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(71) **Applicant** *(for all designated States except US)*: **LONGYEAR TM, INC.** [US/US]; 10808 South River Front Parkway, Suite 600, South Jordan, UT 84095 (US).

(72) **Inventors; and**

(75) **Inventors/Applicants** *(for US only)*: **DRENTH, Christopher, L.** [CA/US]; 14123 Stone Canyon Dr., Draper, UT 84020 (US). **IBRAHIM, George** [CA/CA]; 35 Brookstone Court, Caledon, Ontario L7C 1C8 (CA). **LACHANCE, Anthony** [CA/CA]; 2106-2570 Argyle Road, Mississauga, Ontario L5B 1V2 (CA).

(74) **Agents**: **DECARLO, Kean J.** et al.; Ballard Spahr LLP, 999 Peachtree Street NW, Suite 1000, Atlanta, GA 30309 (US).

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(54) **Title**: INTERNAL TUBING CUTTER

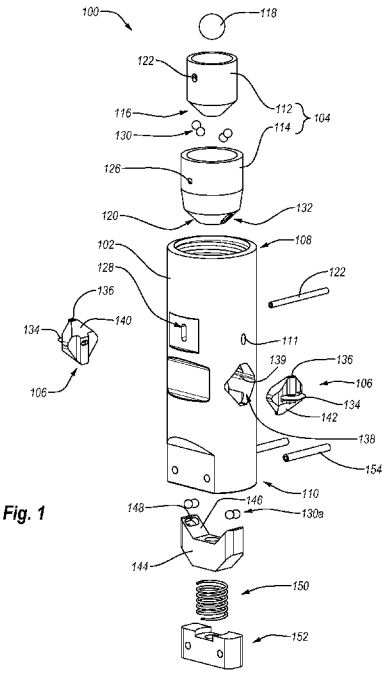



Fig. 1

(57) **Abstract**: Implementations of the present invention include an internal tubing cutter including ramp surface(s) and roller that cause cutters to move linearly between retracted and deployed positions. The linear actuation of the cutters can allow for more robust cutting and increased cutting efficiency. Implementations of the present invention also include cutting systems including an internal tubing cutter, and methods of cutting tubular members, such as borehole casings and drill strings, using such drilling systems.

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# INTERNAL TUBING CUTTER

## BACKGROUND OF THE INVENTION

1. The Field of the Invention

Implementations of the present invention relate generally to internal tubing cutters that may be used cut casing, drill rods, drill pipe, production tubing or other tubing.

2. The Relevant Technology

When drilling to retrieve hydrocarbons (e.g., oil and gas) boreholes are drilled into the earth. Often larger diameter pipe commonly referred to as casing is installed into the borehole and cemented in place. Thereafter, production tubing is often run into the borehole, concentrically inside the casing, in order to provide a conduit for the flow of the hydrocarbons from an underground reservoir to the earth's surface.

Once the hydrocarbons are depleted, the borehole is typically abandoned and the well site is restored to its original condition. Conventionally, surface equipment is removed from the borehole. Thereafter, as much production tubing and casing as possible is often retrieved from the borehole. The retrieved production tubing and casing is then often reused in other wells or sold for salvage. Because the production tubing, and particularly the cemented casing, can be lodged in place, casing cutters are frequently used to cut the tubing at a desired depth to allow removal.

In addition to the oil and gas industry, other drilling industries often employ casing cutters. For example, casing cutters are often used in core drilling and other drilling fields to cut tubing to allow retrieval of at least a portion of the tubing once drilling is completed. Also, casing cutters are often used in core drilling and other drilling fields to cut the rod string when it gets stuck in the bore hole.

Unfortunately, conventional casing cutters suffer from a number of drawbacks. In particular, conventional casing cutters typically include cutters that deploy by swinging outward from a central stored positioned. The swinging of the cutters can cause the cutting point to move as the cutters deploy. The movement of the cutting point can make the cutting action difficult as the drill string has to move up and down during the cutting action to accommodate for this movement.

In addition to the foregoing, the cutters on conventional casing cutters cut using a dragging cutting action (i.e., the cutters are dragged across the tubing as the casing cutter is rotated). Such dragging cutting action can lead to a relatively low cutting life, and the frequent replacement of the cutters. Furthermore, conventional casing cutters that include a swinging deployment often do not last long and are expensive.

Accordingly, there are a number of disadvantages in conventional casing cutters that can be addressed.

## BRIEF SUMMARY OF THE INVENTION

One or more implementations of the present invention overcome one or more problems in the art with drilling tools, systems, and methods for effectively and efficiently cutting tubing. For example, one or more implementations of the present invention include an internal tubing cutter having cutters that deploy linearly outward. The linear deployment of the cutters helps reduce or eliminate movement of the cutting point during the cutting action. Accordingly, one or more implementations of the present invention can increase productivity and efficiency in casing cutters.

For example, one implementation of an internal tubing cutter includes a tubular body and at least one cartridge opening extending through the tubular body. Additionally, the internal tubing cutter includes a cutter cartridge at least partially positioned within the at least one cartridge opening. The cutter cartridge includes a

cutter and at least one axially tapered ramp surface. The internal tubing cutter also includes an inner member configured to move relative to the cutter cartridge. At least one roller is positioned between the ramp surface and the inner member. Axial displacement of the inner member relative to the cutter cartridge causes the at least one roller to move along the ramp surface thereby linearly moving the cutter cartridge radially between a retracted position within the tubular body and a deployed position in which the cutter is at least partially radially outward of the tubular body.

Additionally, another implementation of an internal tubing cutting system includes a tubular body and a plurality of cartridge openings extending through the tubular body. The system further includes a plurality of cutter cartridges configured to hold one or more cutters. Each cutter cartridge is positioned in a cartridge opening of the plurality of cartridge openings. The system also includes an inner member and a plurality of rollers positioned between the cutter cartridges and the inner member. Each roller is positioned against a ramp surface. Movement of the inner member relative to the cutter cartridges causes the plurality of rollers to move along the ramp surface thereby linearly moving the plurality of cutter cartridges at least partially radially outward of the plurality of cartridge openings.

In addition to the foregoing, a method of cutting a tubular member involves lowering an internal tubing cutter into the tubular member. The method also involves pumping a fluid into the internal tubing cutter to cause an inner member to move axially within the tubing cutter. Axial movement of the inner member causes one or more rollers operatively associated with the inner member to move along a ramp surface of a cutter cartridge, thereby moving a cutter linearly at least partially outward of the internal tubing cutter. Additionally, the method involves rotating the internal tubing cutter

relative to the tubular member thereby causing the cutter held within the cutter cartridge to cut the tubular member.

Additional features and advantages of exemplary implementations of the invention will be set forth in the description which follows, and in part will be obvious from the description, or may be learned by the practice of such exemplary implementations. The features and advantages of such implementations may be realized and obtained by means of the instruments and combinations particularly pointed out in the appended claims. These and other features will become more fully apparent from the following description and appended claims, or may be learned by the practice of such exemplary implementations as set forth hereinafter.

## BRIEF DESCRIPTION OF THE DRAWINGS

In order to describe the manner in which the above-recited and other advantages and features of the invention can be obtained, a more particular description of the invention briefly described above will be rendered by reference to specific embodiments thereof which are illustrated in the appended drawings. It should be noted that the figures are not drawn to scale, and that elements of similar structure or function are generally represented by like reference numerals for illustrative purposes throughout the figures. Understanding that these drawings depict only typical embodiments of the invention and are not therefore to be considered to be limiting of its scope, the invention will be described and explained with additional specificity and detail through the use of the accompanying drawings in which:

Figure 1 illustrates an exploded view of an internal tubing cutter in accordance with an implementation of the present invention;

Figure 2 illustrates a cross-sectional view of a cutter of the internal tubing cutter of Figure 1;

Figure 3 illustrates a cross-sectional view of the internal tubing cutter of Figure 1 with the cutters in a retracted position;

Figure 4 illustrates a cross-sectional view of the internal tubing cutter of Figure 1 with the cutters in a deployed position;

Figure 5 illustrates a cross-sectional view of another implementations of an internal tubing cutter with the cutters in a retracted position in accordance with an implementation of the present invention;

Figure 6 illustrates a cross-sectional view of the internal tubing cutter of Figure 5 with the cutters in a deployed position; and

Figure 7 illustrates a schematic view a tubular member cutting system including an internal tubing cutter in accordance with an implementation of the present invention.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Implementations of the present invention are directed toward drilling tools, systems, and methods for effectively and efficiently cutting tubing. For example, one or more implementations of the present invention include an internal tubing cutter having cutters that deploy linearly outward. The linear deployment of the cutters helps reduce or eliminate movement of the cutting point during the cutting action. Accordingly, one or more implementations of the present invention can increase productivity and efficiency in casing cutters.

Additionally, the linear deployment of the cutters can allow the same internal tubing cutter to cut tubing having a wide range of diameters. In addition the foregoing, the internal tubing cutters can employ circular disc blades. The circular disc blades can roll during the cutting action instead of dragging. The rolling of the circular disc blades can increase blade life and provide for faster and more efficient cutting.

More specifically, the internal tubing cutter can include a cutter cartridge that holds one or more cutters. An inner member, such as a piston, can move relative to the cutter cartridge to move the cutter cartridge linearly between a retracted position and a deployed position. More specifically, as the inner member moves relative to the cutter cartridge, one or more rollers operatively associated with the inner member can move along an axially tapered or angled ramp surface thereby moving the cutter cartridge radially between the retracted and deployed positions.

Referring now to the Figures, Figure 1 illustrates an exploded view of an internal tubing cutter 100 in accordance with one or more implementations of the present invention. As shown by Figure 1, the internal tubing cutter 100 can include a body 102, an inner member 104, and cutter cartridges 106. As explained in greater detail below, the inner member 104 can interact with the cutter cartridges 106 to move the cutter cartridges 106 linearly at least partially in and out of the body 102.

The body 102 can be generally hollow and configured to house various components (e.g., inner member 104 and cutter cartridge(s) 106) of the internal tubing cutter 100. The body 102 can include an upper end 108 and a lower end 110. As used herein the terms "lower," "down," and "distal" refer to the end of the internal tubing cutter 100 closet to the to the bottom of the bore hole, whether the borehole be oriented horizontally, at an upward angle, or a downward angle relative to the horizontal. While the terms "upper," "up," or "proximal" refer to the end of the internal tubing cutter 100 closest to the opening of the borehole, whether the borehole be oriented horizontally, at an upward angle, or a downward angle relative to the horizontal.

The upper end 108 of the body 102 can include a connector for securing the internal tubing cutter 100 to a drill string component (e.g., a drill rod, adaptor). For example, Figure 1 illustrates that the upper end 108 of the body 102 can comprise a

female threaded receptacle. Alternatively, the connector of the upper end 108 can comprise a male threaded connector, such as an American Petroleum Institute (API) threaded connection portion or other features to aid in attachment to a drill string component. By way of example and not limitation, the body 102 may be formed from steel, another iron-based alloy, or any other material that exhibits acceptable physical properties.

The body 102 can further include fluid flow passages 111. The fluid flow passages 111 can comprise channels that extend from the inner surface of the body 102 to the outer surface of the body 102. The fluid flow passages 111 can allow fluid to pass from the internal bore of the body 102 outside of the body 102.

The body 102 can additionally be configured to contain the inner member 104. As alluded to earlier, the inner member 104 can comprise one or more components that interact with the cutter cartridges 106 to move the cutter cartridges 106 linearly in and out of the body 102. The inner member 104 can comprise one or more components configured to move relative to the body 102. For example, Figure 1 illustrates that the inner member 104 can include an inner wedge 112 and an outer wedge 114. In alternative implementations, the inner member 104 can comprise a single component.

The inner wedge 112 and an outer wedge 114 can each be generally hollow. The inner member 104 can include or form part of a fluid valve system. For example, Figure 1 illustrates that the inner wedge 112 can include a tapered lower end 116. The inner wedge 112 can also be sized and configured to house a valve stop 118. In one or more implementations the valve stop 118 can engage the inner surface of the tapered lower end 116 and create a seal. The seal created by the valve stop 118 can prevent the passage of fluid through the inside of the inner member 104 and thus prevent the passage of fluid through the central bore of the body 102. As explained in greater detail below, the fluid

valve system (i.e., valve stop 118 and inner wedge 112) can great hydraulic pressure to drive the inner member 104 axially down to move the cutter cartridges 106 to a deployed state.

As shown in Figure 1, in one or more implementations the valve stop 118 can comprise a ball. In alternative implementations the valve stop 118 can comprise a plunger or other device capable of plugging the internal bore of the inner member 104. The inner wedge 112 can be sized and configured to fit within the outer wedge 114. As shown by Figure 1, in one or more implementations the outer wedge 114 can also include a lower tapered surface 120.

The inner member 104 can be moveably coupled within the body 102. For example, Figure 1 illustrates that a wedge pin 122 can extend through a mounting hole 124 in the inner wedge 112 and a mounting hole 126 in the outer wedge 114. The wedge pin 122 can then extend into a slide channel 128 in the body 102. Thus, the inner member 104 can move axially relative to the body 102 as the wedge pin 122 slides along the slide channel 128.

One or more rollers 130 can be operatively associated with the inner member 104. For example, Figure 1 illustrates that one or more roller balls 130 can be positioned between the inner wedge 112 and the outer wedge 114. In particular, the outer wedge 114 can include one or more mounting slots 132 within which the rollers 130 can be positioned. The mounting slots 132 can comprise or act as bushings and allow the rollers 130 to rotate relative to the inner member 104. The rollers 130 may comprise any number of suitable materials. For example, the rollers 130 may be made of steel, or other iron alloys, titanium and titanium alloys, compounds using aramid fibers, lubrication impregnated nylons or plastics, or combinations thereof. The material used for any rollers 130 can be the same or different than any other rollers 130.

As mentioned above, the internal tubing cutter 100 can include one or more cutter cartridges 106. The cutter cartridges 106 can be configured to house one or more cutters 134. For example, the cutter cartridges 106 can include a groove within which a cutter 134 can reside. The cutters 134 can comprise a sharp surface for cutting tubing. The cutters 134 can comprise steel, hard metals such as tool steel or tungsten carbide, other iron alloys, titanium, titanium alloys, or other suitable materials. Furthermore, the cutters 134 can comprise one or more coatings to improve the hardness or cutting ability thereof. Such coatings can include, by example and not limitation, a metal, such as iron, titanium, nickel, copper, molybdenum, lead, tungsten, aluminum, chromium, or combinations or alloys thereof, a ceramic material, such as SiC, SiO, Si02, or the like, diamonds, or other materials.

The cutters 134 can comprise disc blades, non-circular blades, or other cutters. For example, Figure 2 illustrates a cross-section of one implementation of a disc cutter 134. The disc cutter 134 can include a profile that allows for increased ease and efficiency in slitting and cutting tubes. Specifically, the disc cutter 134 can include a body 133 sized and configured to hold a pivot pin as described below. The disc cutter 134 can further include a circular spine 135 and a blade 137. The blade 137 can taper from the spine 135 to an edge 139. In one or more implementations, the blade 137 can be symmetrical about a plane extending through the edge 139 as shown in Figure 2. In alternative implementations, the blade 137 can be non-symmetrical. In any event, in one or more implementations, the edge 139 of the blade can be round to aid in slitting and rolling.

Referring again to Figure 1, in one or more implementations, a pivot pin 136 can secure the cutter 134 within the groove of the cutter cartridge 106. The pivot pin 136 can

allow the cutter 134 to rotate about its center during a cutting operation. The ability to rotate, versus dragging, can increase the cutting life of the cutters 136.

The cutter cartridges 106 can move linearly in and out of the body 102 between a retracted position and a deployed position. For example, the body 102 can include cartridge openings 138 within which the cutter cartridges 106 can move. In one or more implementations, the cutter cartridges 106 and the cartridge openings 138 can each have corresponding diamond shapes as shown in Figure 1. The diamond shape can allow the cutter cartridges to be self-aligned and guided axially when deploying and retracting in and out of the body 102. The body 102 can further included angled channels 139 extending between the cartridge openings 138. The angled channels 139 can correspond to the angled sides of the cutter cartridges 106 and guide the cutter cartridges 106 as they move linearly in and out of the cartridge openings 138.

The cutter cartridges 106 can further include one or more ramp surfaces that interface with the rollers 130 to move the cutter cartridges 106 radially in and out of the body 102. For example, Figure 1 illustrates that each cutter cartridge 106 can include an upper ramp surface 140 and a lower ramp surface 142. The ramp surfaces 140, 142 can each comprise an axially tapered or angled surface. In particular, each of the upper and lower ramp surfaces 140, 142 can extend radially outward and axially upward toward the first end 108 of the tubular body 102.

As explained in greater detail below, as the inner member 104 move toward the cutter cartridges 106, the rollers 130 can move along the ramp surface 140 thereby forcing the cutter cartridges 106 to move radially outward in a linear line of travel. In one or more implementations, the upper ramp surface 140 and the lower ramp surface 142 can extend at the same angle relative to a central axis of the body 102. In other words, the upper ramp surface 140 and the lower ramp surface 142 can extend parallel to

each other. In alternative implementations, the upper ramp surface 140 and the lower ramp surface 142 may extend at different angles relative to the central axis of the body 102.

The internal tubing cutter 100 can further include a return wedge 144. The return wedge 144 can include tapered surfaces 146 that form a recess therein. As explained in greater detail below the recess formed by the tapered surfaces 146 can accommodate for movement of the cutter cartridges 106. Furthermore, the return wedge 144 can include mounting grooves 148 extending into the tapered surfaces 146 that are configured to hold rollers 130a. The mounting grooves 148 can act as or include bushing that allow the rollers 130a to rotate relative to the return wedge 144 and the cutter cartridges 106. Roller 130a can be substantially similar to the rollers 130 described above.

As the inner member 104 moves toward the cutter cartridges 106, the rollers 130a can move along the ramp surface 142 thereby forcing the cutter cartridges 106 to move radially outward in a linear line of travel, similar to the rollers 130 and the ramp surface 140. In one or more implementations, the tapered surfaces 146 of the return wedge 144 can be parallel and offset from the lower ramp surfaces 142 of the cutter cartridges 106.

The return wedge 144 can be biased upward by a biasing member 150. In particular, the biasing member 150 can bias the return wedge 144 axially toward the cutter cartridges 106 and the inner member 106. The biasing of the return wedge 144 toward the cutter cartridges 106 can tend to force the roller 130a against lower ramp surfaces 142 of the cutter cartridges 106. Thus, the biasing member 150 can bias the cutter cartridges 106 radially inward. The biasing member 150 can comprise a mechanical (e.g., spring), magnetic, or other mechanism configured to bias the wedge return 144. For example, Figure 1 illustrates that the biasing member 150 can comprise a coil spring. The biasing member 150 can be positioned between the wedge return 144

and a tail 152. The tail 152 can be coupled to the body 102 by one or more pins 154. The pins 154 can prevent axial movement of the tail 152 relative to the body 102.

Referring now to Figures 3-4 operation of the internal tubing cutter 100 will now be described in greater detail. As previously mentioned, in one or more implementations of the present invention the internal tubing cutter 100 can be lowered into a tubing 200 (such as a casing or drill string). For example, Figure 1 illustrates the internal tubing cutter 100 as it is tripped into or down a casing 200.

As shown, when tripping the internal tubing cutter 100 into the drill string 200, the cutter cartridges 106 can be in the retracted position (i.e., within the body 102). In particular, the biasing member 150 can bias the wedge return 144 toward the cutter cartridges 106 and the upper end 108. The biasing of the wedge return 144 upward can cause the roller 130a to roll along the lower ramp surfaces 142 of the cutter cartridges 106 toward the upper end of the lower ramp surfaces 142; thereby drawing the cutter cartridges 106 into a radially retracted position as shown in Figure 3.

One will appreciate in light of the disclosure herein that the biasing of the wedge return 144 upward can also cause the inner member 104 to be biased into a first upward position. In particular, movement of the cutter cartridges 106 radially inward can cause the rollers 130 to roll or slide along the upper ramp surfaces 140 of the cutter cartridges toward an upper end of the upper ramp surfaces 140. This in turn pushes the inner member 104 upward toward the first end 108 of the body 102. As shown in Figure 3, when the inner member 104 is in the first upward position, the walls of the inner member 104 can block fluid flow passages 111. The blockage of the fluid flow passages 111 can aid in building pressure to cause the inner member 104 to move toward the cutter cartridges 106 as explained below.

With the internal tubing cutter 100 in the retracted position as shown in Figure 3, an operator can lower the internal tubing cutter 100 down the casing 104 to a desired position. Once the internal tubing cutter 100 has reached the desired position within the casing 104, a fluid can be sent into the body 102 of the internal tubing cutter 100. The fluid can then be pressurized. The pressurization of the fluid can cause the pressurized fluid to enter the inner wedge 112 of the inner member 104. The pressurized fluid can then force the valve stop 118 against the inner surface of the tapered lower end 116 of the inner wedge 112; thereby, creating a seal. Pressurized fluid entering the inner member 104 can then produce a distally directed fluid force against the inner member 104.

This distally directed fluid force can exert a force in opposition to the upward force created by the biasing member 150. As the distally directed fluid force increases it can overcome the upward force created by the biasing member 150. As the distally directed fluid force overcomes the upward force created by the biasing member 150, the inner member 104 in turn can exert a distally acting force that drives the rollers 130 against the upper ramp surfaces 140 of the cutter cartridges 106. Once forced downward against the upper ramp surfaces 140, the rollers 130 can roll or slide along the upper ramp surfaces 140 to the lower end of the upper ramp surfaces 140. This movement can force the cutter cartridges 106 to move linearly radially outward toward the casing 200 and into a deployed position as shown in Figure 4.

One will appreciate in light of the disclosure herein that the movement of the cutter cartridges 106 radially outward can also cause the wedge return 144 to move distally. In particular, movement of the cutter cartridges 106 radially outward can cause the rollers 130a to roll or slide along the lower ramp surfaces 142 of the cutter cartridges toward a lower end of the lower ramp surfaces 142. This in turn can cause the wedge

return 144 to move distally toward the tail 152 and the second end 110 of the body 102. Downward movement of the wedge return 144 can compress the biasing member 150.

Thus, movement of the inner member 104 toward the cutter cartridges 106 can urge the cutting cartridges 106 radially outward through the cartridge openings 138 in the body 102. This movement can cause the cutters 134 to move radially outward in a linear motion and into engagement with the inner surface of the casing 200. The linear movement of the cutters 134 can help ensure that the cutting point (i.e., axial position of the cutters 134 relative to the casing 200) remains constant during the cutting process.

Furthermore, the ramp surfaces 140, 142 in conjunction with the rollers 130, 130a and the downward fluid force acting on the inner member 104 can bias the cutter cartridges 106 radially outward during a cutting process. Thus, the cutters 134 can be biased linearly outward against the inner surface of the casing 200 during a cutting process. One will appreciate in light of the disclosure herein that the rollers 130 above and rollers 130a below the cutter cartridges 106 can decrease friction, reduce the applied moment, and help prevent the cutter cartridges 106 from tipping over. The rollers 130 and ramps 140, 142 can eliminate or reduce sticking, seizing, and wear that are common with angled-key and slot or sliding ramp interaction.

During a cutting process, a drill rig can spin a rod string attached to the internal tubing cutter 100 as the cutters 134 are deployed. The cutting action can displace the casing material inside-out. Furthermore, the cutters 134 can rotate about two axes of rotation during the cutting process. In particular, the cutters 134 can rotate (i.e., orbit) about the central axis of the internal tubing cutter 100 as the internal tubing cutter 100 is rotated with the rod string. Furthermore, the cutters 134, when disc blades, can rotate about the pivot pins 136 extending through the central axis of the cutters 134. The

rotation of the cutters 136 can decrease drag and heat due to friction and otherwise increase the efficiency of the cutting process and lead to longer cutting life.

Once the cutting process is complete (i.e., the cutters 134 have complete cut through the casing 200), the cutting cartridges 106 can be in a fully deployed position, as shown by Figure 4. When in the deployed position, the inner member 104 can be positioned below the fluid flow passages 111. Thus, fluid can flow from the internal bore of the body 102, through the fluid flow passages 111, and down the recess between the outer surface of the internal tubing cutter 100 and the inner surface of the casing 200. This can cause a drop in fluid pressure that can signal an operator that the cutting process is complete.

Furthermore, the drop in pressure can allow the upward biasing force created by the biasing member 150 to overcome the downward fluid force acting on the inner member 104. In particular, the biasing member 150 can bias the wedge return 144 toward the cutter cartridges 106 and the upper end 108. The biasing of the wedge return 144 upward can cause the rollers 130a to roll along the lower ramp surfaces 142 of the cutter cartridges 106 toward the upper end of the lower ramp surfaces 142; thereby drawing the cutter cartridges 106 into a radially retracted position as shown in Figure 3.

One will appreciate in light of the disclosure herein that the biasing of the wedge return 144 upward can also cause the inner member 104 to move upward. In particular, movement of the cutter cartridges 106 radially inward can cause the rollers 130 to roll or slide along the upper ramp surfaces 140 of the cutter cartridges 106 toward an upper end of the upper ramp surfaces 140. This in turn pushes the inner member 104 upward toward the first end 108 of the body 102.

For ease of reference, the cutter cartridges 106 shown and described above include generally planar ramp surfaces 140, 142 and spherical rollers 130, 130a. It will

be appreciated that the cutter cartridges 106 can have any number of ramp surfaces 140, 142 with any desired shape, including, but not limited to, convex, concave, patterned or any other shape or configuration capable of moving along a roller (e.g., roller ball) as desired. Further, the rollers 130, 130a can have any shape and configuration possible. In at least one example, a universal-type joint can replace the generally spherical rollers, tapered planar drive surfaces, and accompanying sockets.

Additionally, Figures 1, 3, and 4 show two cutter cartridges 106. In alternative implementations, the internal tubing cutter 100 can include one, three, four, or more cutter cartridges 106. Similarly, the precise configuration of components as illustrated may be modified or rearranged as desired by one of ordinary skill. Thus, the present invention can be embodied in other specific forms without departing from its spirit or essential characteristics. The described embodiments are to be considered in all respects only as illustrative and not restrictive.

In other words, the foregoing and the following description supplies specific details in order to provide a thorough understanding of the invention. Nevertheless, the skilled artisan would understand that the apparatus and associated methods of using the apparatus can be implemented and used without employing these specific details. Indeed, the apparatus and associated methods can be placed into practice by modifying the illustrated apparatus and associated methods and can be used in conjunction with any other apparatus and techniques.

For example, Figures 5 and 6 illustrate another implementation of an internal tubing cutter 100a. The internal tubing cutter 100a can include many of the same parts and components as the internal tubing cutter 100 described above. Such parts and components are labeled with the same reference numbers. As explained in greater detail below, the internal tubing cutter 100a can include different design than the internal

tubing cutter 100, but function under the same principles to linearly retract and deploy the cutters 134. In particular, the inner member 104a can include a ramp surface that acts to push the cartridge cutters 106 radially outward in a linear motion rather than upper ramp surfaces on the cartridge cutters 106.

More specifically, the inner member 104a can comprise a single component rather than nested wedges. In particular, the inner member 104a can comprise a generally conical or tapered outer or ramp surface 141. As explained in greater detail below, axial translation of the inner member 104a can result in radial displacement of the cutter cartridges 106 in and out of the body as explained in greater detail below. The inner member 104a can house the valve stop 118. The valve stop 118 can mate with the inner surface of the inner member 104 to move a seal to create a downward directed fluid force on the inner member 104a. The rollers 130 can be positioned within bushings in the cutter cartridges 106 so as to allow the rollers 130 to roll and/or slide along the ramp surface 141 as the inner member 104a moves axially.

Referring to Figures 5-6 operation of the internal tubing cutter 100a will now be described in greater detail. As shown in Figure 5, when tripping the internal tubing cutter 100a into a casing 200 or other tubular member, the cutter cartridges 106 can be in the retracted position (i.e., within the body 102). In particular, the biasing member 150 can bias the wedge return 144 toward the cutter cartridges 106 and the upper end 108. The biasing of the wedge return 144 upward can cause the rollers 130a to roll along the lower ramp surfaces 142 of the cutter cartridges 106 toward the upper end of the lower ramp surfaces 142; thereby drawing the cutter cartridges 106 into a radially retracted position as shown in Figure 3.

With the internal tubing cutter 100a in the retracted position as shown in Figure 5, an operator can lower the internal tubing cutter 100a down the casing to a desired

position. Once the internal tubing cutter 100a has reached the desired position within the casing 200, a fluid can be sent into the body 102 of the internal tubing cutter 100a. The fluid can then be pressurized. The pressurization of the fluid can cause the pressurized fluid to enter the inner member 104a. The pressurized fluid can then force the valve stop 118 against the inner surface of the inner member 104a; thereby, creating a seal. Pressurized fluid entering the inner member 104a can then produce a distally directed fluid force against the inner member 104a.

This distally directed fluid force can exert a force in opposition to the upward force created by the biasing member 150. As the distally directed fluid force increases it can overcome the upward force created by the biasing member 150. As the distally directed fluid force overcomes the upward force created by the biasing member 150, the inner member 104a can move toward the lower end 110 of the body 102. As the inner member 104a moves downward, the rollers 130 can roll along the ramp surface 141 as it increases in diameter; thereby forcing the cutter cartridges 106 to move linearly radially outward toward a deployed position.

Thus, movement of the inner member 104a downward can urge the cutting cartridges 106 radially outward through the cartridge openings 138 in the body 102. This movement can cause the cutters 134 to move radially outward in a linear motion and into engagement with the inner surface of a casing. The linear movement of the cutters 134 can help ensure that the cutting point (i.e., axial position of the cutters 134 relative to the casing) remains constant during the cutting process.

As previously mentioned, in one or more implementations, the inner member 104a can include a taper such that the diameter of the inner member 104a varies along its length. This in combination with the downward directed fluid force can ensure that the cutter cartridges 106 are biased radially outward. Once the cutting process is complete

(i.e., the cutters 134 have complete cut through the casing), the cutting cartridges 106 can be in a fully deployed position, as shown by Figure 6. When in the deployed position, the inner member 104a can be positioned below the fluid flow passages 111. Thus, fluid can flow from the internal bore of the body 102, through the fluid flow passages 111, and down the recess between the outer surface of the internal tubing cutter 100a and the inner surface of the casing. This can cause a drop in fluid pressure that can signal an operator that the cutting process is complete.

Furthermore, the drop in pressure can allow the upward biasing force created by the biasing member 150 to overcome the downward fluid force acting on the inner member 104a. In particular, the biasing member 150 can bias the wedge return 144 toward the cutter cartridges 106 and the upper end 108. The biasing of the wedge return 144 upward can cause the rollers 130a to roll along the lower ramp surfaces 142 of the cutter cartridges 106 toward the upper end of the lower ramp surfaces 142; thereby drawing the cutter cartridges 106 into a radially retracted position as shown in Figure 5.

One will appreciate in light of the disclosure herein that the biasing of the wedge return 144 upward can also cause the inner member 104a to move upward. In particular, movement of the cutter cartridges 106 radially inward can cause the rollers 130 to roll or slide along the ramp surface 141. This in turn pushes the inner member 104a upward toward the first end 108 of the body 102.

As shown in Figure 7, a drilling system 300 may be used to cut and retrieve a tubular member, such as a casing, within a formation 304. The drilling system 300 may include a rod string 302 that may include an internal tubing cutter 100 secured to the end thereof. The drilling system 300 may include a drill rig 301 that may rotate the rod string 302 and internal tubing cutter 100 to cut the casing. The drill rig 301 may include, for example, a rotary drill head 306, a sled assembly 308, and a mast 310. The drill head

306 may be coupled to the rod string 302, and can rotate the rod string 302 and internal tubing cutter 100.

It will be appreciated, however, that the drill rig 301 does not require a rotary drill head, a sled assembly, a slide frame or a drive assembly and that the drill rig 301 may include other suitable components. It will also be appreciated that the drilling system 300 does not require a drill rig and that the drilling system 300 may include other suitable components that may rotate rod string 302 and internal tubing cutter 100. For example, sonic, percussive, or down hole motors may be used.

As previously alluded to previously, numerous variations and alternative arrangements may be devised by those skilled in the art without departing from the spirit and scope of this description. Thus, the present invention may be embodied in other specific forms without departing from its spirit or essential characteristics. The described embodiments are to be considered in all respects only as illustrative and not restrictive. The scope of the invention is, therefore, indicated by the appended claims rather than by the foregoing description. All changes that come within the meaning and range of equivalency of the claims are to be embraced within their scope.

# CLAIMS

We claim:

1. An internal tubing cutter, comprising:

a tubular body having a first end and a lower end;

at least one cartridge opening extending through the tubular body;

a cutter cartridge at least partially positioned within the at least one cartridge opening, the cutter cartridge including a cutter and at least one axially tapered ramp surface;

an inner member configured to move relative to the cutter cartridge; and

at least one roller positioned between the ramp surface and the inner member;

wherein axial displacement of the inner member relative to the cutter cartridge causes the at least one roller to move along the ramp surface thereby linearly moving the cutter cartridge radially from a retracted position within the tubular body to a deployed position in which the cutter is at least partially radially outward of the tubular body.

2. The internal tubing cutter as recited in claim 1, wherein the cutter comprises a disc blade.

3. The internal tubing cutter as recited in claim 2, further comprising a pivot pin adapted to couple the disc blade to the cutter cartridge and allow the disc blade to rotate relative to the cutter cartridge.

4. The internal tubing cutter as recited in claim 1, wherein the cutter cartridge comprises a diamond shape.

5. The internal tubing cutter as recited in claim 1, wherein the at least one axially tapered ramp surface comprises an upper ramp surface positioned on an upper end of the cutter cartridge and a lower ramp surface positioned on a lower end of the cutter cartridge.

6. The internal tubing cutter as recited in claim 5, wherein each of the upper and lower ramp surfaces extend radially outward and axially toward the first end of the tubular body.

7. The internal tubing cutter as recited in claim 5, further comprising:

a wedge return; and

a second roller positioned between the lower ramp surface and the wedge return;

wherein axial displacement of the wedge return relative to the cutter cartridge causes the second roller to move along the lower ramp surface thereby linearly moving the cutter cartridge radially from the deployed position to the retracted position.

8. The internal tubing cutter as recited in claim 7, further comprising a biasing member configured to bias the wedge return toward the cutter cartridge.

9. The internal tubing cutter as recited in claim 7, wherein the wedge return comprises an axially tapered surface against which the second roller is positioned.

10. The internal tubing cutter as recited in claim 1, further comprising a valve stop positioned within the inner member, the value stop being configured to create a seal with the inner member and prevent the passage of fluid through the tubular body.

11. The internal tubing cutter as recited in claim 10, further comprising one or more fluid flow passages extending through the tubular body.

12. The internal tubing cutter as recited in claim 11, wherein the inner member is configured to block the one or more fluid flow passages when the cutter cartridges are in the retracted position.

13. The internal tubing cutter as recited in claim 1, wherein:

the inner member comprises an inner wedge and an outer wedge; and

the at least one roller is positioned in a mounting slot in the outer wedge.

14. An internal tubing cutting system, comprising:

a generally hollow body;

a plurality of cartridge openings extending through the body;

a plurality of cutter cartridges configured to hold one or more cutters, each cutter cartridge being positioned in a cartridge opening of the plurality of cartridge openings;

an inner member;

a plurality of rollers positioned between the cutter cartridges and the inner member, each roller of the plurality of rollers being positioned against a ramp surface;

wherein movement of the inner member relative to the cutter cartridges causes the plurality of rollers to move along the ramp surface thereby linearly moving the plurality of cutter cartridges at least partially radially outward of the plurality of cartridge openings.

15. The internal tubing cutting system as recited in claim 14, wherein the ramp surface comprises an outer surface of the inner member.

16. The internal tubing cutting system as recited in claim 15, wherein the outer surface of the inner member is a conical surface.

17. The internal tubing cutting system as recited in claim 14, wherein the ramp surface comprises a plurality of ramp surfaces on upper ends of each cutter cartridge.

18. The internal tubing cutting system as recited in claim 17, further comprising a plurality of lower ramp surfaces, the lower ramp surfaces being positioned on lower ends of cutter cartridge.

19. The internal tubing cutting system as recited in claim 18, wherein each of the plurality of ramp surfaces and the plurality of lower surfaces extend radially outward and axially toward a first of the tubular body.

20. The internal tubing cutting system as recited in claim 19, further comprising:

a wedge return; and

a plurality of second rollers positioned between the plurality of lower ramp surfaces and the wedge return;

wherein axial displacement of the wedge return relative to the cutter cartridges causes the second rollers to move along the lower ramp surfaces thereby linearly moving the cutter cartridges radially from the deployed position to the retracted position.

21. The internal tubing cutting system as recited in claim 20, further comprising a biasing member configured to bias the wedge return toward the cutter cartridges.

22. The internal tubing cutting system as recited in claim 14, wherein the plurality of rollers are positioned at least partially within the inner member.

23. The internal tubing cutting system as recited in claim 14, wherein the plurality of rollers are positioned at least partially within the cutter cartridges of the plurality of cutter cartridges.

24. A method of cutting a tubular member, comprising:

lowering an internal tubing cutter into the tubular member;

pumping a fluid into the internal tubing cutter to cause an inner member to move axially within a body of the internal tubing cutter, wherein axial

movement of the inner member causes one or more rollers operatively associated with the inner member to move along a ramp surface of a cutter cartridge thereby moving a cutter linearly at least partially outward of the internal tubing cutter; and

rotating the internal tubing cutter relative to the tubular member thereby causing the cutter held within the cutter cartridge to cut the tubular member.

25. The method as recited in claim 0, further comprising causing the cutter to rotate about two parallel and offset axes.

26. The method as recited in claim 25, wherein causing the cutter to rotate about two parallel and offset axes comprises causing the cutter:

to rotate about a pivot pin extending securing the cutter to the cutter cartridge; and

orbit about a central axis of the internal tubing cutter.

27. The method as recited in claim 0, further comprising pumping a fluid into the internal tubing cutter so as to move the inner member beyond one or more fluid flow passages extending through the body thereby causing a pressure drop in the fluid.

28. The method as recited in claim 27, further comprising biasing a wedge return toward the cutter cartridge such that upon the pressure drop in the fluid the wedge return automatically moves the cutter linearly into the internal tubing cutter.

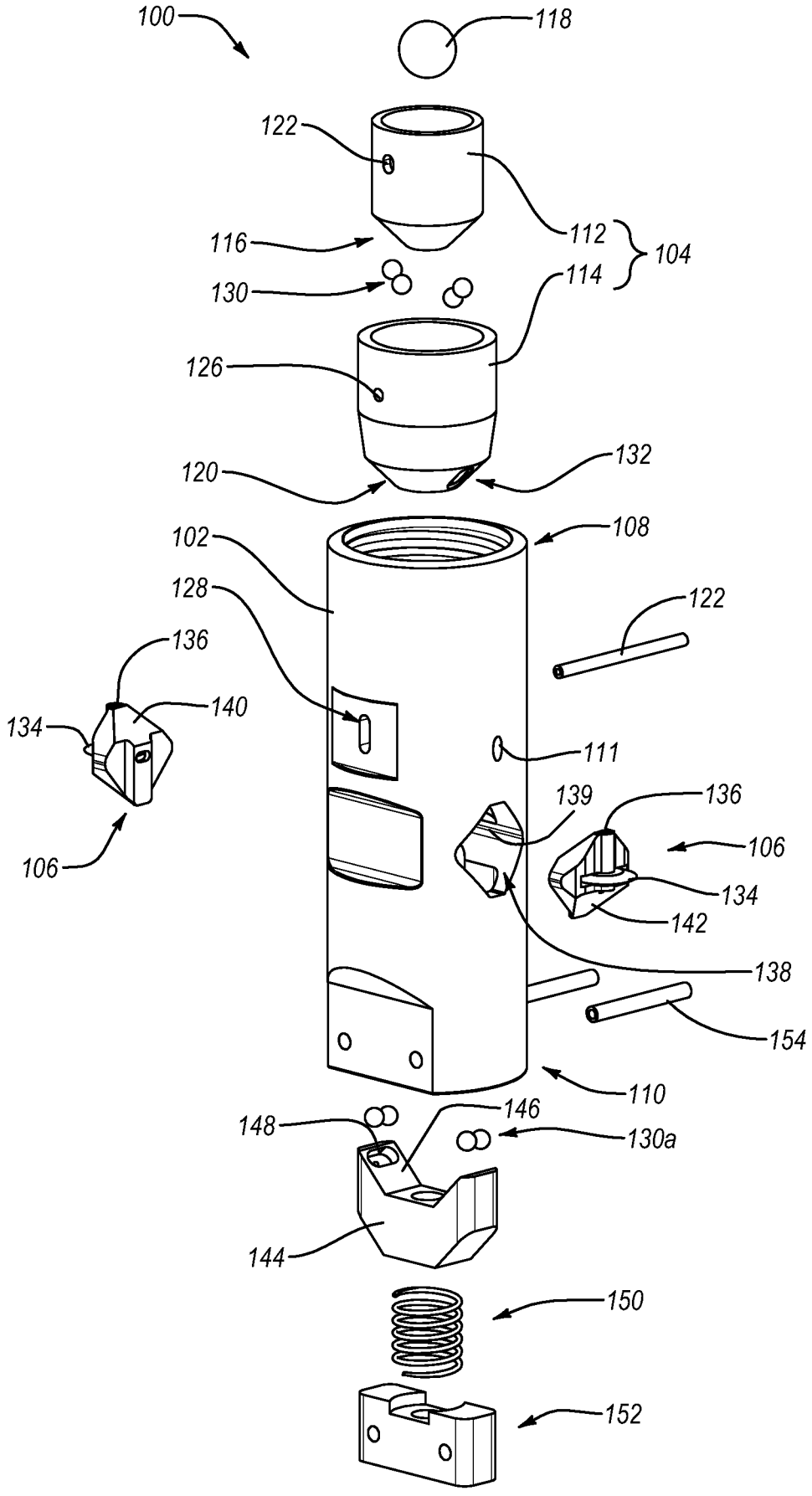

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Fig. 1

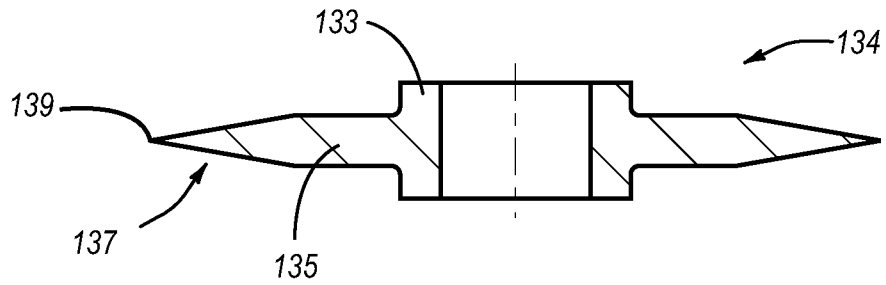



*Fig. 2*

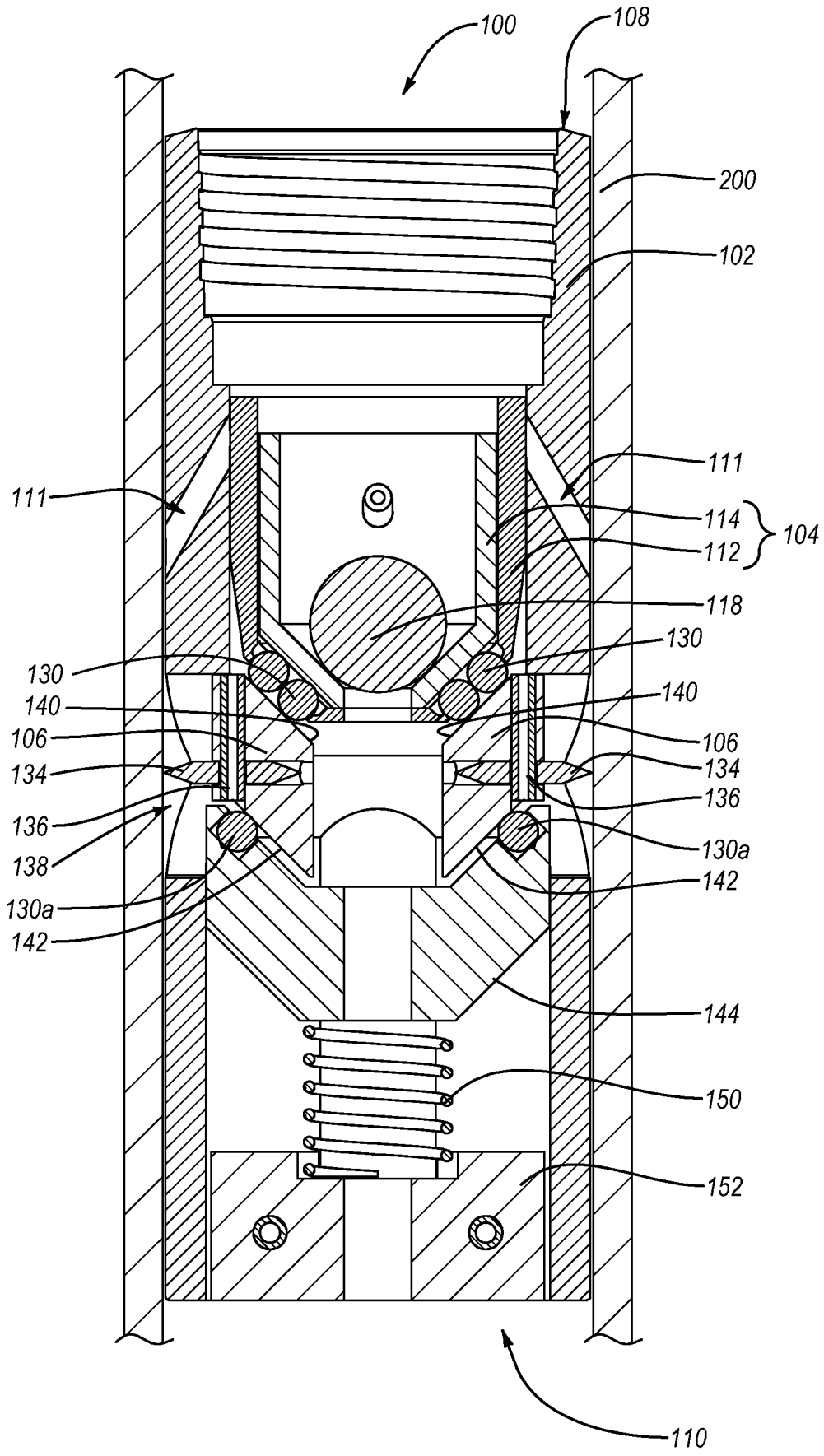

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Fig. 3

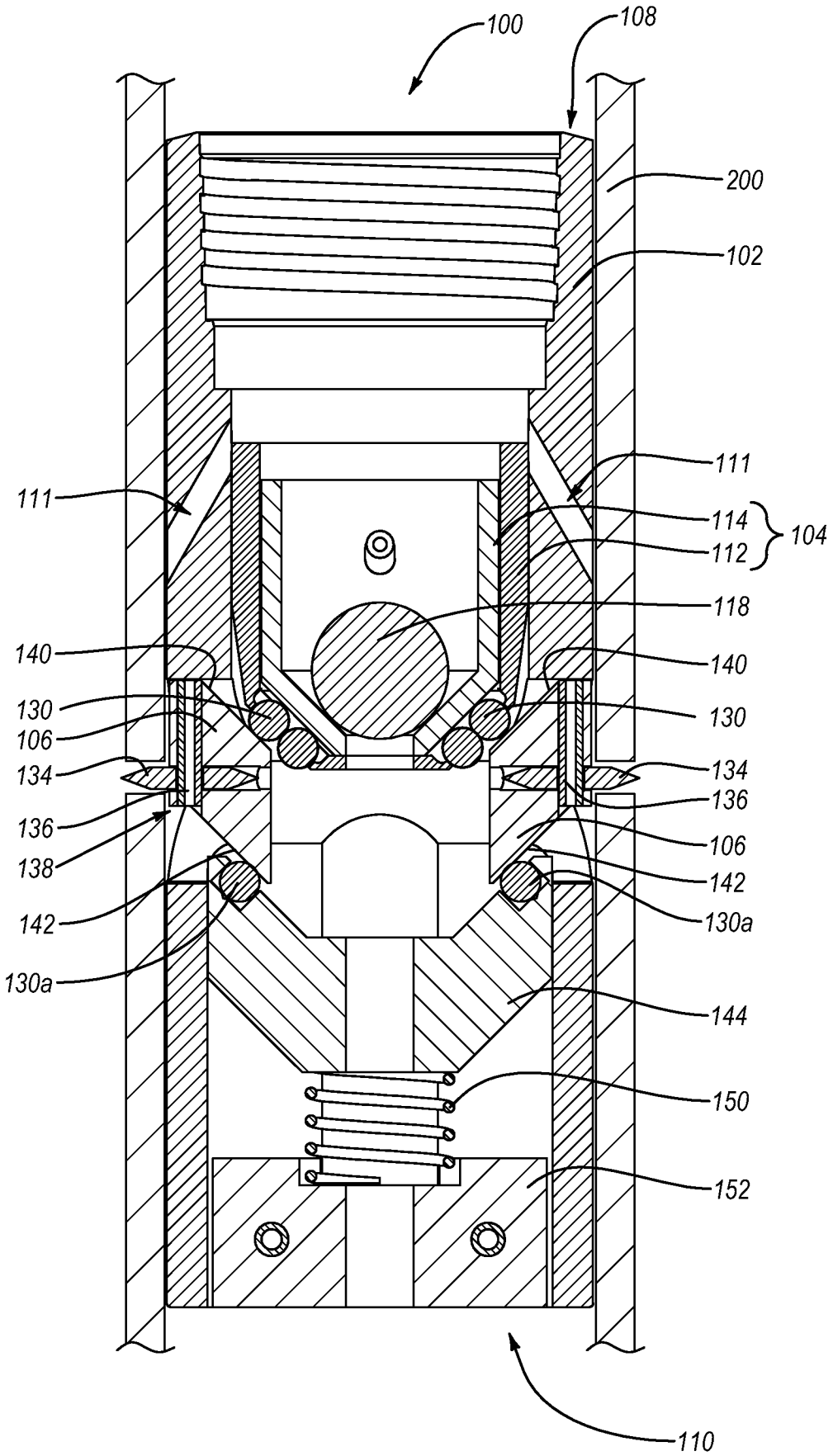

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Fig. 4

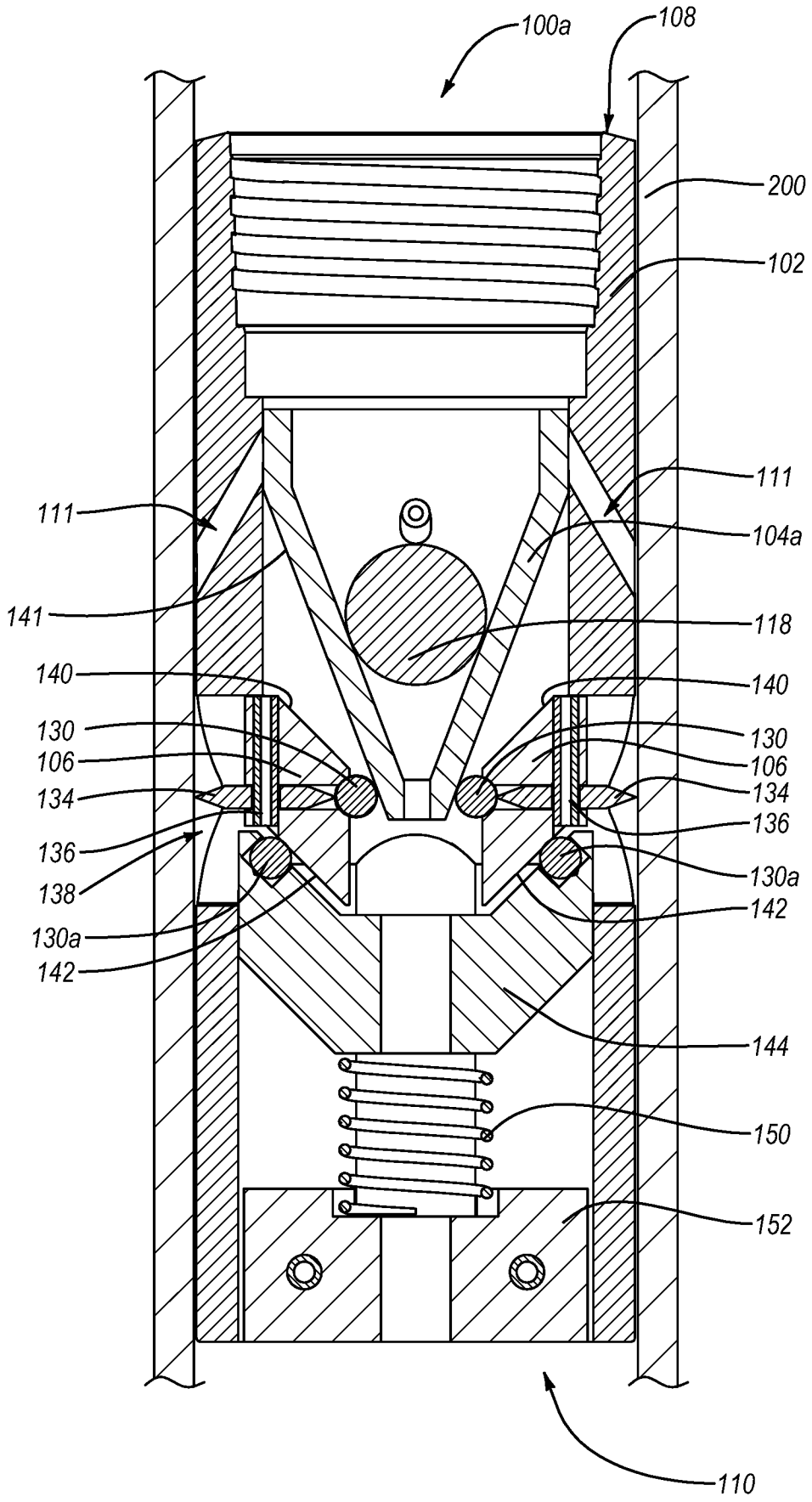

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Fig. 5

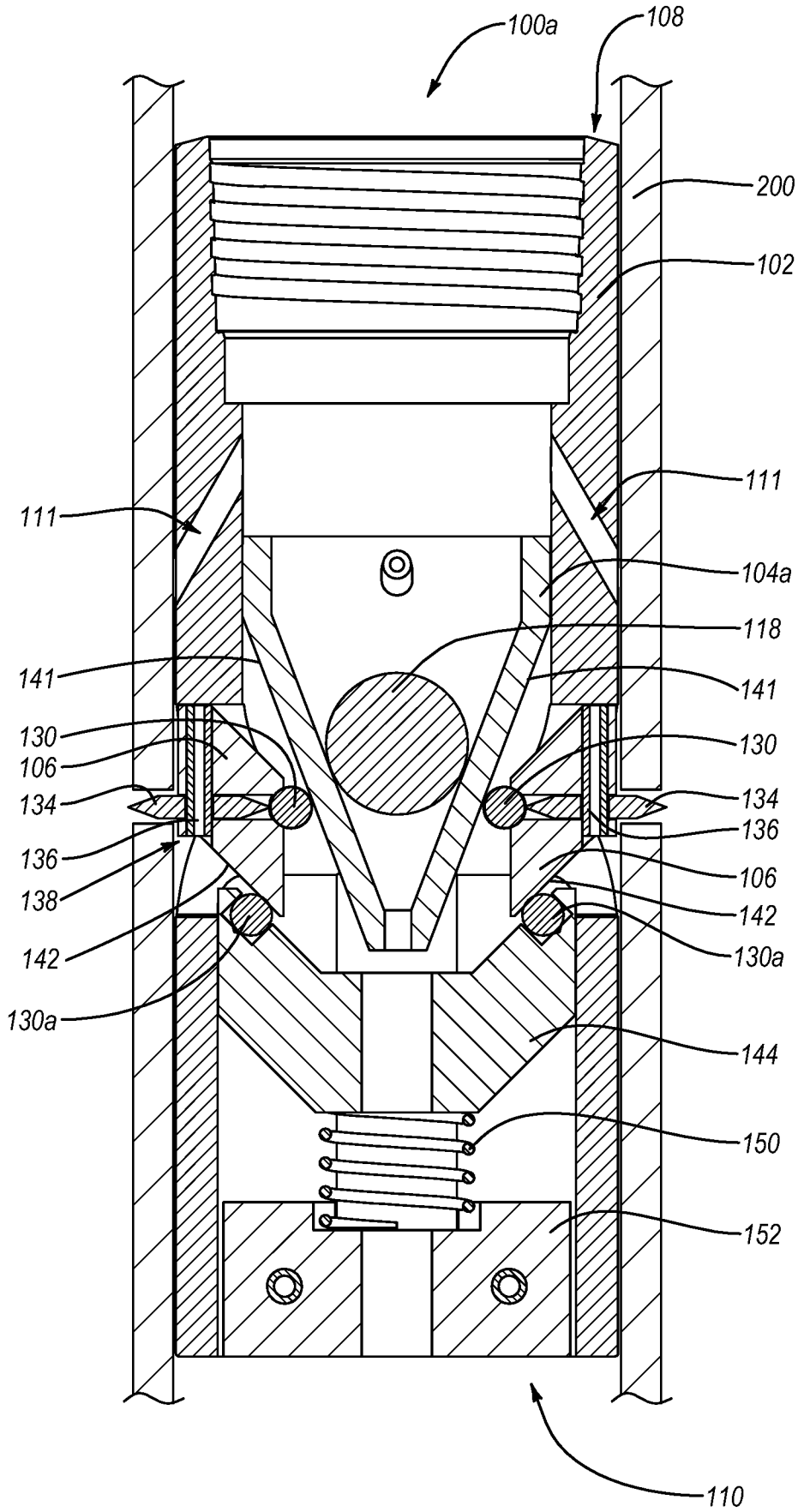

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Fig. 6

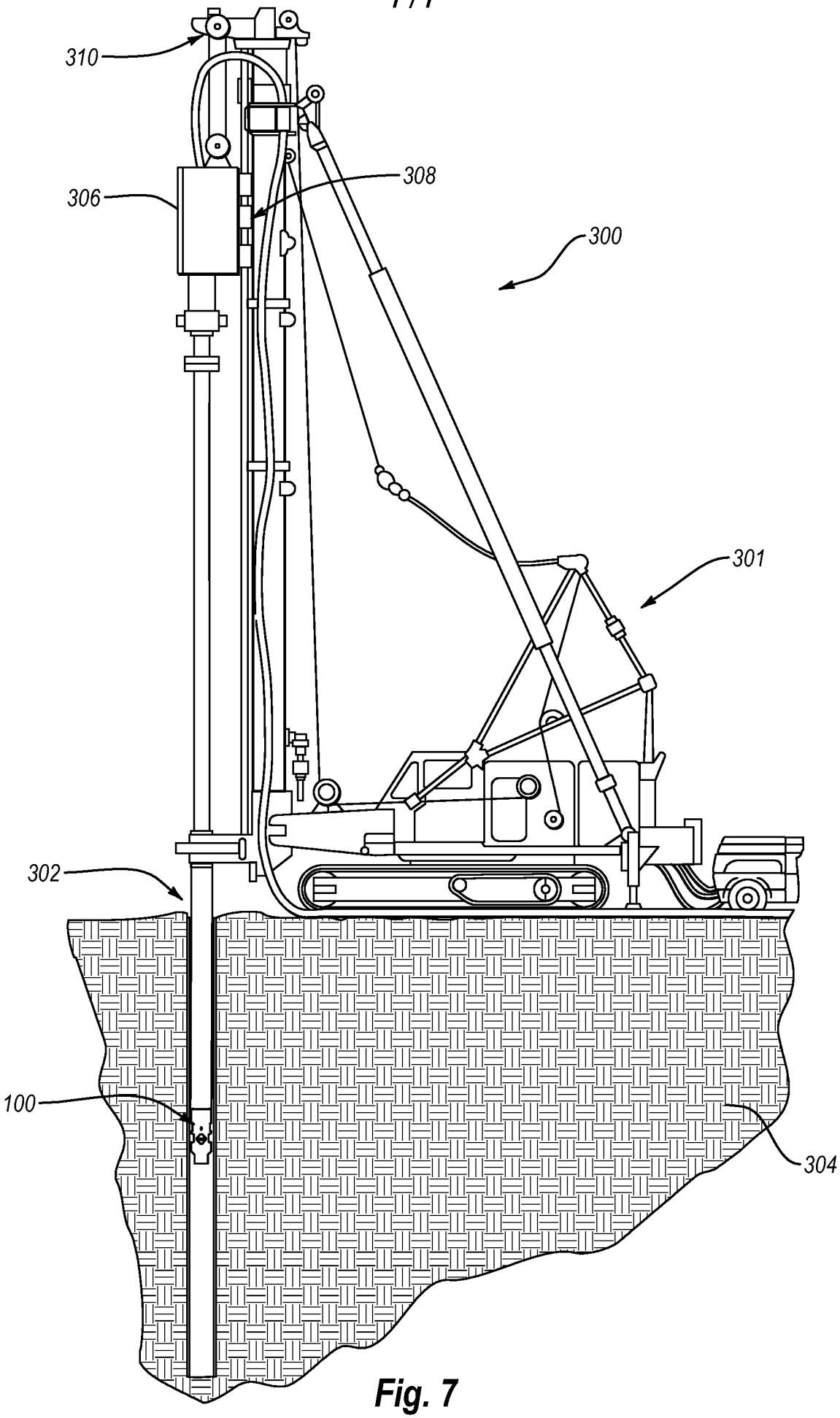



Fig. 7

**INTERNATIONAL SEARCH REPORT**

International application No.
**PCT/US2012/027067**

**A. CLASSIFICATION OF SUBJECT MATTER**

***E21B 29/08(2006.01)i, E21B 29/04(2006.01)i***

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 29/08; E21B 29/04

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & Keywords: cutter, cartridge, taper, ramp, roller, wedge, linearly and similar terms

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| Y<br>A | US 2007-0089912 A1 (EDDISON, ALAN MARTYN et al.) 26 April 2007<br>See abstract, paragraphs 58-61 and figures 1, 4, 5. | 1-4,14-17,22-24<br>5-13,18-21 |
| Y<br>A | US 4068711 A (AULENBACHER, MERLE W.) 17 January 1978<br>See abstract, column 2 line 38-column 4 line 44, column 4 lines 54-56 and figures 1-3, 8. | 1-4,14-17,22-24<br>5-13,18-21 |
| A | US 2009-0277689 A1 (LEE, PAUL BERNARD) 12 November 2009<br>See abstract, paragraphs 96-98 and figures 15-18. | 1-24 |
| A | US 2007-0131410 A1 (HILL, FREEMAN L. et al.) 14 June 2007<br>See abstract, paragraph 26 and figure 6. | 1-24 |

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

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

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"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

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art

"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 25 FEBRUARY 2013 (25.02.2013) | **26 FEBRUARY 2013 (26.02.2013)** |


Name and mailing address of the ISA/KR

Korean Intellectual Property Office
189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea

Facsimile No. 82-42-472-7140

Authorized officer

LEE, Eun Ju

Telephone No. 82-42-481-5469

# INTERNATIONAL SEARCH REPORT

International application No.
**PCT/US2012/027067**

**Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 25-28
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

Claim 25 refers to claim 0 which is not exist. Thus claim 25 and its dependent claim 26 do not meet the requirement of PCT Article 6, because the subject matter for which protection is sought is not clearly defined. A similar observation would apply to claims 27 and 28.

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

**Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required addtional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

**Remark on Protest**

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
☐ No protest accompanied the payment of additional search fees.

**INTERNATIONAL SEARCH REPORT**

Information on patent family members

International application No.

**PCT/US2012/027067**

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