may be laterally extendable and retractable via a cam member 18. Here, the cam member 18 is connected to a mandrel 20. The mandrel 20 is mounted within a housing 22 of the apparatus 10 and extends longitudinally along the axis 16 of the apparatus 10. Here the mandrel 20 forms part of an actuator 24, with the mandrel 20 being selectively longitudinally movable to extend or retract the cutters 12 as desired.

Here the actuator 24 is positioned downhole of the cutters 12 (to the right as shown in Figure 2), noting that downhole need not be vertically down, but may merely be in a direction towards a target location (e.g. towards a well or hydrocarbon-bearing formation, or away from surface), which could be at an angle to vertical or horizontal, or even upwards beyond horizontal depending on the bore trajectory. It will also be appreciated that in other embodiments (not shown), the actuator 24 may be positioned uphole of the cutters 12 or another downhole tool to be actuated by the actuator 24. For example, if space or length is at a premium below the cutters 12 or another tool associated with the actuator 24, then the actuator 24 may be positioned uphole of the cutters 12 or other tool (e.g. for near-bit applications or the like).

As is shown in more detail in Figure 3, the mandrel 20 comprises a fluid passage in the form of a central throughbore 25. The throughbore 25 extends through

the entire length of the mandrel 20 such that fluid flow through the mandrel 20 is permitted in all configurations. Accordingly, fluid may flow through the apparatus 10 in all configurations. For example, fluid may flow or be pumped through the apparatus 10 irrespective of whether the apparatus 10 is or has been activated. Accordingly, fluid
5 (e.g. a drilling mud or the like) may flow such as to supply a drill-bit or the like (not shown) downhole of the apparatus 10 when the apparatus 10 is activated and also when the apparatus 10 is inactive.

Figure 3 also shows the actuator 24 in more detail. Here the mandrel 20 is longitudinally moveable within the housing 22 and operates as a piston and defines a
10 fluid-activated device of the actuator 24. In particular, the mandrel 20 represents a flow restriction for fluid flowing in the string 2. Accordingly, the mandrel 20 may be longitudinally moveable in response to a variation in a fluid parameter, such as fluid pressure and or flow rate. For example, the flow rate through the string may be varied (e.g. by controlling pumps at surface) such that a pressure differential is generated
15 longitudinally across (or otherwise within) the mandrel 20 to cause the mandrel 20 to move longitudinally. However, the actuator also comprises a rotationally-activated device 26, which is shown in more detail in Figures 4, 5, 6, 7, 8 and 9.

The mandrel 20 and the rotationally-activated device 26 are operatively associated such that the actuator 24 can only be reconfigured from the first
20 configuration (shown in each of Figures 2 to 10) to a second configuration (as shown in Figures 11, 12 and 13) by following a predetermined sequence of variation of both a fluid parameter and a rotational parameter controlling the activation of the mandrel 20 and the rotationally-activated device 26 respectively, as will be described in more detail below. It will be appreciated from Figures 2 and 3 that the rotationally-activated device
25 26 is also housed internally of the housing 22. Here an outer diameter of the housing 22 defines an outer diameter of the apparatus 10 – when the cutters 12 are not extended. The rotationally-activated device 26 is mounted around the mandrel 20, both being coaxial with the central longitudinal axis 16 of the apparatus (and the string 2).

As can clearly be seen from Figure 5, the rotationally-activated device 26
30 comprises three mass members 30a, 30b, 30c in the form of elongated segments. The mass members 30a, 30b, 30c are circumferentially evenly distributed about the rotationally-activated device 26. Each of the three mass members 30a, 30b, 30c is pivotally mounted on a respective torsion bar 32a, 32b, 32c. The torsion bars 32a, 32b, 32c extend between an upper device ring 34 and a lower device ring 36. The mass
35 members 30a, 30b, 30c are mounted to the torsion bars 32a, 32b, 32c such that the

torsion bars bias the mass members 30a, 30b, 30c inwardly to the positions shown in Figures 2 to 10.

Within the upper ring device 34 is located a ring gear 38. The ring gear 38 cooperates with a respective planet gear 39a, 39b, 39c associated with each mass member 30a, 30b, 30c. Accordingly the mass members' 30a, 30b, 30c lateral movements (about their respective pivot axes defined by the torsion bars 32a, 32b, 32c) are linked. The mass members 30a, 30b, 30c move laterally in unison. Accordingly, the mass members 30a, 30b, 30c can all move laterally outwards provided a centrifugal force threshold is reached, irrespective of whether one or more of the mass members 30a, 30b, 30c is located on a low side, such as a low side of a non-vertical bore, during the rotation of the apparatus 10.

The mass members 30a, 30b, 30c are configured to be operatively associatable with the mandrel 20. In particular each of the mass members 30a, 30b, 30c comprises a first portion 40 of an inter-engaging coupling arrangement for coupling with a second portion 42 of the coupling arrangement, the second portion 42 being associated with the mandrel 20. Here, the first portion 40 of the inter-engaging coupling arrangement comprises a series of longitudinally-spaced recesses; and the second portion 42 comprises a corresponding series of protrusions. However, in other embodiments it will be appreciated that the first and second portions 40, 42 may be reversed, or other inter-engaging coupling portions may be provided.

The interengaging coupling arrangement ensures axial movement of the mandrel 20 in at least one direction is prevented when the rotationally-activated device 26 is inactive in the first configuration of Figures 2 to 10, with the mass members 30a, 30b, 30c positioned in the inner position. Here, the mandrel 20 is prevented from extending axially downhole (here, to the right as shown) when the inter-engaging coupling arrangement is engaged, as can clearly be seen in Figure 9.

In this embodiment, the inter-engaging coupling arrangement is configured to provide directionally-dependent locking engagement. Accordingly, when the mass members 30a, 30b, 30c are biased inwards in the inactive configuration of Figures 2 to 10, the mandrel 20 is prevented from moving in a single axial direction (here, downhole, to the right) to prevent extension of the mandrel 20. However, once extended, such as to the position of Figure 12, angled or chamfered shoulders of both the recesses and the protrusions allow the mandrel 20 to retract to the position of Figures 2 to 10, such as as a result of a decrease in fluid flow or pressure.

In the first configuration as shown in Figures 2 to 10, fluid may flow through the throughbore 25 such as to be pumped to aid a downhole tool located downhole of the apparatus 10, such as a drill-bit located downhole for drilling a pilot hole. The fluid generates a downhole force on the mandrel 20, pushing the protrusions of the mandrel 20 against the recesses of the mass members 30a, 30b, 30c. Accordingly downhole movement of the mandrel 20, such as an extension of the mandrel 20 that may be associated with movement of the cam member 18 and extension of the cutters 12, is prevented. In addition the downhole force of the protrusions acting on the recesses inhibits a lateral movement of the mass members 30a, 30b, 30c, such as a lateral pivoting movement of the mass members 30a, 30b, 30c outwards. The greater the downhole force acting on the recesses (or shoulders thereof) by the protrusions, the greater the friction preventing the mass members 30a, 30b, 30c moving laterally. Accordingly, provided the downhole force of the protrusions is sufficient.

Accordingly, provided the fluid pressure is kept above a fluid pressure threshold and the rotation of the apparatus 10 is kept below a rotational velocity threshold, the mass members 30a, 30b, 30c cannot be laterally moved outwards. That is to say, the centrifugal force generated by the rotation of the apparatus 10 will be insufficient to move the mass members 30a, 30b, 30c outwards when the fluid pressure is above a threshold and the rotational velocity of the apparatus is below a threshold.

In this embodiment, the apparatus 10 may only be reconfigured from the first inactive configuration of Figures 2 to 10 to the active configuration of Figures 11 to 13 by following a predetermined sequence of rotational and flow steps. The apparatus 10 must first be rotated above the maximum rotational velocity threshold such that a sufficient centrifugal force is generated to overcome the inwards torsional bias of the torsion bars 32a, 32b, 32c - and any friction present between the recesses and protrusions of the inter-engaging coupling arrangement. The apparatus 10 must first be rotated above the maximum rotation threshold whilst the fluid pressure is maintained below a maximum fluid pressure threshold – such as by maintaining the pumps at low flow whilst the rotational velocity of the apparatus 10 is increased (e.g. by rotation of the toolstring 2 from surface). Whilst the rotational velocity is maintained above the rotation threshold, the mandrel 20 is axially extendable and retractable, such as in response to variations in fluid pressure. Here, the mandrel 20 is freely axially extendable and retractable repeatedly, and also endlessly extendable and retractable here, whilst the rotational velocity is maintained above the threshold. In this particular embodiment, the interengaging coupling arrangement will only engage in the first

configuration, and only engage when both the rotational velocity and the fluid pressure drop below their respective thresholds. Accordingly, here the mandrel 20 can only be locked by the rotationally-activated device 26 in the retracted position – in the first configuration. Here, the mandrel 20 is always retractable in response to control via the fluid parameter, irrespective of the rotationally-activated device 26, such as independently of the rotational velocity of the downhole apparatus 10. Accordingly, improved reliability or certainty of mandrel 20 and associated cutter 12 retraction may be achieved. Ensuring that the mandrel 20 may be retracted irrespective of the rotationally-activated device 26 may prevent the cutters 12 being undesirably extended, or prevent the cutters 12 remaining undesirably extended.

Figure 10 shows a cross-sectional end or plan view of the downhole apparatus 10 in the first configuration; and Figure 11 shows a corresponding view with the apparatus 10 in the second configuration. As can also be seen from the cross-sectional view of Figure 12, from the first configuration of Figures 9 and 10, to move to the position of Figure 11 the mass members 30a, 30b, 30c have been rotated about their pivot axes defined by their respective torsion bars 32a, 32b, 32c. The respective recesses and protrusions are moved out of engagement such that the mandrel 20 is free to axially extend to the position of Figure 12. As can be seen from the cross-sectional view of Figure 13, the axially extension of the mandrel 20 causes the cutters 12 to laterally extend to a reaming diameter to underream a pilot hole bore (not shown), formed by a downhole drill-bit (not shown).

Figure 14 schematically represents the sequential method of selectively activating the apparatus 10. As can be seen, the cutters may only be extended if the rotational velocity is increased above the threshold prior to the fluid flow being increased. If the fluid flow is increased above the fluid flow threshold first, then it is not possible to extend the cutters – even at a rotational velocity that would otherwise be sufficient to generate a centrifugal force to overcome the biasing force of the torsion bars 32a, 32b, 32c to laterally rotate the mass members 30a, 30b, 30c outwards. In this configuration, a high flow above the threshold first may be followed by a high rotation above the threshold such as for drilling a pilot hole, without reaming. If it is desired to ream then the flow must be reduced below the flow threshold. In this embodiment, it may not be necessary to reduce the rotational velocity to extend the cutters 12. That is to say to move from the cutters in position on the right of Figure 14 (corresponding to the configuration of the apparatus 10 in Figures 2 to 20) to the cutters out position on the left in Figure 14 (corresponding to the configuration of the apparatus 10 in Figures

11 to 13) it may only be necessary to reduce the flow below the threshold. Once the flow drops below the threshold, the friction between the first and second portions 40, 42 drops sufficiently to allow the mass members 30a, 30b, 30c to move laterally outwards provided the centrifugal force is above the threshold. It may of course also be desirable to reduce the rotational velocity below the threshold and reduce the flow below the threshold before initiating lateral movement of the mass members 30a, 30b, 30c outwards by increasing the rotational velocity above the threshold, whilst maintaining the flow below the threshold.

In other embodiments (not shown) it may be required to reduce both the flow and the rotational velocity below the threshold before lateral movement of the mass members 30a, 30b, 30c can be initiated. For example, in other embodiments the inter-engaging coupling arrangement may comprise first and second portions 40, 42 that are insensitive to lateral friction between the respective portions 40, 42 (e.g. the recesses may comprise a rim or lip engageable by a corresponding rim or lip of the protrusions to prevent lateral movement of the mass members 30a, 30b, 30c when engaged, always irrespective of rotational velocity).

In the embodiment shown, to retract the cutters 12, corresponding to the left portion of Figure 14 (and the configuration shown in Figures 11 to 13), it is necessary to reduce flow below the threshold. Accordingly, the mandrel 20 may be retracted. For example, the mandrel 20 may be retracted by a mandrel biasing member 62 when the flow drops below the threshold. Here, the mandrel 20 may be retracted when the flow drops below the threshold irrespective of the rotational velocity. Here, when the rotational velocity is sufficiently high and the flow above the flow threshold, the mandrel 20 is extended such that the first and second portions 40, 42 are axially misaligned such that the first and second portions cannot reengage when the mandrel 20 is extended, even when the rotational velocity drops below the threshold – as clearly visible in Figure 12. To reengage the first and second portions with both the mass members 30a, 30b, 30c and the cutters 12 retracted, it is necessary here to reduce both the flow and the rotational velocity below the respective thresholds.

Figures 15, 16 and 17 show a portion of an actuator according to an alternative embodiment. The portion shown comprises a rotationally-activated device 126 generally similar to that shown in Figures 2 to 13, with like reference numerals referencing like features, incremented by 100. Accordingly, by way of example, the rotationally-activated device 126 of Figures 15 to 17 comprises three mass members 130a, 130b, 130c. It will be appreciated that the rotationally-activated device 126 may

be incorporated in the downhole apparatus 10 of Figure 2 (and the drillstring 2 of Figure 1), in place of the rotationally-activated device shown in Figure 2.

5 In this arrangement, the rotational velocity of the portion of the rotationally-activatable device 126 is indirectly related to the rotational velocity of the downhole apparatus 10. The rotational velocity of the portion is in a same rotational direction as the rotational direction of the downhole apparatus 10. Here, the rotational velocity of the portion of the rotationally-activated device 126 is different from the rotational velocity of the downhole apparatus 10. Here, the rotational velocity of the portion of the rotationally-activated device 126 is greater than the rotational velocity of the downhole apparatus 10. The rotational velocity of the portion of the rotationally-activatable device 126 is proportional to the rotational velocity of the downhole apparatus 10.

The rotationally-activated device 126 comprises a transmission arrangement 170. The portion of the rotationally-activatable device 126 is rotatable via the transmission arrangement 170. The transmission arrangement 170 comprises a ratio 15 for converting relative rotational movements. The transmission arrangement 170 comprises a gearing. The transmission arrangement 170 transmits relative movement (e.g. rotation) to the portion of the rotationally-activated device 126. The transmission arrangement 170 is indirectly connected to the rotation of the downhole apparatus 10. Here, the transmission arrangement 170 comprises a plurality of borewall-contacting 20 members 172 for contacting an inner surface of a bore (not shown) within which the downhole apparatus 10 is located, the transmission arrangement 170 being powered or driven by movement relative to the borewall. Here, the plurality of borewall-contacting members 172 comprise three rollers evenly arranged around a circumference of the rotationally-activated device 126. The rollers 172 are configured to rollingly engage or 25 grip the borewall such that each roller 172 is rotated about its axis by relative movement with the borewall. Each roller 172 has an axis of rotation parallel to the axis of rotation of the downhole apparatus 10. Each roller's 172 axis of rotation is offset from the downhole apparatus' 10 axis of rotation 16. Each roller 172 has a diameter that is proportionally smaller than the diameter of the downhole apparatus 10 such that 30 each revolution of the downhole apparatus 10 results in more than one revolution of each roller 172. The transmission arrangement 172 comprises a gearing 174 to transmit the rotation of each roller 172 to the rotatable portion of the rotationally-activated device 126. Here, the gearing comprises a planet gear 176 connected to each roller 172, each planet gear 176 engaging a central sun gear 178 that rotates the 35 portion of the rotationally-activated device 126 comprising the mass members 130a,

130b, 130c. Accordingly the rotation of the rollers 172 is also synchronized and the rotation of each roller 172 driven by the respective rolling contacts with the internal borewall adjacent the exterior of the housing 118 contributes to the rotation of the portion of the rotationally-activated device 126. The gearing 174 ensures that the
5 portion of the rotationally-activated device 126 (that rotates about the axis 16 of rotation of the downhole apparatus 10) rotates in the same direction as the downhole apparatus 10 (e.g. clockwise or counter-clockwise as appropriate), which is opposite to a direction of rotation of the rollers 172. The gearing 174 comprises a ratio that provides an increased rotational velocity of the sun gear 178 and connected rotating portion with
10 the mass members 130a, 130b, 130c – relative to the downhole apparatus' 10 rotational velocity.

Accordingly, this transmission arrangement 170 allows rotation of the portion of the rotationally-activated device 126 about the axis of rotation 16 of the downhole apparatus 10 at a higher rotational velocity than the rotational velocity of the downhole
15 apparatus 10 as such. Accordingly, a greater centrifugal force may be generated for a given mass at a given rotational velocity of the downhole apparatus 10 (e.g. compared to embodiments with the same given mass and for the same given rotational velocity of the downhole apparatus 10 where the portion of the rotationally-activated device 126 rotates at the same velocity as the downhole apparatus 10). Accordingly, centrifugal
20 activation of the rotationally-activated device 126 may be achieved at a lower or relatively low rotational velocity of the downhole apparatus 10; and/or a greater centrifugal force may be generated at a same rotational velocity of the downhole apparatus 10. Here, the mass members 130a, 130b, 130c may pivot laterally outwards at a lower rotational velocity of the apparatus 10. In addition, the mass members 130a,
25 130b, 130c may comprise a smaller mass than the mass members 30a, 30b, 30c of the embodiment of Figures 2 to 13 as the higher rotational velocity of the portion of the rotationally-activated device 126 that rotates generates a sufficient centrifugal force at a similar rotational velocity of the downhole apparatus 10. Accordingly, the length of the mass members 130a, 130b, 130c of this embodiment may be relatively short, which
30 may be useful where toolstring length may be at a premium, such as for particular applications (e.g. near-bit in a BHA).

It will be appreciated that although shown here as an alternative embodiment of the rotationally-activated device of the apparatus 10 of Figure 2, the transmission arrangement 170 may be useful in other applications. For example, where the mass
35 members are or comprise portions of a generator (e.g. magnets or a coil), the

transmission arrangement 170 may provide for an increased rotational velocity of the portions of the generator, resulting in an increased power generation for a similar rotational velocity of a downhole apparatus 10 or string 2.

Figure 18 shows a schematic representation of a further toolstring 202 comprising an embodiment of a selective downhole actuator 210. The toolstring schematically shown is generally similar to that of Figure 1. However, here the actuator 210 is located uphole of the BHA, connected to an upper toolstring portion 211. It will be appreciated that the actuator 210 may be used for the actuation of one or more associated tools or functions (not shown). It will also be appreciated, that the toolstring 202 may comprise a plurality of actuators 210 according to the present invention. In addition, or alternatively, the toolstring 202 may comprise one or more additional actuators (not shown) such as one or more conventional actuators.

Figure 19 shows a schematic representation of a yet further toolstring 302 comprising an embodiment of a selective downhole actuator 310. Here, the actuator 310 is shown at an intermediate portion of the toolstring 302, between a lower toolstring portion 309 and an upper toolstring portion 311. It will again be appreciated that the actuator 310 may be used for the selective actuation of one or more associated tools or functions (not shown). It will also be appreciated that the toolstring 302 may comprise one or more additional actuators, such as one or more actuators according to the present application and/or conventional actuator/s. For example, the BHA 303 may comprise one or more additional actuators (not shown).

Figure 20 shows a detail of a cross-sectional side representation of a portion of a rotationally-activated device 426 in accordance with a further embodiment of the present invention, generally similar to Figure 12, but with a different first portion 440 of an inter-engaging coupling arrangement; and with like features referenced by like numerals, incremented by 400. Accordingly, the rotationally-activated device 426 comprises a first portion 440 of the inter-engaging coupling arrangement in the form of a series of longitudinally-spaced recesses for engaging a second portion 442 of a mandrel 420, the second portion 442 of the coupling arrangement associated with the mandrel 420 comprising a series of protrusions. However, it will be appreciated that in the embodiment shown in Figures 20 and 21, additional recesses of the first portion 440 are provided, at locations corresponding to the protrusions of the second portion when the second portion 442 is in the position of the second configuration, as shown in Figure 20 (located towards the right as shown when viewing Figure 20). The shoulders of the additional recesses are not directionally-dependent in the same manner as those

common to Figure 12, such that the additional recesses of the embodiment of Figure 20 may be used to lock the mandrel 420 in the extended position by reducing the rotational velocity below the threshold with the mandrel 420 extended. The functionality here is generally identical to that of Figure 12, with the only difference being that the mass members 430a, 430b, 430c are able to move (e.g. pivot) inwards if the rotational velocity drops below the threshold, whilst the mandrel 420 is still extended, in the second configuration – as is shown in Figure 21.

It will be appreciated that the embodiment shown in Figures 20 and 21 may be useful in operations where activation and/or extension is desired to be continued with low RPM's. It will be appreciated that in at least some uses, the device 426 of Figures 20 and 21 can be reset by sequentially increasing RPMs, then reducing flow/pressure and then reducing RPMs.

Here, the device 426 may effectively be locked in the first configuration, similarly to that shown in Figure 9. That is to say, the device 426 may effectively be locked in the first configuration by maintaining the rotational parameter at the first predetermined rotational value (not shown, but prior to extension to the configuration shown in Figure 20). The device 426 is effectively locked in the first configuration by varying the fluid parameter to the second predetermined value whilst the rotational parameter is at the first predetermined value, such as below the threshold. The device 426 is effectively locked in the first configuration by setting the fluid parameter to the second predetermined fluid value before the rotational parameter is varied from the first predetermined rotational value to the second predetermined rotational value, such as above the threshold. To unlock the device 426 from the locked first configuration requires the fluid parameter to be set to the first predetermined fluid value, such as below the threshold; and then the rotational parameter set to the second predetermined rotational value.

In the embodiment of Figures 20 and 21, the device 426 can effectively be locked in the second configuration by setting the rotational parameter to the first predetermined rotational value whilst the device 426 is in the second configuration, as shown in Figure 21. The device 426 is effectively locked in the second configuration by first setting the rotational parameter to the first predetermined rotational value whilst the fluid parameter is in the second configuration, before the fluid parameter is varied from the second predetermined fluid value to the first predetermined fluid value. To unlock the device 426 from the locked second configuration of Figure 21 requires the fluid parameter to be set to the second predetermined fluid value and then the rotational

parameter to be set to the second predetermined rotational value. Once unlocked in the second configuration (e.g. returned from the configuration of Figure 21 to the configuration of Figure 20), the device may only be returned to the first configuration by setting the rotational parameter (RPMs) to the first predetermined rotational value (below the RPM threshold) before the fluid parameter is set to the first predetermined fluid value (e.g. when pressure is reduced, such as by reducing or stopping pumping).

It will be appreciated that such an embodiment as shown in Figures 20 and 21 may have particular utility in the operation of a downhole adjustable stabilizer. The ability to lock the device 426 in the second configuration may enable the stabilizer to be set at a particular diameter. Allowing the fluid parameter to vary, such as due to a fluctuation in pressure (e.g. at the pumps) without the mandrel 420 necessarily moving may allow the device 426 to be maintained at the second configuration to allow the performance of operations, such as with the adjustable stabilizer set at a particular diameter; and without requiring resetting via the first configuration.

It will be appreciated that the apparatus of the present application may find utility in or at various locations along or within a toolstring, such as according to particular functional requirements of particular toolstrings.

It will be apparent to those of skill in the art that the above described embodiments are merely exemplary of the present invention, and that various modifications and improvements may be made thereto, without departing from the scope of the invention. For example, it will also be appreciated that in other embodiments, a toolstring comprises a plurality of downhole actuators, each downhole actuator being configured to actuate and/or deactuate an associated tool.

It will be appreciated that any of the aforementioned apparatus may have other functions in addition to the mentioned functions, and that these functions may be performed by the same apparatus.

Where some of the above apparatus and methods have been described in relation to actuating an underreaming tool; it will readily be appreciated that a similar actuator may be for use with other downhole tools, such as for actuating drilling, cleaning, and/or injection tools, or valves or the like.

Where features have been described as downhole or uphole; or proximal or distal with respect to each other, the skilled person will appreciate that such expressions may be interchanged where appropriate. For example, the skilled person will appreciate that where the piston or mandrel extends downhole to actuate; in an alternative embodiment, the piston or mandrel may be extended uphole to actuate.

The applicant hereby discloses in isolation each individual feature described herein and any combination of two or more such features, to the extent that such features or combinations are capable of being carried out based on the present specification as a whole in the light of the common general knowledge of a person skilled in the art, irrespective of whether such features or combinations of features solve any problems disclosed herein, and without limitation to the scope of the claims. The applicant indicates that aspects of the present invention may consist of any such individual feature or combination of features. In view of the foregoing description it will be evident to a person skilled in the art that various modifications may be made within the scope of the invention.

CLAIMS:

- 5 1. A downhole apparatus, wherein the downhole apparatus is selectively reconfigurable between a first configuration and a second configuration, the downhole apparatus comprising an actuator for controlling the reconfiguration between the first and second configurations, wherein the actuator comprises a rotationally-activatable device, the rotationally-activatable device being substantially unaffected by gravitational orientation such that the apparatus is suitable for use in at least one of: a deviated bore, and a horizontal bore.
- 10 2. The downhole apparatus of claim 1, wherein the apparatus is reconfigurable between at least the first and the second configuration according to a rotational parameter.
- 15 3. The downhole apparatus of claim 2, wherein the rotational parameter comprises a centrifugal force.
4. The downhole apparatus of claim 2 or 3, wherein the rotational parameter is at least associated with a rotation of the downhole apparatus.
- 20 5. The downhole apparatus of any preceding claim, wherein the downhole apparatus is reconfigurable between at least the first and the second configuration according to a fluid parameter.
- 25 6. The downhole apparatus of claim 5, wherein the apparatus is reconfigurable between at least the first and the second configuration according to a rotational parameter, and wherein the downhole apparatus is selectively reconfigurable between the first and second configurations according to a combination of both the fluid parameter and the rotational parameter.

7. The downhole apparatus of claim 6, wherein the downhole apparatus is selectively reconfigured only when both the fluid parameter and the rotational parameter correspond to respective predetermined parameter values.
- 5 8. The downhole apparatus of claim 6 or 7, wherein the combination of both the fluid parameter and the rotational parameter comprises a sequential combination.
- 10 9. The downhole apparatus of any of claims 6, 7 or 8, wherein the downhole apparatus is reconfigurable according to a predetermined sequence of a variation in the rotational parameter and a variation in the fluid parameter, such as a predetermined sequence comprising the following sequential steps:
- (i) providing for or setting both the rotational and fluid parameters at respective first predetermined values;
- 15 (ii) varying one of the rotational and fluid parameters from the first predetermined value to a second value.
- 20 10. The downhole apparatus of any of claims 5 to 9, wherein the actuator comprises a fluid-activated device, the fluid-activated device being activatable in response to the fluid parameter.
11. The downhole apparatus of claim 10, wherein the fluid-activated device comprises a longitudinally movable device.
- 25 12. The downhole apparatus of claim 11, wherein the longitudinally movable device comprises a piston.
- 30 13. The downhole apparatus of claim 11 or 12, wherein the apparatus is configured such that a longitudinal movement of the fluid-activated device is prevented in the first configuration and the rotationally-activated device controls or defines allowance of longitudinal movement of the fluid-activated device.
- 35 14. The downhole apparatus of claims 10 to 13, wherein the fluid-actuated device and the rotationally-activatable device are operatively associated with each other such that the operation or activation of at least one of said devices is at

least partially dependent upon the operation or activation of the other said device.

5 15. The downhole apparatus of any of claims 2 to 14, wherein the apparatus is reconfigurable between at least the first and the second configuration according to a rotational parameter and wherein the rotationally-activated device comprises a lock, the lock being selectively activatable in response to the rotational parameter.

10 16. The downhole apparatus of claim 15, wherein the lock is deactivatable in response to the rotational parameter.

 17. The downhole apparatus of claim 15 or 16, wherein the lock is for selectively locking the fluid-activated device.

15 18. The downhole apparatus of claim 17, wherein the lock is for one or more of: selectively locking the fluid-activated device to prevent reconfiguration to the second configuration, selectively locking the fluid-activated device in the first configuration, selectively locking the fluid-activated device in both the first and
20 second configurations.

 19. The downhole apparatus of any of claims 2 to 18, wherein the apparatus is reconfigurable between at least the first and the second configuration according to a rotational parameter and wherein the rotationally-activated device
25 comprises at least one portion that is laterally movable in response to the rotational parameter.

 20. The downhole apparatus of claim 19, wherein the rotationally-activated device comprises a mass, the mass comprising the portion that is laterally movable.

30 21. The downhole apparatus of claim 20, wherein the mass is a longitudinally-extending mass, extending in or along a longitudinal direction of the apparatus.

 22. The downhole apparatus of claim 21, wherein the mass extends parallel to a
35 bore axis or axis of a toolstring or the like.

23. The downhole apparatus of claim 20, 21 or 22, wherein the mass is pivotably laterally movable.

5 24. The downhole apparatus of any of claims 20 to 23, wherein the mass is biased.

25. The downhole apparatus of claim 24, wherein the mass is biased by a torsion bar.

10 26. The downhole apparatus of any of claims 20 to 25, wherein the mass comprises a plurality of mass members arranged about the axis of rotation.

27. The downhole apparatus of claim 26, wherein the mass members are linked so as to be laterally movable in unison in response to the centrifugal force.

15

28. The downhole apparatus of any preceding claim, wherein the apparatus comprises a transmission arrangement, a portion of the rotationally-activatable device being rotatable via the transmission arrangement, wherein the transmission arrangement is for transmitting a relative movement to the portion of the rotationally-activated device.

20

29. The downhole apparatus of claim 29, wherein the relative movement comprises a relative movement between the downhole apparatus and the portion of the rotationally-activated device.

25

30. The downhole apparatus of claim 28 or 29, wherein the transmission arrangement is directly connected to the rotation of the downhole apparatus.

30

31. The downhole apparatus of claim 28 or 29, wherein the transmission arrangement is indirectly connected to the rotation of the downhole apparatus.

32. The downhole apparatus of claim 31, wherein the transmission arrangement is indirectly connected via one or more borewall-contacting members of the transmission arrangement contacting an inner surface of a bore within which

the downhole apparatus is located, the transmission arrangement being powered or driven by movement relative to the borewall.

5 33. The downhole apparatus of any preceding claim, wherein the downhole apparatus is repeatedly reconfigurable between the first and second configurations.

10 34. The downhole apparatus of claim 33, wherein the downhole apparatus is endlessly reconfigurable between the first and second configurations.

35. The downhole apparatus of any preceding claim, wherein the downhole apparatus comprises one or more of: a reamer, underreamer, stabilizer, BHA, drill-bit assembly, scraper, valve, bypass tool, percussion tool, agitator, or the like.

15 36. A method of reconfiguring a downhole apparatus between at least a first and a second configuration, the method comprising providing:

20 a downhole apparatus comprising an actuator for controlling the reconfiguration between the first and second configurations, wherein the actuator comprises a rotationally-activatable device, the rotationally-activatable device being substantially unaffected by gravitational orientation such that the apparatus is suitable for use in at least one of: a deviated bore, and a horizontal bore; and

25 rotationally activating the rotationally-activatable device of an actuator to control the reconfiguration between the first and second configurations.

30 37. The method of reconfiguring a downhole apparatus of claim 36, the method comprising reconfiguring the downhole apparatus according to at least one of a rotational parameter and a fluid parameter.

35 38. The method of reconfiguring a downhole apparatus of claim 37, the method comprising reconfiguring the downhole apparatus according to a predetermined sequence of a variation in the rotational parameter and a variation in the fluid parameter.

39. The method of reconfiguring a downhole apparatus of claim 38, wherein the predetermined sequence comprises one or more sequential variations in both the rotational parameter and the fluid parameter.

5 40. The method of reconfiguring a downhole apparatus of claim 38 or 39, wherein the predetermined sequence for reconfiguring the apparatus from the first configuration to the second configuration comprises the following sequential steps:

10 (i) providing for or setting both the rotational and fluid parameters at the first predetermined values;

(ii) varying one of the rotational and fluid parameters from the first predetermined value to a second value.

15 41. The method of reconfiguring a downhole apparatus of claim 40, wherein the predetermined sequence comprises the additional step (iii) after step (ii), wherein step (iii) comprises:

(iii) varying the other one of the rotational and fluid parameters from the first predetermined value to a second value, the other of the rotational and fluid parameters being the parameter that was not previously varied during step (ii).

20

42. The method of reconfiguring a downhole apparatus of claim 41, wherein the predetermined sequence comprises the additional step (iii) directly after step (ii).

25 43. The method of reconfiguring a downhole apparatus of claim 40, 41 or 42, wherein step (ii) additionally comprises maintaining the other of the rotational and fluid parameters at the first predetermined value.

30 44. The method of reconfiguring a downhole apparatus of claim 41, 42 or 43, wherein step (iii) additionally comprises maintaining the one of the rotational and fluid parameters at the second value of step (ii).

45. The method of reconfiguring a downhole apparatus of any of claims 40 to 44 wherein the apparatus is reconfigured from the second configuration to the first

configuration by at least one of: substantially reversing steps (ii) and (iii), or reversing steps (i) and (ii).

Exemplary Portion of Tool string

2 ↗

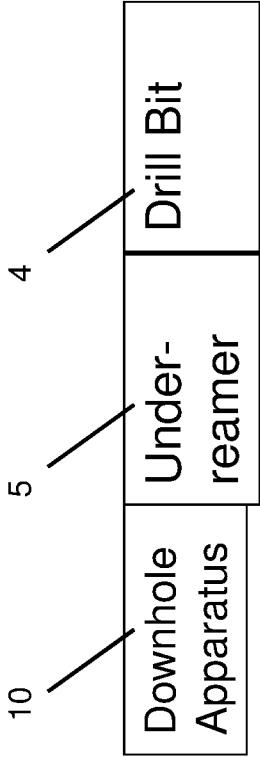


Fig. 1

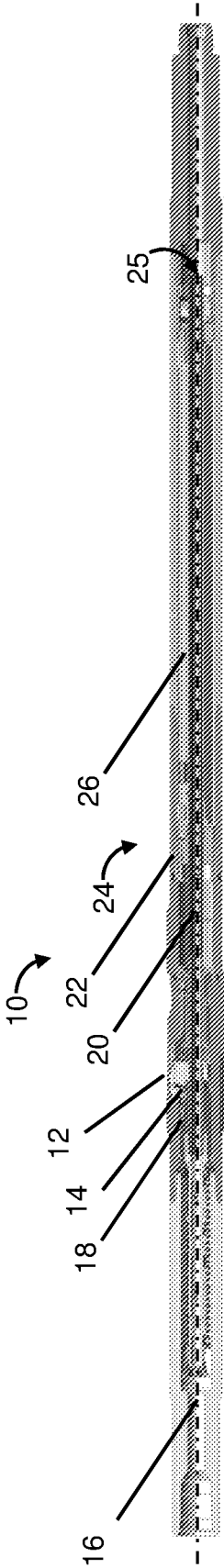
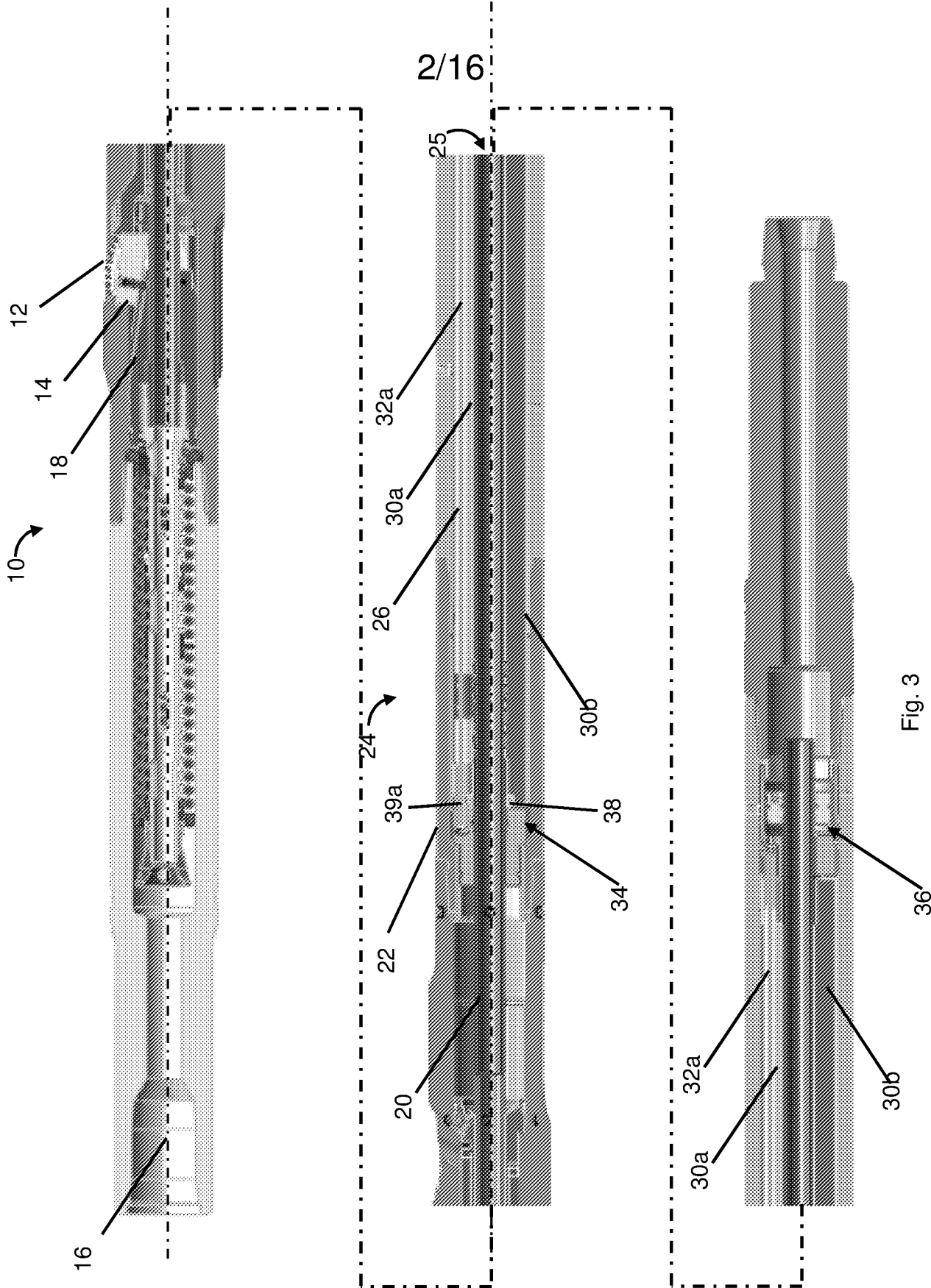
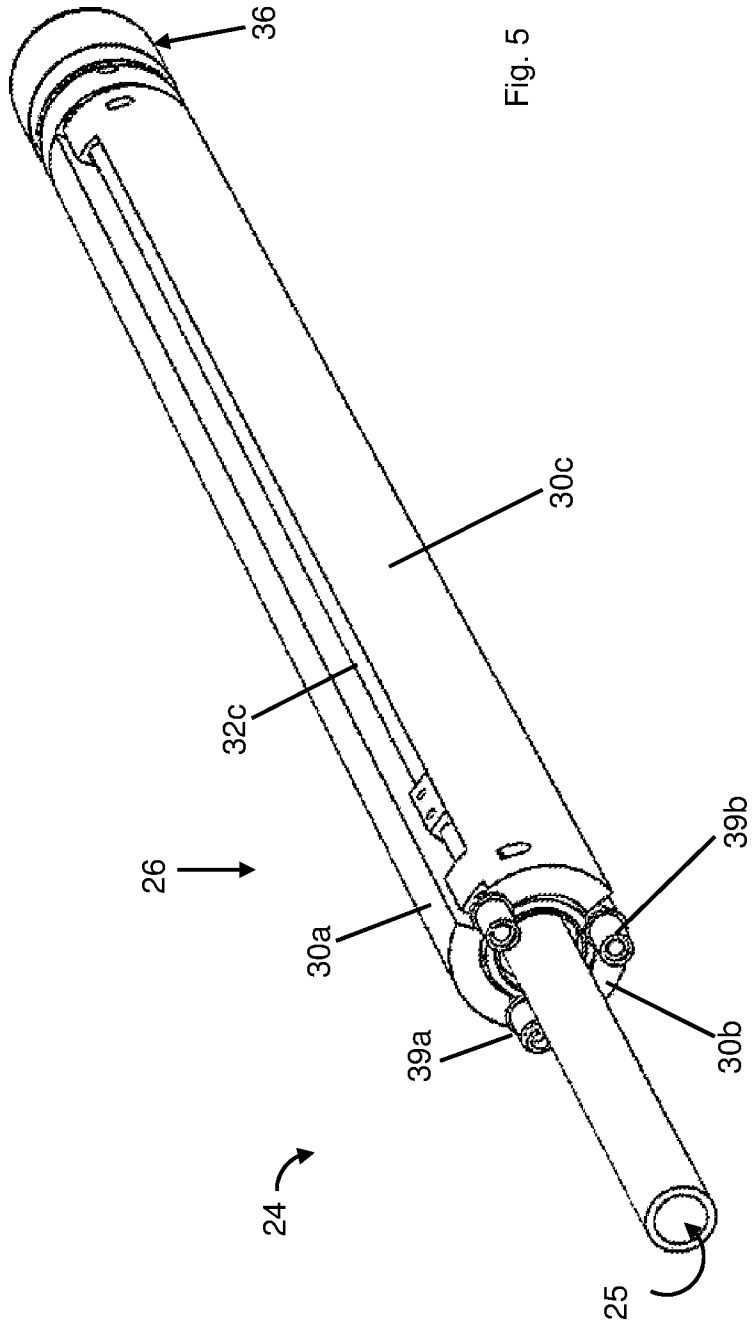
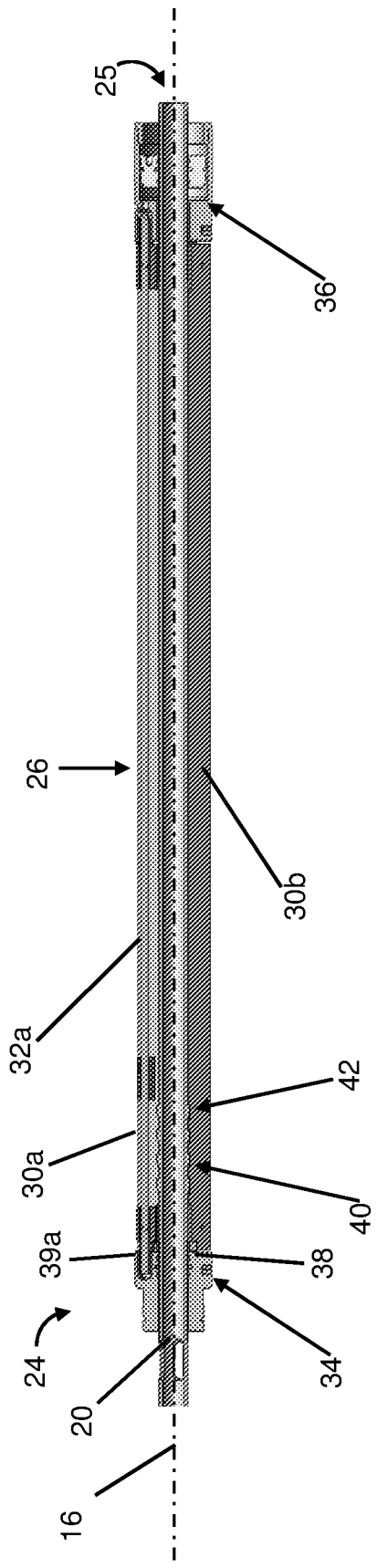


Fig. 2





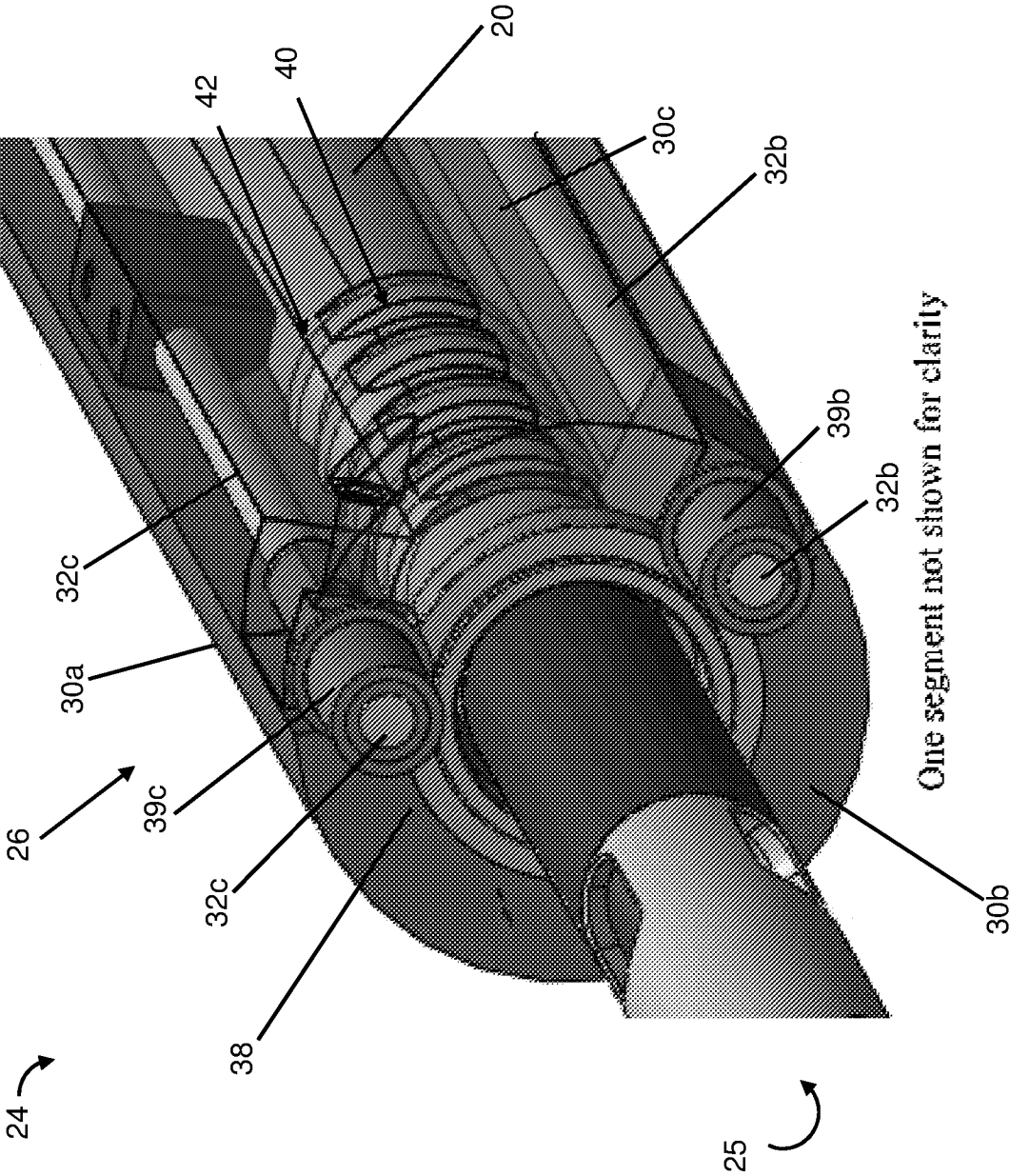


Fig. 6

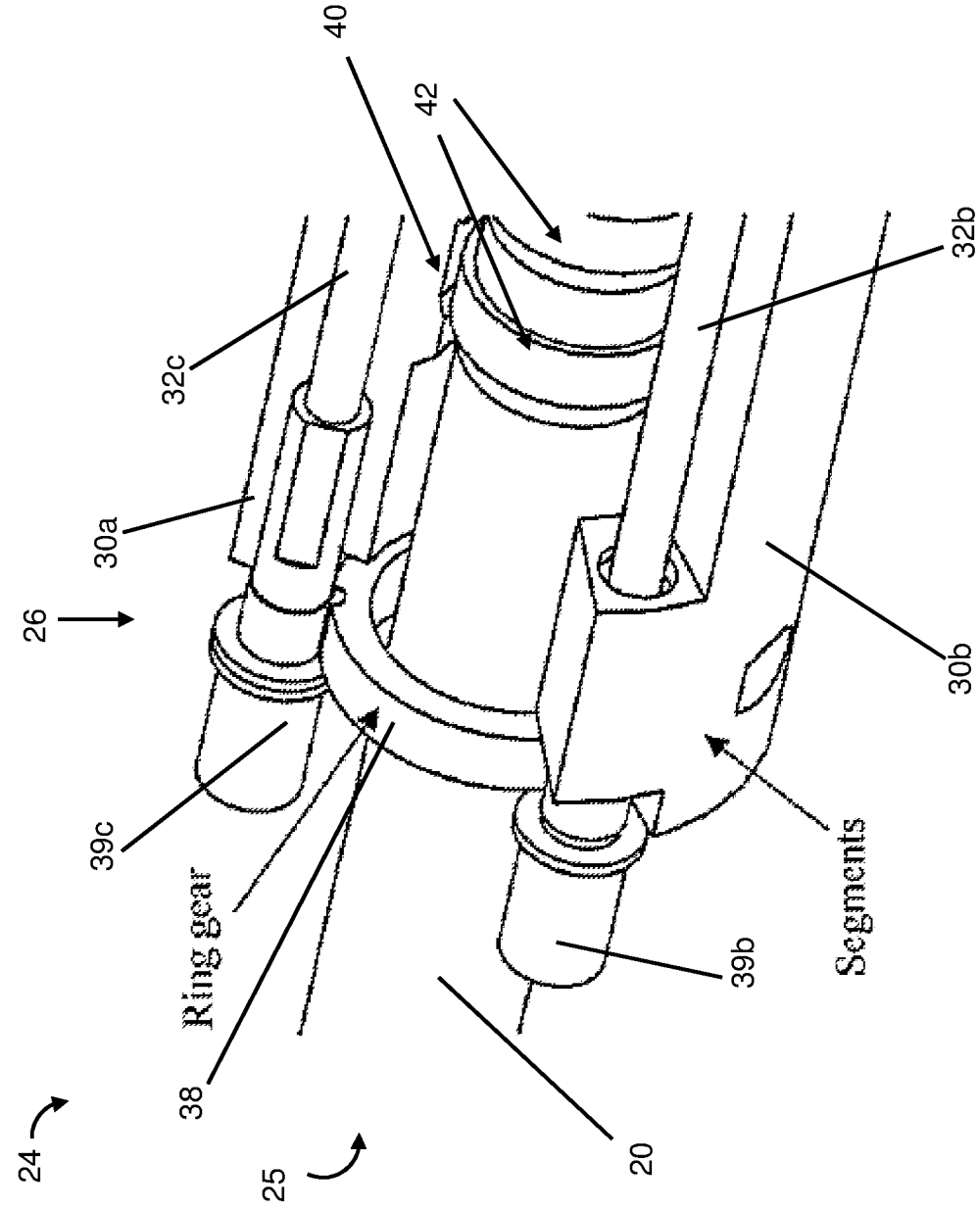


Fig. 7

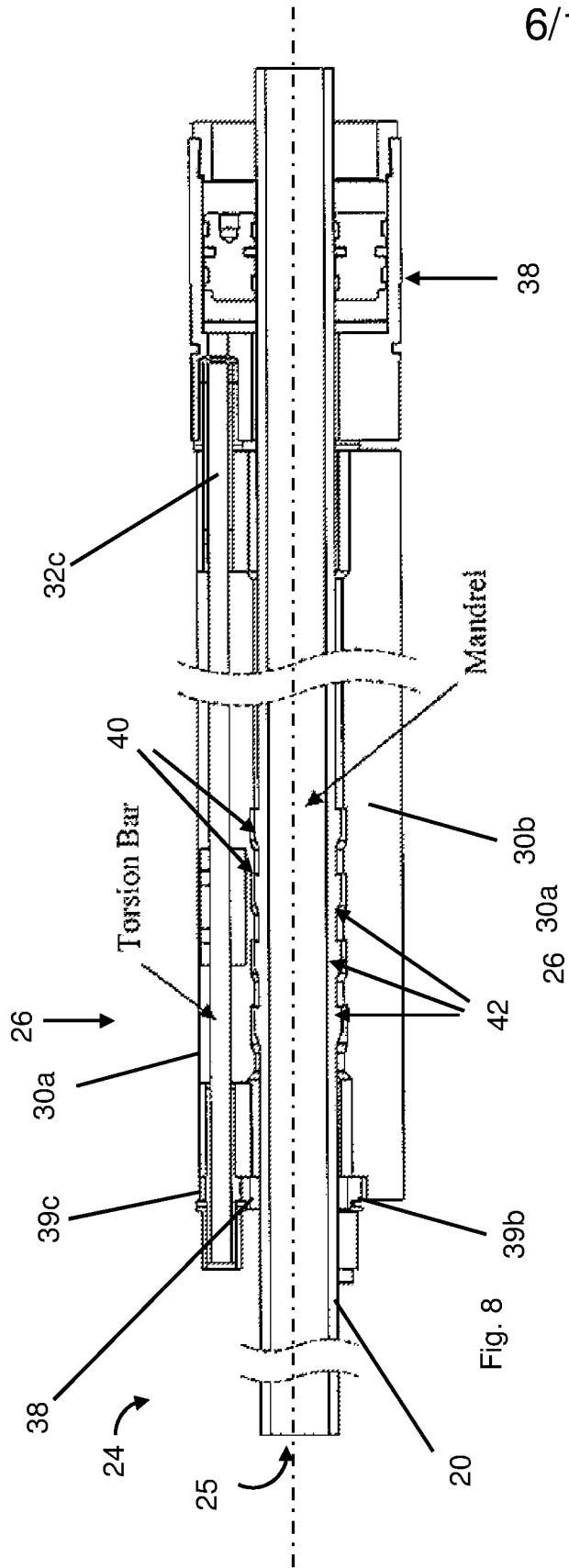


Fig. 8

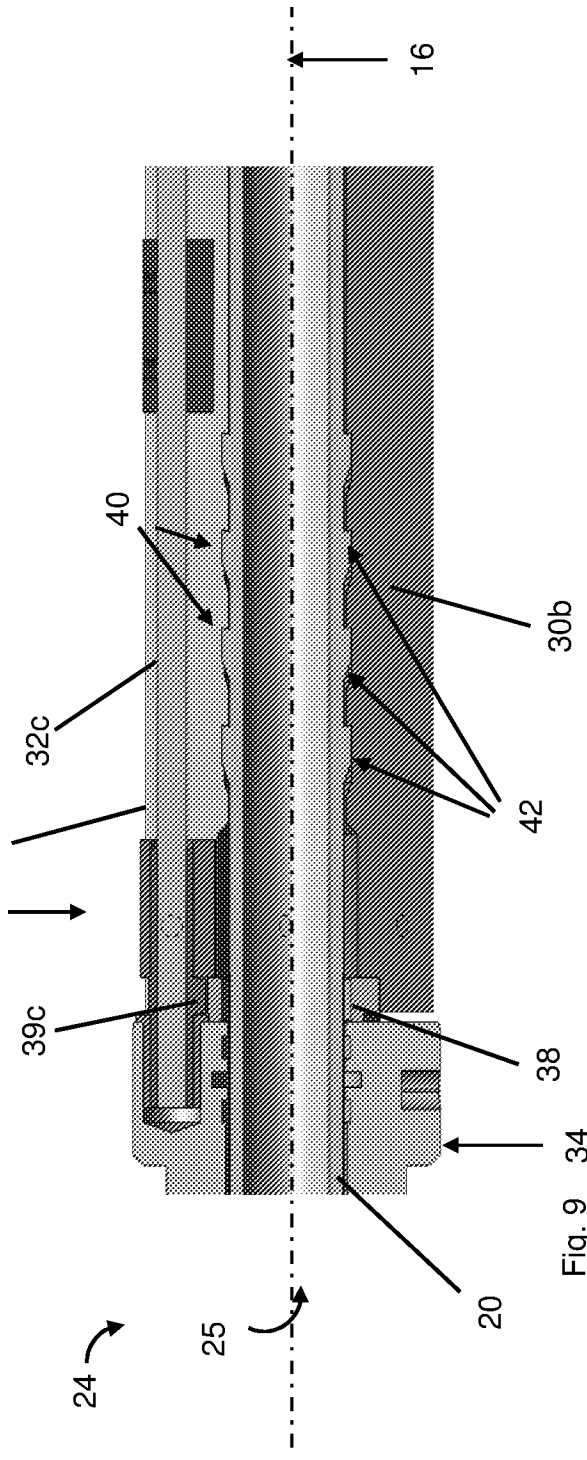


Fig. 9

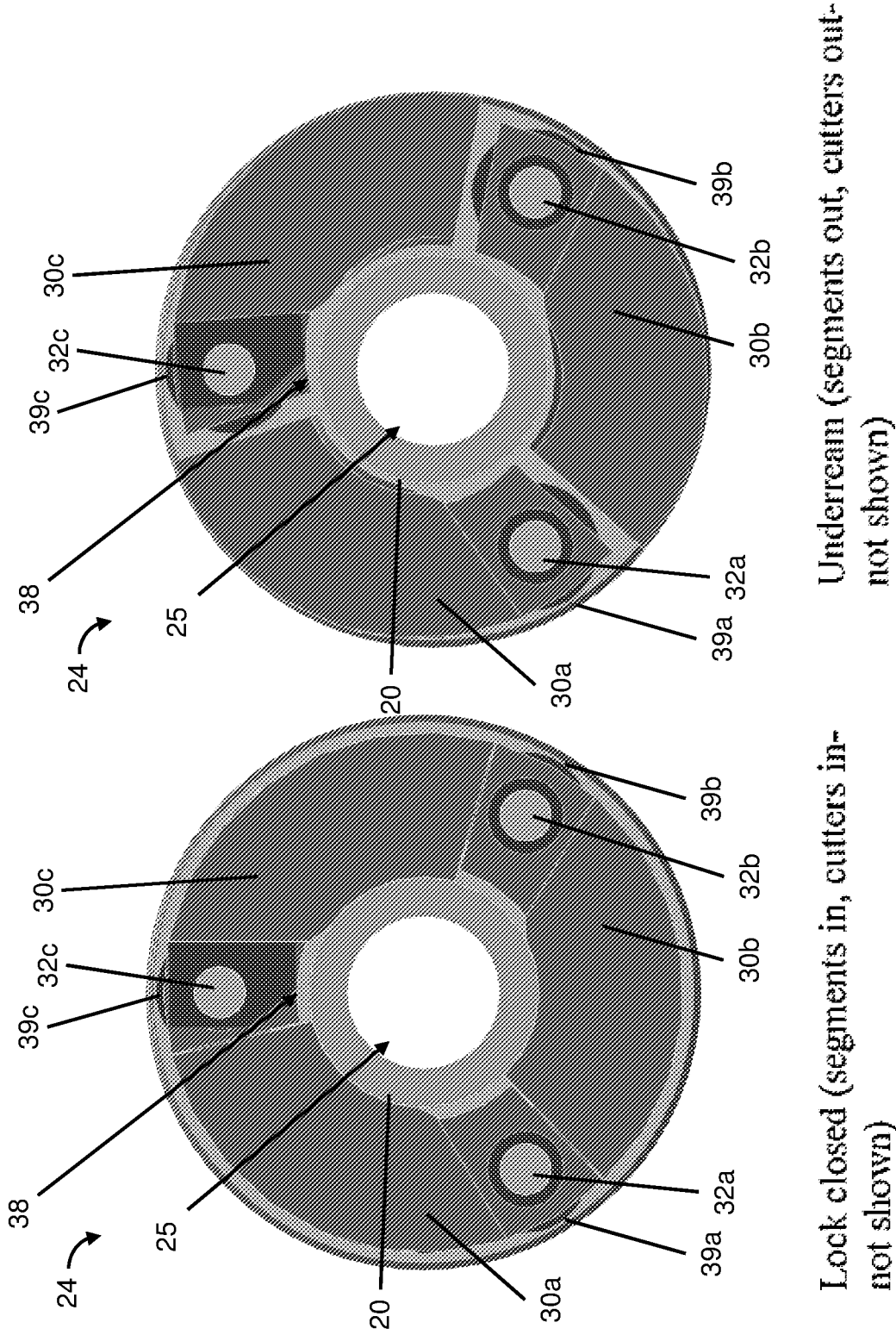


Fig. 10

Fig. 11

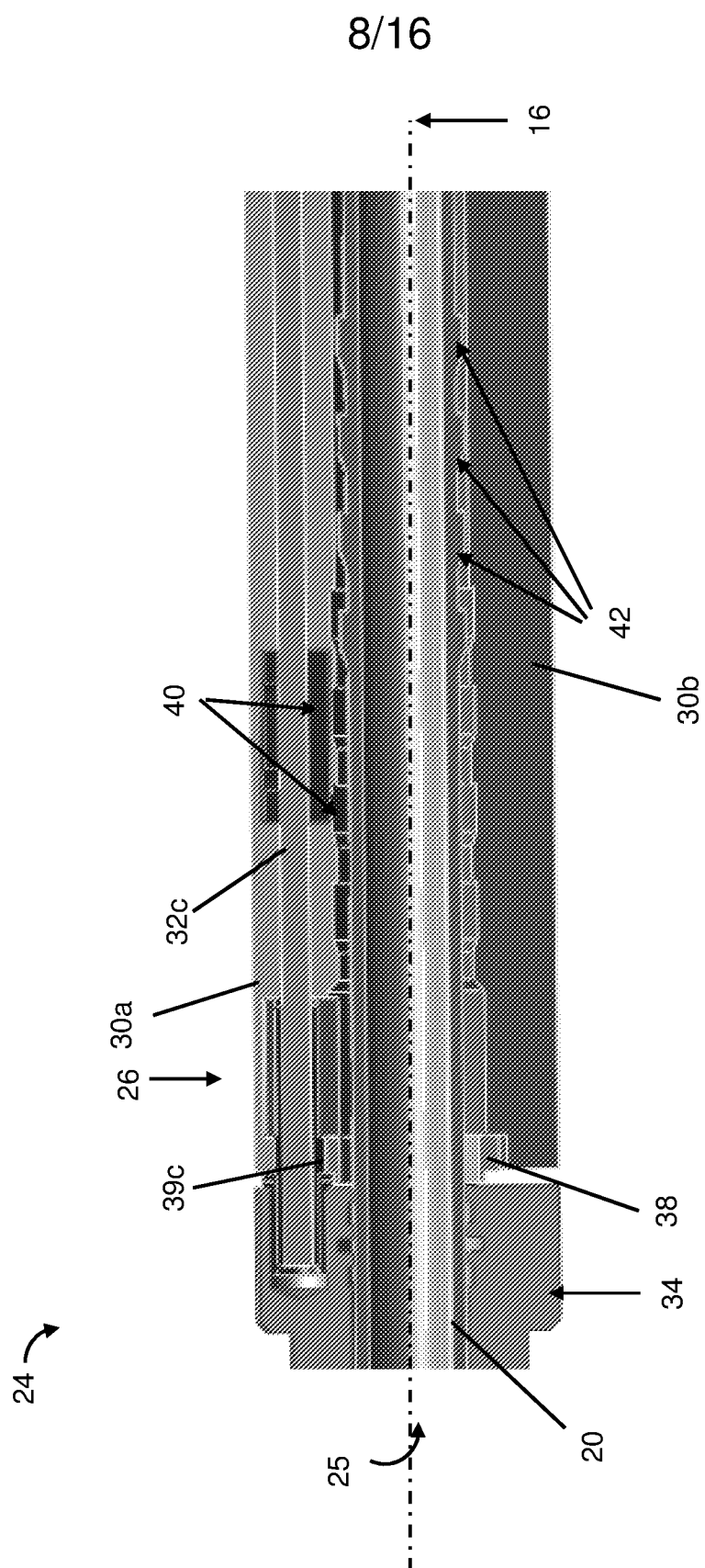


Fig. 12

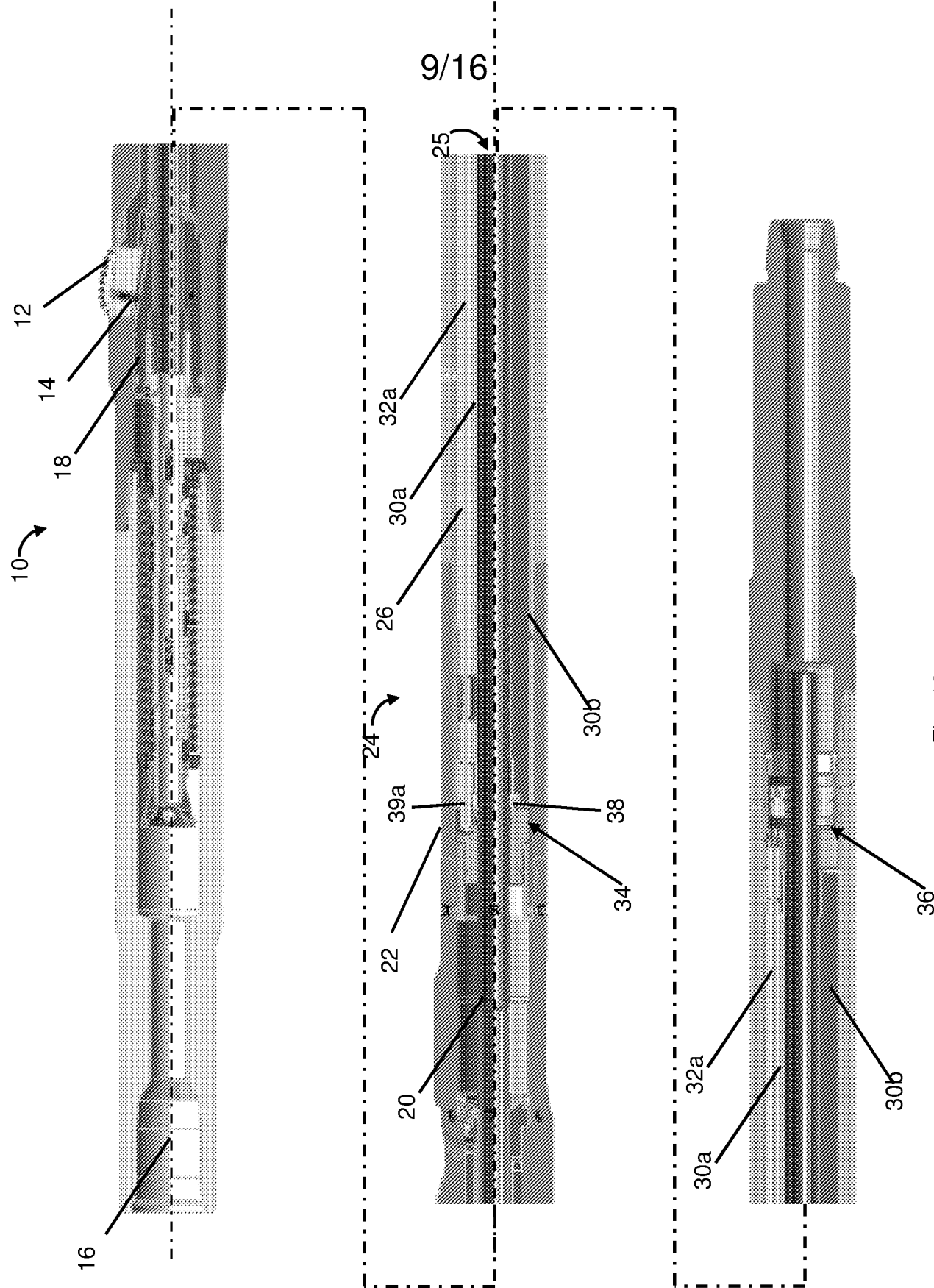


Fig. 13

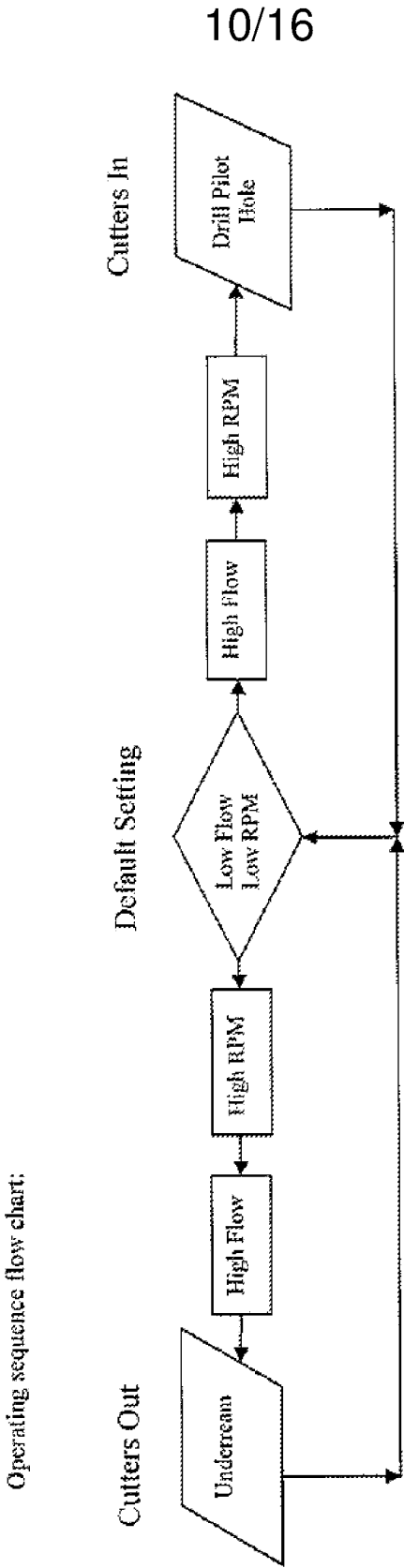


Fig. 14

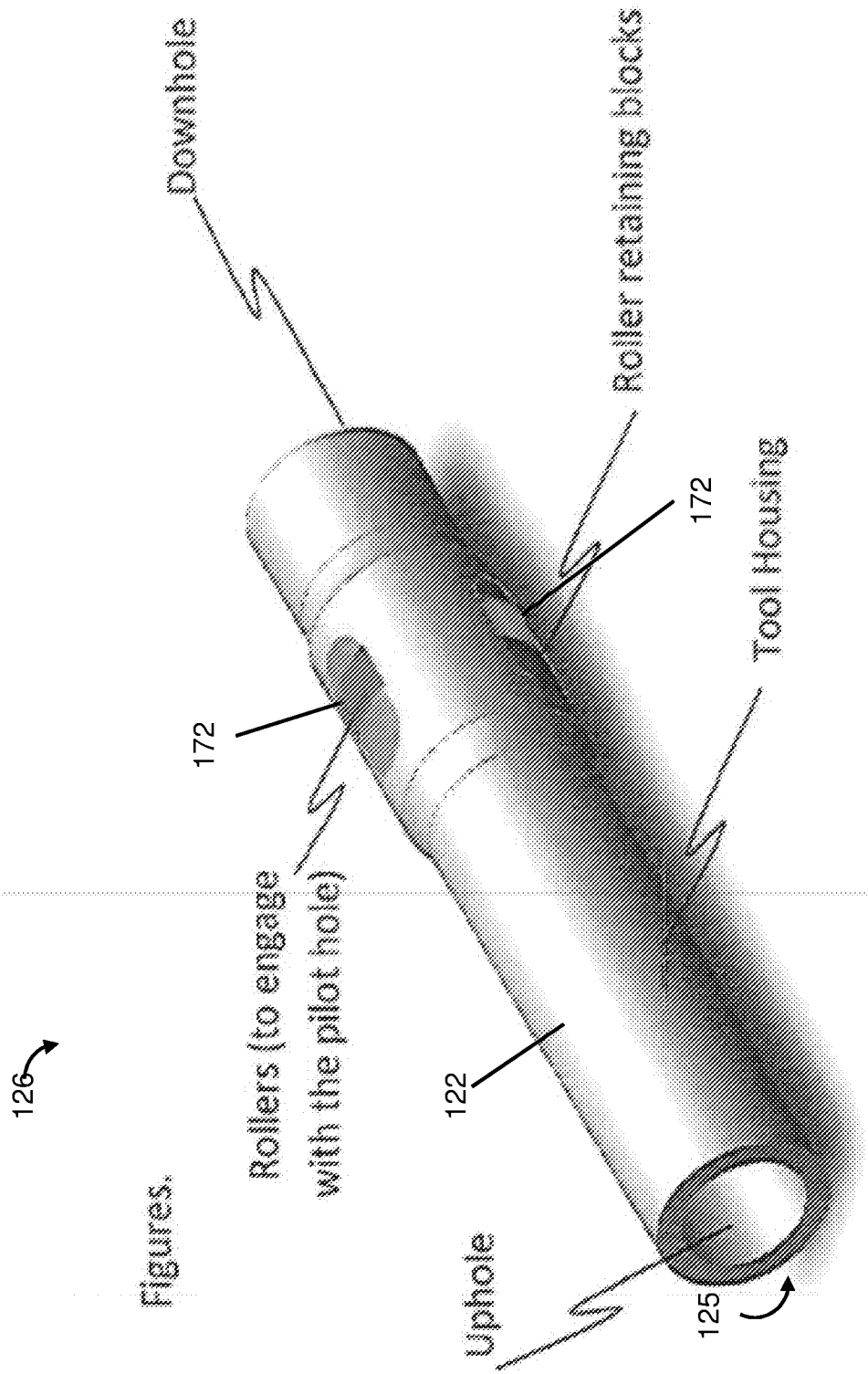


Fig. 15

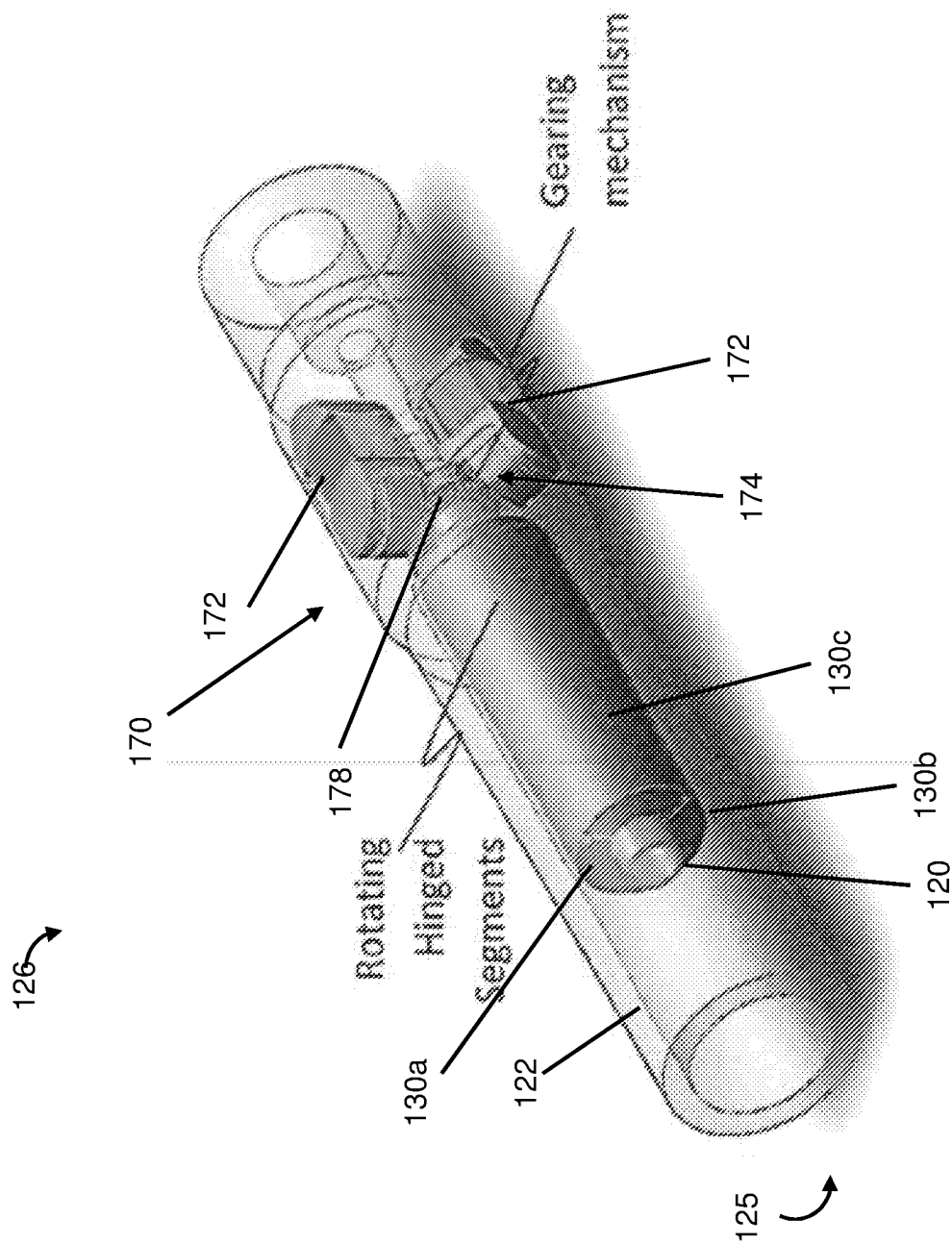
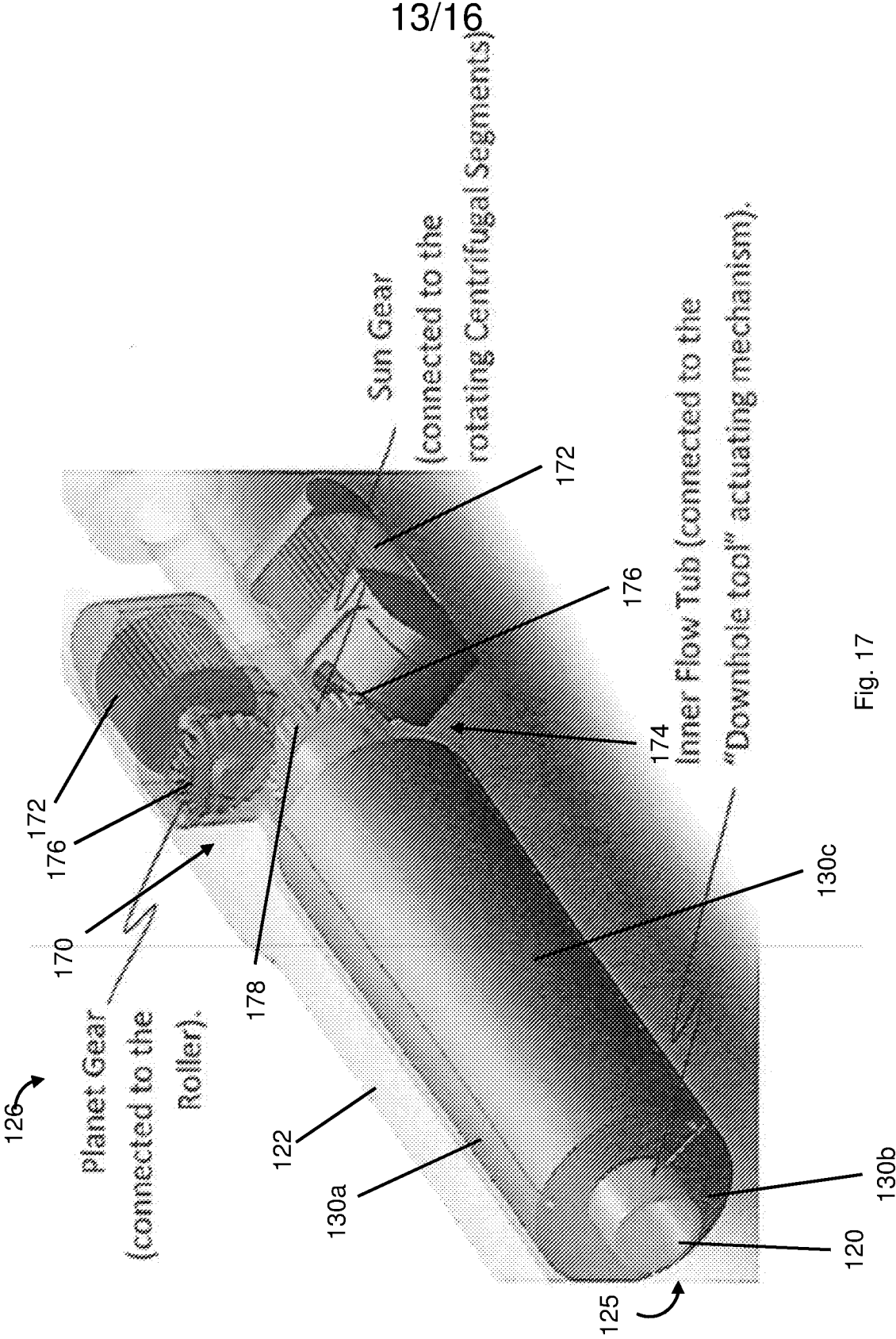


Fig. 16



202 ↗

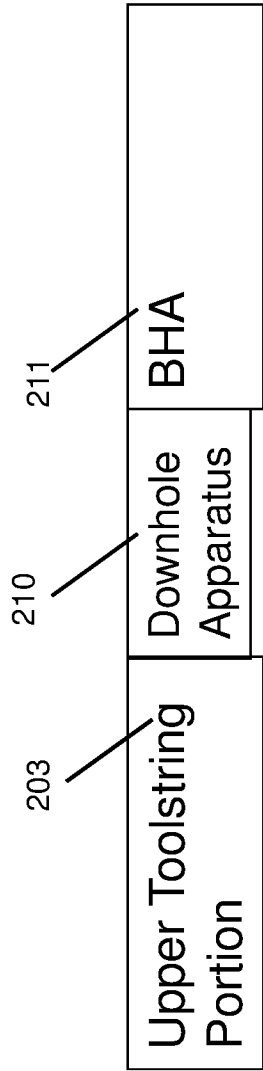


Fig. 18

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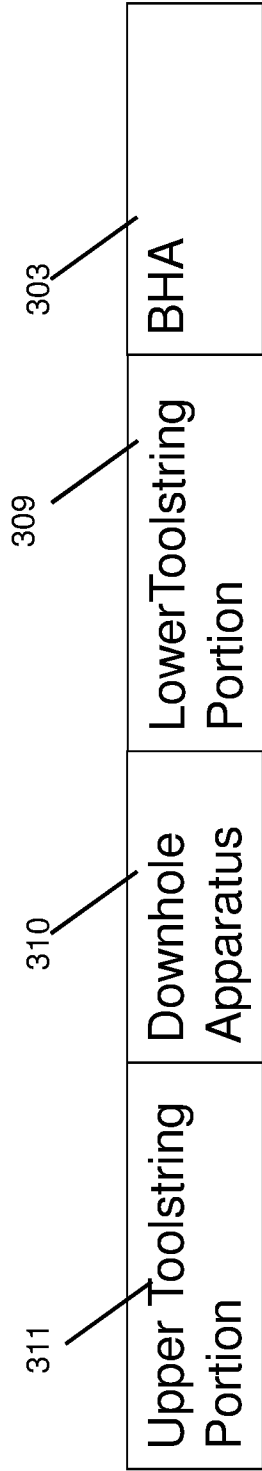


Fig. 19

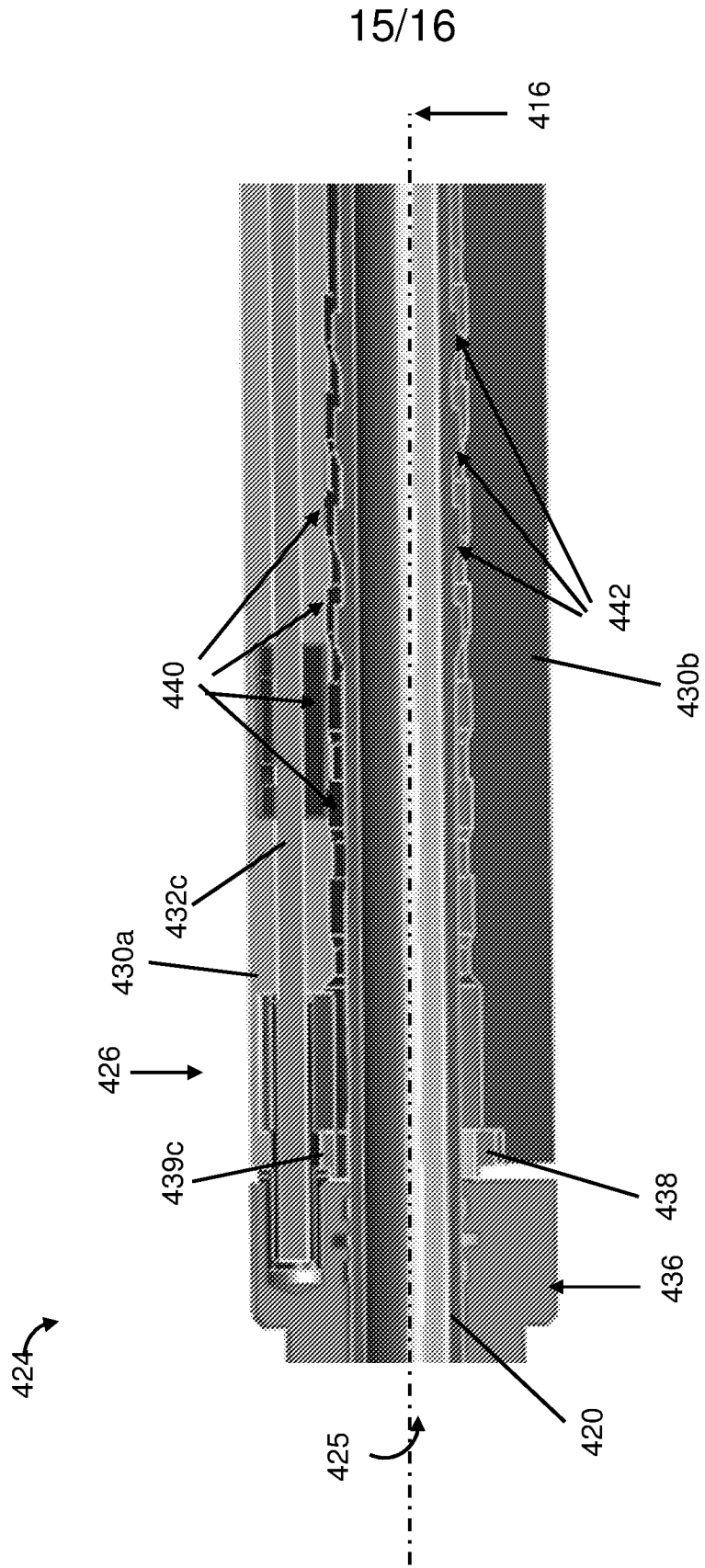


Fig. 20

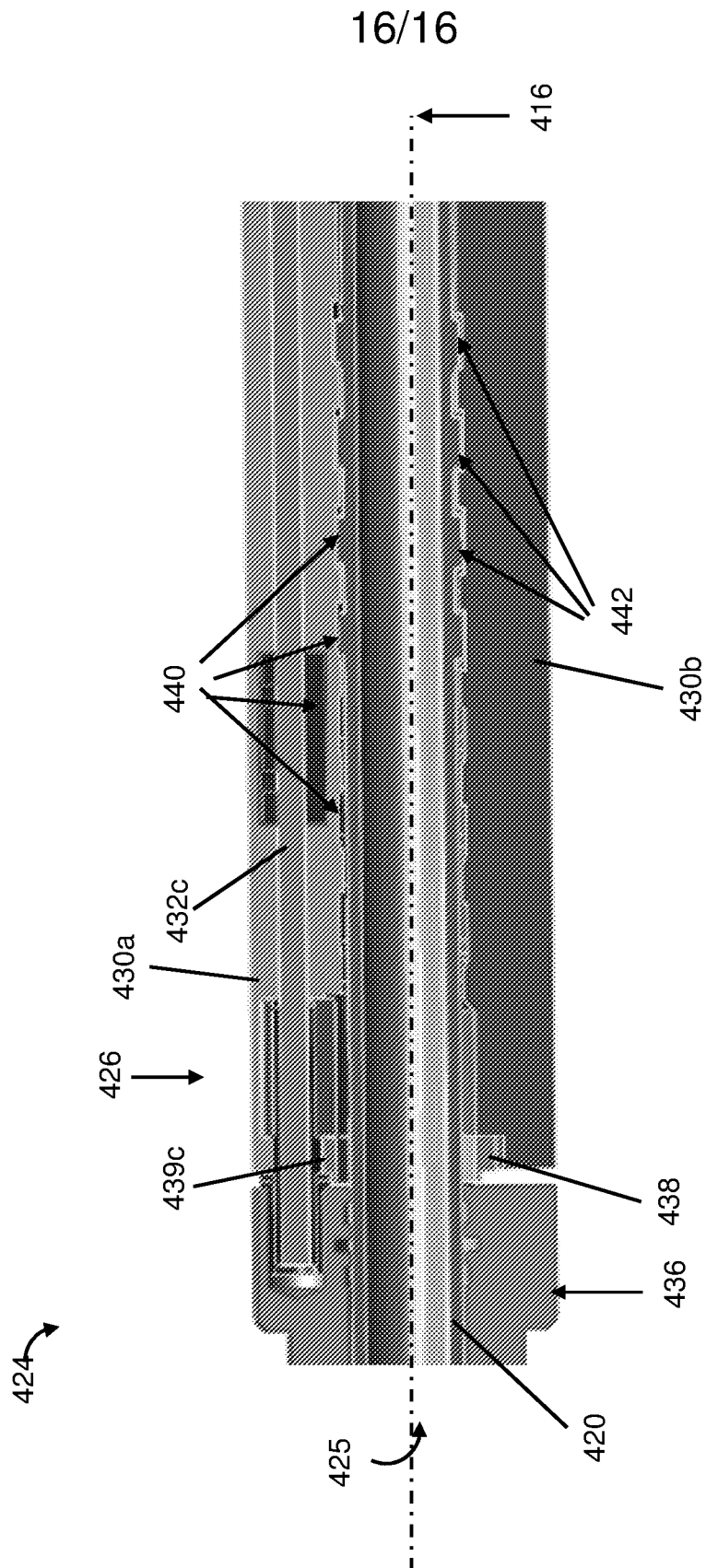


Fig. 21

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2016/052076

A. CLASSIFICATION OF SUBJECT MATTER

INV. E21B23/00 E21B29/00 E21B37/02 E21B41/00 E21B49/10
E21B7/28 E21B10/32

ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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Date of the actual completion of the international search

23 September 2016

Date of mailing of the international search report

10/10/2016

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Authorized officer

Brassart, P

INTERNATIONAL SEARCH REPORT

International application No

PCT/GB2016/052076

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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