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(54) Title: PRESSURE PULSE GENERATING TOOL

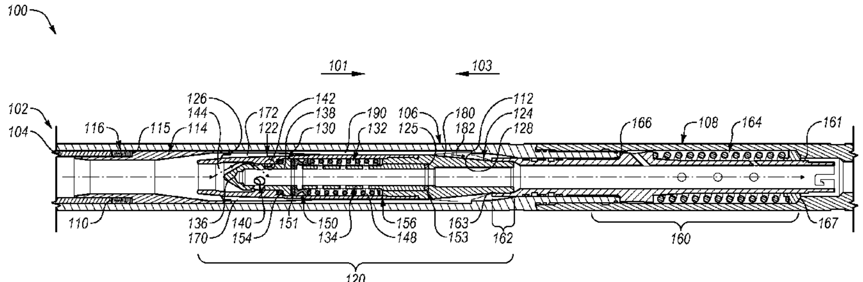

FIG. 1

(57) Abstract: A pressure pulse generating tool may include an upper valve assembly disposed within the bore of a housing, where the upper valve assembly is configured to allow a fluid to flow through the upper valve assembly when in an open state. The upper valve assembly may also be configured to restrict the fluid from flowing through the upper valve assembly when in a closed state. The pressure pulse generating tool may further include a lower valve assembly disposed within the bore of the housing, where the lower valve assembly is configured to receive the fluid flow from the upper valve assembly. The lower valve assembly may also be configured to separate from the upper valve assembly in response to an increase in fluid pressure in an annulus defined between the upper valve assembly and the housing.

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PRESSURE PULSE GENERATING TOOL

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims priority to United States Provisional Application 61/905,436 filed November 18, 2013, and United States Application 14/539,512 filed on November 12, 2014, both of which are hereby incorporated by reference in their entireties.

FIELD OF THE INVENTION

[0002] Aspects relate to tools used in downhole environments. More specifically, aspects relate to downhole tools that generate pressure pulses.

BACKGROUND

[0003] During well drilling operations, friction of a drill string against a wellbore may be generated. In particular, horizontal sections of the wellbore may produce higher friction than vertical or directional sections of the wellbore. With the increase in friction, a weight transfer to a drill bit may not be immediately realized, rates of penetration may decline, the drill string and bit wear may be amplified, and productivity may be reduced.

[0004] Various drilling tools may be used to attenuate the friction, such as those which induce a vibration, hammering effect, or reciprocation in the drill string. For example, a shock sub may be used with a pressure pulse tool to generate an axial force at a specified frequency, causing an axial vibration which oscillates the drill string and reduces friction. To generate the axial force, the pressure pulse tool may be used to create and apply cyclical pressure pulses to a pump open area of the shock sub. In another example, the cyclical pressure pulses of the pressure pulse tool may produce a water hammering effect, causing the axial vibration needed to oscillate the drill string and reduce friction.

[0005] Certain pressure pulse tools may need an external prime mover, such as a mud motor or turbine, in order to produce the cyclical pressure pulses. Implementing these external prime movers may increase the cost and complexity of the well drilling operation. Additionally, a pressure pulse tool utilizing the external prime mover may not allow for wireline accessibility downhole of the pressure pulse tool.

SUMMARY

[0006] Described herein are implementations of various technologies for a pressure pulse generating tool. In one or more implementations, the pressure pulse generating tool may include a housing having a housing bore extending at least partially through the housing. The pressure pulse generating tool may also include an upper valve assembly disposed within the housing bore. The upper valve assembly is arranged to permit a fluid to flow through at least a portion of the upper valve assembly when in an open state. The upper valve assembly may also be arranged to at least partially restrict fluid from flowing through the upper valve assembly when in a closed state. In the closed state, fluid pressure is increased in an annulus within the housing bore. The pressure pulse generating tool may further include a lower valve assembly also disposed within the housing bore. The lower valve assembly is arranged to receive any fluid flowing from the upper valve assembly when the upper valve assembly is in the open state. At least a portion of the lower valve assembly may also be arranged to move within the housing bore in response to the increase in fluid pressure in the annulus. This causes the annular fluid to flow through at least a portion of the lower valve assembly and decreases the fluid pressure in the annulus.

[0007] In another implementation, the pressure pulse generating tool may include a housing having a housing bore extending at least partially therethrough. The pressure pulse generating tool may also include an upper valve assembly disposed within the housing bore and having an upper valve housing and an upper valve body. The upper valve assembly is arranged to permit a fluid to flow through one or

more flow ports disposed in the upper valve body when in an open state. The upper valve assembly may also be arranged to restrict the one or more flow ports from flowing fluid therethrough when in a closed state. This causes an increase in fluid pressure in an annulus defined between the upper valve assembly and the housing. The pressure pulse generating tool may further include a lower valve assembly also disposed within the housing bore. The lower valve assembly is arranged to receive the fluid from the upper valve assembly when the upper valve assembly is in the open state. The lower valve assembly may also be arranged to separate from the upper valve assembly when the upper valve assembly is in the closed state in response to the increase in fluid pressure in the annulus. This causes the annular fluid to flow through the lower valve assembly and decreases the fluid pressure in the annulus.

[0008] The above referenced summary section is provided to introduce a selection of concepts in a simplified form that are further described below in the detailed description section. The summary is not intended to be used to limit the scope of the claimed subject matter. Furthermore, the claimed subject matter is not limited to implementations that solve disadvantages noted in any part of this disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] Implementations of various techniques will hereafter be described with reference to the accompanying drawings. It should be understood, however, that the accompanying drawings illustrate various implementations described herein and are not meant to limit the scope of various techniques disclosed herein.

[0010] Figure 1 illustrates a cross-sectional view of a pressure pulse generating tool in accordance with implementations of various techniques disclosed herein.

[0011] Figure 2 illustrates a perspective view of the upper valve body in accordance with implementations of various techniques disclosed herein.

[0012] Figure 3 illustrates a close up cross-sectional view of a pressure pulse generating tool in accordance with implementations of various techniques disclosed herein.

[0013] Figure 4 illustrates a perspective view and Figure 5 illustrates a cross-sectional top view of the upper valve housing in accordance with implementations of various techniques disclosed herein.

[0014] Figure 6 illustrates a perspective view of the lower valve seat in accordance with implementations of various techniques disclosed herein.

[0015] Figures 7 through 11 illustrate cross-sectional views of the pressure pulse generating tool in accordance with implementations of various techniques disclosed herein.

[0016] Figures 11 and 12 illustrate cross-sectional views of a pressure pulse generating tool in accordance with implementations of various techniques disclosed herein.

[0017] Figures 13 and 14 illustrate cross-sectional views of a pressure pulse generating tool in accordance with implementations of various techniques disclosed herein.

[0018] Figures 15 through 22 illustrate cross-sectional views of a pressure pulse generating tool in accordance with implementations of various techniques disclosed herein.

[0019] Figures 23 through 27 illustrate cross-sectional views of a pressure pulse generating tool with an axial activation section in accordance with implementations of various techniques disclosed herein.

[0020] Figures 28 through 32 illustrate cross-sectional views of a pressure pulse generating tool with a torsional activation section in accordance with implementations of various techniques disclosed herein.

DETAILED DESCRIPTION

[0021] The discussion below is directed to certain specific implementations. It is to be understood that the discussion below is for the purpose of enabling a person with ordinary skill in the art to make and use any subject matter defined now or later by the patent "claims" found in any issued patent herein.

[0022] It is specifically intended that the claims not be limited to the implementations and illustrations contained herein, but include modified forms of those implementations including portions of the implementations and combinations of elements of different implementations as come within the scope of the following claims.

[0023] Reference will now be made in detail to various implementations, examples of which are illustrated in the accompanying drawings and figures. In the following detailed description, numerous specific details are set forth in order to provide a thorough understanding of the present disclosure. However, it will be apparent to one of ordinary skill in the art that the present disclosure may be practiced without these specific details. In other instances, well-known methods, procedures, components, apparatuses and systems have not been described in detail so as not to obscure aspects of the embodiments.

[0024] It will also be understood that, although the terms first, second, etc. may be used herein to describe various elements, these elements should not be limited by these terms. These terms are used to distinguish one element from another. For example, a first object could be termed a second object, and, similarly, a second object could be termed a first object, without departing from the scope of the claims. The first object and the second object are both objects, respectively, but they are not to be considered the same object.

[0025] The terminology used in the description of the present disclosure herein is for the purpose of describing particular implementations and is not intended to be limiting of the present disclosure. As used in the description of the present disclosure and the appended claims, the singular forms “a,” “an” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will also be understood that the term "and/or" as used herein refers to and encompasses one or more possible combinations of one or more of the associated listed items. It will be further understood that the terms "includes" and/or "including," when used in this specification, specify the presence of stated features, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, operations, elements, components and/or groups thereof.

[0026] As used herein, the terms "up" and "down"; "upper" and "lower"; "upwardly" and downwardly"; "below" and "above"; and other similar terms indicating relative positions above or below a given point or element may be used in connection with some implementations of various technologies described herein. When applied to equipment and methods for use in wells or boreholes that are deviated or horizontal, or when applied to equipment and methods that when arranged in a well or borehole are in a deviated or horizontal orientation, such terms may refer to a left to right, right to left, or other relationships as appropriate.

[0027] Various implementations will now be described in more detail with reference to Figures 1 through 32.

<u>Pressure Pulse Generating Tool</u>

[0028] Figure 1 illustrates a cross-sectional view of a pressure pulse generating tool 100 in accordance with implementations of various techniques disclosed herein, where the pressure pulse generating tool 100 may utilize a fluid flow through the tool. The fluid flow may include a flow of drilling fluid, drilling mud, or any other fluid known to those skilled in the art. One or more components of the pressure pulse generating tool 100 may be composed of steel, tungsten carbide, or any other implementation known to those skilled in the art.

[0029] In one or more implementations, the pressure pulse generating tool 100 may include a housing 102 having a top sub 104, an upper valve cylinder 106, a lower valve cylinder 108, and a bottom sub (not shown). The top sub 104 may be coupled to the upper valve cylinder 106, the upper valve cylinder 106 may be coupled to the lower valve cylinder 108, and the lower valve cylinder 108 may be coupled to the bottom sub through the use of threads, bolts, welds, or any other attachment feature known to those skilled in the art. The housing 102 may be oriented such that the top sub 104 may engage with uphole members of a drill string, such as a shock sub, and the bottom sub may engage with downhole members of the drill string.

[0030] The pressure pulse well tool 100 may also include an upper valve assembly 120 and a lower valve assembly 160 disposed within the housing 102. The upper valve assembly 120 may include an upper valve housing 122 and a lower valve seat 124 positioned within the upper valve cylinder 106. The upper valve assembly 120 may be oriented such that the upper valve housing 122 is located uphole relative to the lower valve seat 124.

[0031] In one or more implementations, the upper valve housing 122 and the lower valve seat 124 may be manufactured as a single component. In another implementation, the upper valve housing 122 may be coupled to the lower valve seat 124 through the use of threads, bolts, welds, or any other attachment feature known to those skilled in the art. For example, an uphole end portion of the lower valve seat 124 may be threaded into a downhole end portion of the upper valve housing 122.

[0032] Axial movement of the upper valve assembly 120 may be limited by an upper shoulder 110 and a lower shoulder 112 of the housing 102. In particular, uphole movement of the upper valve assembly 120 may be constrained by the upper shoulder 110. The upper shoulder 110 may be located within a bore of the upper valve cylinder 106. The upper shoulder 110 may be formed by a downhole end portion of the top sub 104.

[0033] In one or more implementations, a retaining shoulder 126 along an outer diameter of the upper valve housing 122 may engage with the upper shoulder 110 to constrain the uphole movement of the upper valve assembly 120. In such an implementation, the retaining shoulder 126 may be located proximate to the uphole end portion of the upper valve housing 122 and may have a greater outer diameter than the rest of the upper valve housing 122.

[0034] As shown in Figure 1, a fluid diverter 114 may be disposed between the upper shoulder 110 and the upper valve assembly 120. The fluid diverter 114 may be configured to divert a fluid flow from a bore of the top sub 104. A shoulder 115 of the fluid diverter 114 may engage with the upper shoulder 110 to restrict an uphole movement of the fluid diverter 114. One or more Belleville washers 116, one or more spacers, and/or the like may be placed between the shoulder 115 of the fluid diverter 114 and the upper shoulder 110. The retaining shoulder 126 of the upper valve housing 122 may be seated against a downhole end portion of the fluid diverter 114, such that the uphole movement of the upper valve assembly 120 may be stopped by the fluid diverter 114.

[0035] Downhole movement of the upper valve assembly 120 may be constrained by the lower shoulder 112. In one or more implementations, the lower shoulder 112 may be formed by a change in the inner diameter of the upper valve cylinder 106. A retaining shoulder 128 along an outer diameter of the lower valve seat 124 may engage with the lower shoulder 112 to constrain the downhole movement of the upper valve assembly 120. In such an implementation, the retaining shoulder 128 may be located proximate to the downhole end portion of the lower valve seat 124 and may have a greater outer diameter than the rest of the lower valve seat 124. In one or more implementations, the upper valve housing 122, the lower valve seat 124, and the fluid diverter 114 may be affixed or coupled within the housing 102.

[0036] The upper valve assembly 120 may further include an upper valve body 130, an upper biasing mechanism 132, and a spring guide 134. In one or more implementations, the upper valve body 130, the upper biasing mechanism 132, and/or the spring guide 134 may be disposed at least partially within the upper valve housing 122.

[0037] As illustrated in Figure 2, the upper valve body 130 may include a head portion 136 and a base portion 138. Figure 2 illustrates a perspective view of the upper valve body 130 in accordance with implementations of various techniques disclosed herein. The upper valve body 130 may be oriented such that the head portion 136 is uphole relative to the base portion 138. In addition, an outer diameter of the base portion 138 may be greater than an outer diameter of the head portion 136. The head portion 136 may include one or more flow ports 140, which allow a fluid flow to pass from a bore of the upper valve housing 122 to a bore of the upper valve body 130 (see Figure 1). The head portion 136 may also include one or more stress grooves 142 disposed on its outer diameter, where the stress grooves 142 may be indentations in the head portion 136, as further described below. In one or more implementations, the head portion 136 may be shaped to mitigate a force of the fluid flow against the upper valve body 130.

[0038] Returning to Figure 1, the bore of the upper valve housing 122 may include a bypass bore 144, a restrictive bore 146 (see Figure 3), and a central bore 148. The bypass bore 144 may be uphole relative to the restrictive bore 146, and the restrictive bore 146 may be uphole relative to the central bore 148. In addition, the bypass bore 144 may have a smaller inner diameter than the restrictive bore 146, and the restrictive bore 146 may have a smaller inner diameter than the central bore 148. In such an implementation, the upper valve body 130 may be disposed within the upper valve housing 122, such that the head portion 136 may be substantially disposed within the bypass bore 144 and the restrictive bore 146, and the base portion 138 may be disposed within the central bore 148. In one or more implementations, a load ring 150 may be disposed at a downhole end portion of the base portion 138. In a further implementation, an impact ring 151 may be disposed between the load ring 150 and the downhole end portion of the base portion 138.

[0039] The spring guide 134 may be a substantially cylindrical tube positioned within the central bore 148 and having a downhole end portion coupled to an inner diameter of the lower valve seat 124. In particular, the downhole end portion of the spring guide 134 may be seated against an inner shoulder 125 of the lower valve seat 124. The inner shoulder 125 may be formed by a change in the inner diameter of the lower valve seat 124. In one or more implementations, an impact ring 153 may be disposed between the downhole end portion of the spring guide 134 and the inner shoulder 125. The spring guide 134 may also have an uphole end portion disposed within a downhole end portion of the load ring 150 or against the downhole end portion of the base portion 138. In another implementation, the spring guide 134 and the upper valve body 130 may be manufactured as one piece. In yet another implementation, the spring guide 134 and the lower valve seat 124 may be manufactured as one piece.

[0040] The upper biasing mechanism 132 may bias the upper valve body 130 in an uphole direction 103. The upper biasing mechanism 132 may be a coiled spring, a Belleville washer spring, or any other biasing device known to those skilled in the art. In one or more implementations, the upper biasing mechanism 132 may be disposed around the spring guide 134 within the central bore 148, where the upper biasing mechanism 132 may be positioned between an uphole end portion of the lower valve seat 124 and the downhole end portion of the base portion 138. In another implementation, a load ring 156 may be disposed between the upper biasing mechanism 132 and the uphole end portion of the lower valve seat 124. In yet another implementation, the upper biasing mechanism 132 may be positioned against the downhole end portion of the load ring 150 disposed on the downhole end portion of the base portion 138.

[0041] The lower valve assembly 160 may be positioned within the upper valve cylinder 106 and the lower valve cylinder 108. The lower valve assembly 160 may include a lower valve body 161 and a lower biasing mechanism 164. The lower biasing mechanism 164 may bias the lower valve body 161 in the uphole direction

103. The lower biasing mechanism 164 may be a coiled spring, a Belleville washer spring, or any other biasing mechanism known to those skilled in the art.

[0042] The lower valve body 161 may include an impact section 166 extending radially from an outer diameter of the lower valve body 161. The impact section 166 may be formed by a portion of the lower valve body 161 having a greater outer diameter than the rest of the lower valve body 161. The lower biasing mechanism 164 may bias the lower valve body 161 in such a manner that an uphole side portion of the impact section 166 may be seated against a shoulder formed by a downhole end portion of the upper valve cylinder 106.

[0043] The lower biasing mechanism 164 may be disposed around the lower valve body 161. In one or more implementations, the lower biasing mechanism 164 may be positioned between a downhole side portion of the impact section 166 and a bottom shoulder 167 formed by a change in an inner diameter of the lower valve cylinder 108. In a further implementation, a load ring 168 may be disposed between the lower biasing mechanism 164 and the bottom shoulder 167.

[0044] An uphole end portion of the lower valve body 161 may include an overlap section 162. In one or more implementations, the lower biasing mechanism 164 may bias the lower valve body 161 in the uphole direction 103 such that the downhole end portion of the lower valve seat 124 may be inserted into the overlap section 162. A lower valve restriction 163 may be formed between an outer diameter of this downhole end portion of the lower valve seat 124 and an inner diameter of the overlap section 162. An extent to which the lower valve seat 124 is inserted into the overlap section 162 (*i.e.*, a length of the lower valve restriction 163) may be referred to as an overlap length. In one or more implementations, and as described further hereinafter, the fluid flow may be substantially restricted from flowing through the lower valve restriction 163 from the bore of the upper valve cylinder 106. In another implementation, a portion of the fluid flow may leak into a bore of the lower valve body 161 from the bore of the upper valve cylinder 106 via the lower valve restriction 163.

[0045] As further described hereinafter, the upper valve assembly 120 may transition between an “open” state and a “closed” state. Figure 3 illustrates a close up cross-sectional view of a pressure pulse generating tool 100 in accordance with implementations of various techniques disclosed herein, where the upper valve assembly 120 may be in the “open” state. In such implementation, the upper biasing mechanism 132 (Figure 1) may bias the upper valve assembly 120 into the “open” state. As illustrated, the head portion 136 may be positioned such that its flow ports 140 are at least partially disposed in the bypass bore 144. In addition, an uphole side portion of the base portion 138 may engage with a valve shoulder 152 of the upper valve housing 122, either by being directly seated against the valve shoulder 152 or via an impact ring 154 disposed between. The valve shoulder 152 may be disposed within the central bore 148 and may be formed by a downhole end portion of the restrictive bore 146.

[0046] Initially, as illustrated in Figures 1 and 3, the fluid flow may pass from the bore of the upper sub 104 to the fluid diverter 114. The bypass bore 144 may receive the fluid flow from the fluid diverter 114, and the fluid flow may then pass through a restriction 155 formed by an outer diameter of the head portion 136 and the inner diameter of the bypass bore 144. With the upper valve assembly 120 in the “open” state, the fluid flow may pass from the restriction 155 and into the flow ports 140. The fluid flow may then pass into the bore of the inner valve body 130, through the spring guide 134, through the bore of the lower valve seat 124, and then through a bore of the lower valve body 161.

[0047] When the upper valve assembly 120 is in the “closed” state, a spring force of the upper biasing mechanism 132 may be overcome, and the upper valve body 130 may be positioned farther downhole than when in its “open” state. In particular, the head portion 136 may be positioned such that its flow ports 140 may be substantially covered by the inner diameter of the upper valve housing 122 proximate its restrictive bore 146. In one or more implementations, the upper valve body 130 may be positioned downhole such that its downhole end portion is seated against the uphole end portion of the spring guide 134. In another implementation, the upper valve body 130 may be positioned downhole such that an internal seat of the load ring 150 may be seated against the uphole end portion of the spring guide 134.

[0048] In the “closed” state, the bypass bore 144 may receive the fluid flow from the fluid diverter 114, and the fluid flow may pass through the restriction 155. However, due to the flow ports 140 being substantially covered by the inner diameter of the upper valve housing 122 proximate its restrictive bore 146, the fluid flow may be substantially unable to pass into the flow ports 140 from the restriction 155. In one or more implementations, the fluid flow may be diverted elsewhere in the tool 100, as disclosed hereinafter. In another implementation, a portion of the fluid flow may leak into the flow ports 140 from the restriction 155. In a further implementation, the fluid flow may be non-existent.

[0049] With the upper valve assembly 120 in its “closed” state, the fluid flow may be diverted into one or more passageways within an annulus 190 (illustrated in Figures 1 and 8) defined by an inner diameter of the upper valve cylinder 106 and an outer diameter of the upper valve assembly 120. In one or more implementations, the upper valve housing 122 may include a plurality of splines 170 (see Figure 4) extending radially from an outer surface of the upper valve housing 122. In such an implementation illustrated in Figure 4, one or more channels 172 allowing for passage of fluid flow may be formed between the splines 170. In another implementation, the fluid diverter 114 (Figure 1) may be configured to divert the fluid flow from the bore of the top sub 104 to the channels 172 within the annulus 190.

[0050] For example, Figure 4 illustrates a perspective view and Figure 5 illustrates a cross-sectional top view of the upper valve housing 122 in accordance with implementations of various techniques disclosed herein. As shown, the splines 170 may be positioned proximate to the uphole end portion of the upper valve housing 122, and may have an outer diameter which decreases in a downhole direction 101. The retaining shoulder 126 may be disposed on the splines 170.

[0051] In one or more implementations, an outer diameter of the splines 170 may engage with the inner diameter of the upper valve cylinder 106 such that the upper valve assembly 120 may be centralized within the upper valve cylinder 106. In such an implementation, the splines 170 may be distributed equidistantly along the outer surface of the upper valve housing 122.

[0052] Similarly, in one or more implementations, the lower valve seat 124 may include a plurality splines 180 extending radially from an outer surface of the lower valve seat 124. For example, Figure 6 illustrates a perspective view of the lower valve seat 124 in accordance with implementations of various techniques disclosed herein. As shown, the splines 180 may be positioned proximate to the downhole end portion of lower valve seat 124. The splines 180 may also be used to centralize the upper valve assembly 120 within the upper valve cylinder 106. The retaining shoulder 128 may be disposed on the splines 180. One or more channels 182, allowing for passage of fluid flow, may be formed between the splines 180.

[0053] Accordingly, with the upper valve assembly 120 in its “closed” state, the fluid flow may be diverted within the annulus 190 through the channels 172 and then through the channels 182. In one or more implementations, the channels 172 may be aligned with the channels 182.

Pressure Pulse Generating Tool in Operation

[0054] An operation of the pressure pulse generating tool 100 will now be described with respect to Figures 7 through 10 in accordance with one or more implementations described herein.

[0055] Figure 7 illustrates a cross-sectional view of the pressure pulse generating tool 100 in accordance with implementations of various techniques disclosed herein. As illustrated, the upper valve assembly 120 may initially be in its “open” state. In particular, the upper biasing mechanism 132 may bias the upper valve body 130 in the uphole direction 103, such that its flow ports 140 are at least partially disposed in the bypass bore 144. In addition, the lower biasing mechanism 164 may bias the lower valve body 161 in the uphole direction 103 such that the downhole end portion of the lower valve seat 124 may be inserted into the overlap section 162, forming the lower valve restriction 163.

[0056] With the upper valve assembly 120 in its “open” state, a fluid flow 200 may pass from the bore of the top sub 104 to the bore of the lower valve body 161, as described above. In particular, the fluid flow 200 may travel through the bypass bore 144, through the restriction 155, and into the flow ports 140. In the “open state”, the fluid flow 200 may have a flow rate less than a predetermined threshold flow rate.

[0057] Figure 8 illustrates the upper valve assembly 120 in its “closed” state in accordance with implementations of various techniques disclosed herein. To bring about this “closed state”, a fluid flow 300 may pass from the bore of the top sub 104 to the bypass bore 144 at a flow rate greater than or equal to the predetermined threshold flow rate. With the flow rate greater than or equal to the predetermined threshold flow rate, a fluid pressure differential across the upper valve body 130 may increase, producing a pressure force from the fluid flow 300. This pressure force may act against the upper valve body 130 in the downhole direction 101, such that the pressure force may overcome the upper biasing mechanism 132 and move the upper valve body 130 in the downhole direction 101. In one or more implementations, the fluid pressure differential may be at least partly produced due to a size of the restriction 155.

[0058] The upper valve body 130 may move until the downhole end portion of its base portion 138 or the internal seat of the load ring 150 may be seated against the uphole end portion of the spring guide 134. Once moved downhole, the flow ports 140 may be substantially covered by the inner diameter of the upper valve housing 122 proximate restrictive bore 146. As such, the fluid flow 300 may be substantially unable to pass through the flow ports 140 from the restriction 155. However, a portion of the fluid flow may leak into the flow ports 140 from the restriction 155.

[0059] The predetermined threshold flow rate may be defined as a flow rate needed or sufficient to move the upper valve body 130 such that its flow ports 140 may be substantially covered by the inner diameter of the upper valve housing 122 proximate restrictive bore 146. In one or more implementations, the predetermined threshold flow rate may be altered based on the extent or strength of a bias of the upper biasing mechanism 132.

[0060] The fluid flow 300 may lack a fluid path from the bypass bore 144 to the bore of the lower valve body 161, *e.g.*, due to the covering of flow ports 140. As described above, the fluid flow 300 may then instead pass from the fluid diverter 114 to the channels 172 formed by the splines 170, and then pass through the channels 182 formed by the splines 180. This fluid flow 300 may then travel to the bore of the upper valve cylinder 106 proximate to the lower valve body 161.

[0061] The fluid flow 300 may deadhead against the overlap section 162 surrounding the downhole end portion of the lower valve seat 124, as this fluid flow 300 may be substantially restricted from passing through the lower valve restriction 163 (Figure 1). In one or more implementations, however, a portion of the fluid flow 300 may leak into the bore of the lower valve body 161 via the lower valve restriction 163.

[0062] As the fluid flow 300 deadheads, this fluid flow 300 may produce a fluid pressure which begins to act against the lower valve body 161. In particular, a fluid pressure may increase through the channels 172 and 182 and the bore of the upper valve cylinder 106 proximate to the lower valve body 161, which may lead to an increase in a pressure force acting on the overlap section 162.

[0063] As shown in Figure 9, the increase in the pressure force acting on the overlap section 162 and the momentum of the fluid flow 300 may overcome the lower biasing mechanism 164 and move the lower valve body 161 in the downhole direction 101. As the lower valve body 161 moves downhole, the lower valve restriction 163 may be maintained between the outer diameter of the downhole end portion of the lower valve seat 124 and the inner diameter of the overlap section 162. However, the extent of the overlap length may decrease as the lower valve body 161 moves downhole. In one or more implementations, once the lower valve body 161 begins to move downhole, the lower valve body 161 may accelerate in the downhole direction 101 as long as the lower valve restriction 163 is maintained, *i.e.*, over the entire distance of the overlap length.

[0064] As shown in Figure 10, a momentum of the lower valve body 161 and the pressure force acting against the overlap section 162 may continue to move the lower valve body 161 in the downhole direction 101. As a result, the lower valve body 161 may separate from the lower valve seat 124, opening the lower valve restriction 163. The fluid flow 300 may then be allowed to pass from the bore of the upper valve cylinder 106 proximate to the lower valve body 161 to the bore of the lower valve body 161. As such, a substantial amount of the fluid flow 300 may pass from the bore of the upper sub 104, through the fluid diverter 114, through the channels 172 and 182, and to the bore of the lower valve body 161.

[0065] As the fluid flow 300 passes through the bore of the lower valve body 161, the fluid pressure differential across the upper valve body 130 may then decrease, leading to a decrease in the pressure force acting on the upper valve body 130. In turn, the upper biasing mechanism 132 may overcome the pressure force acting on the upper valve body 130 and bias the upper valve assembly 120 back to its “open” state. With the upper valve assembly 120 in its “open” state, the flow ports 140 may again allow the fluid flow 300 to pass from the bypass bore 144 to the bore of the upper valve body 130. As illustrated in Figure 10, the fluid flow 300 may pass through the flow ports 140 and also through the channels 172 and 182 to reach the bore of the lower valve body 161. In one or more implementations, the upper biasing mechanism 132 may overcome the pressure force acting on the upper valve body 130 if the lower valve body 161 separates from the upper valve assembly 120 by a predetermined clearance.

[0066] Further, as the fluid pressure decreases in the channels 172 and 182 and the bore of the upper valve cylinder 106 proximate to the lower valve body 161, the lower biasing mechanism 164 may overcome the pressure force acting on the lower valve body 161. The downhole movement of the lower valve body 161 may decrease or may have decreased until it reaches a zero velocity point, at which point the lower biasing mechanism 164 may cause the lower valve body's velocity to reach zero. At that point, the lower biasing mechanism 164 may begin to move the lower valve body 161 in the uphole direction 103. In particular, the lower biasing mechanism 164 may again bias the lower valve body 161 in the uphole direction 103 such that the downhole end portion of the lower valve seat 124 may again be inserted into the overlap section 162, re-creating the lower valve restriction 163. In one or more implementations, and as shown in Figure 10, the upper valve assembly 120 may return to the "open" state before the lower biasing mechanism 164 biases the lower valve body 161 into re-creating the lower valve restriction 163.

[0067] In one or more implementations, as long as the flow rate of the fluid flow 300 may be greater than or equal to the predetermined threshold flow rate, the upper valve assembly 120 may continue to oscillate between its "open" state and its "closed" state, as described with respect to Figures 7 through 10. As a result, a fluid pressure in the pressure pulse generating tool 100 may cyclically increase and decrease, particularly as described with respect to the channels 172 and 182 and the bore of the upper valve cylinder 106 proximate to the lower valve body 161 in Figures 9 through 10.

[0068] This cyclical increase and decrease in fluid pressure may produce pressure pulses which travel through the upper sub 104, where these pressure pulses may be used by other drilling tools, as described hereinafter. In one or more implementations, the pressure pulse generating tool 100 may generate pressure pulses at a rate of about 5-25 hertz (Hz), at a rate of about 10-20 Hz or at a rate of about 15 Hz. In effect, the application of the fluid flow 300 at a flow rate greater than or equal to the predetermined threshold flow rate “activates” the tool 100 by transitioning the upper valve assembly 120 to its “closed” state.

[0069] In another implementation, the oscillation of the upper valve body 130 may result in an impact against the impact ring 154, the impact ring 151, the load ring 150, and/or the uphole end portion of the spring guide 134 (see Figures 1 and 3). This impact may produce an axial stress throughout the upper valve body 130, resulting in fatigue and/or failure in the upper valve body 130. In such an implementation, the placement of the one or more stress grooves 142 (see Figures 1-2) on the outer diameter of the upper valve body 130 may help to mitigate the effects of the axial stress. In particular, the stress grooves 142 may more widely distribute the axial stress throughout the upper valve body 130, specifically in areas proximate to the fluid ports 140. In such an implementation, the stress grooves may reduce the axial stress on the upper valve body 130 by about 1% to about 15%, about 3% to 10% or about 5% to about 7%.

[0070] In yet another implementation, the fluid flow may continuously pass into the bore of the lower valve body 161 when the upper valve assembly 120 may be in either the “open” state or the “closed” state. For example, when the upper valve assembly 120 is in the “open” state, as described with respect to Figures 1 and 7, the fluid flow may pass from the bore of the top sub 104 to the bore of the lower valve body 161. In addition, as stated previously with respect to Figures 1 and 8, when the upper valve assembly 120 is in its “closed” state, a portion of the fluid flow may leak into the flow ports 140 from the restriction 155 and ultimately travel to the bore of the lower valve body 161, and/or a portion of the fluid flow may leak into the bore of the lower valve body 161 via the lower valve restriction 163. This continuous passage of at least a portion of the fluid flow into the bore of the lower valve body 161 may help to produce an output of pressure pulses that is sinusoidal in nature.

[0071] In addition, varying the overlap length of the lower valve restriction 163 may help to determine a frequency and magnitude of the pressure pulses. For example, decreasing the overlap length may allow the lower valve body 161 to separate from the lower valve seat 124 in a shorter amount of time. In turn, the cyclical increase and decrease in fluid pressure may occur more frequently, thereby increasing the frequency of the pressure pulses. In another example, increasing the overlap length may cause the lower valve body 161 to separate from the lower valve seat 124 in a longer amount of time. In turn, the fluid pressure may increase in the pressure pulse generating tool 100 over the longer amount of time, thereby increasing the magnitude of the pressure pulses.

[0072] The cyclic increase and decrease in fluid pressure may also result in an oscillation of the lower valve body 161 within the pressure pulse generating tool 100, as described with respect to Figures 7 through 10. Such oscillation may cause an impact between the impact section 166 and the downhole end portion of the upper valve cylinder 106. In one or more implementations, this impact may cause an axial vibration which oscillates the drill string and reduces friction.

Pressure Pulse Generating Tool Configurations

[0073] In some implementations of the pressure pulse generating tool, various configurations of an upper valve assembly may be used. Returning to Figure 1, in one or more implementations, when the upper valve assembly 120 is in the “closed” state, the head portion 136 of the upper valve body 130 may form a metal-to-metal seal with restrictive bore 146 of the upper valve housing 122. In such an implementation, a portion of the fluid flow may not leak into the flow ports 140 from the restriction 155.

[0074] In another implementation, a nozzle (not shown) may be placed within an inner diameter of the upper valve body 130, allowing for higher flow rates to be used for the predetermined threshold flow rate. In yet another implementation, the upper valve body 130 may be composed of an elastomeric material. The upper valve assembly 120 may also be configured to be retrievable via shear pins or the like.

[0075] In a further implementation, as illustrated in Figures 11 and 12, the upper valve body 130 (Figure 1) may be positioned outside of the upper valve housing 122 (Figure 1) and in an external cylinder, *e.g.*, a top sub. Figures 11 and 12 illustrate cross-sectional views of a pressure pulse generating tool 1100 in accordance with implementations of various techniques disclosed herein. Similar to the tool 100 described previously, the pressure pulse generating tool 1100 may include an upper valve assembly 1120 (which includes the fluid diverter 1114, the upper valve housing 1122 and the lower valve seat 1124) and a lower valve assembly 1160.

[0076] The upper valve assembly 1120 may also include an upper valve body 1130, positioned within the top sub 1104, with its base portion 1138 located uphole relative to its head portion 1136. Similarly, the base portion 1138 may have a greater outer diameter than the head portion 1136. An upper biasing mechanism 1132 may be disposed within a bore of the top sub 1104 and may bias the upper valve body 1130 in the uphole direction 1103. In particular, the upper valve assembly 1120 may be biased into an "open" state, where one or more ports 1140 in the head portion 1136 may allow a fluid flow to pass through to the bypass bore 1144. From the bypass bore 1144, the fluid flow may pass through to the lower valve assembly 1160.

[0077] The ports 1140 may be located proximate to an opening or aperture for the bypass bore 1144 and may be disposed within the fluid diverter 1114. Upon the fluid flow reaching a flow rate that is greater than or equal to a predetermined flow rate, a pressure force acting on upper valve body 1130 may overcome the upper biasing mechanism 1132 and move the upper valve body 1130 in the downhole direction 1101, as shown in Figure 12.

[0078] When moved in the downhole direction 1101, a downhole end portion of the head portion 1136 may be inserted into the bypass bore 1144 and may form a restriction with the inner diameter of the upper valve housing 1122 proximate bypass bore 1144. At this position, the upper valve assembly 1120 may be in its "closed" state. Accordingly, the fluid flow may be diverted through the channels 1172 and

1182 as similarly described previously with respect to Figures 1 through 10. The tool 1100 may thus cyclically produce pressure pulses similar to the tool 100 disclosed herein. Due to its placement in the top sub 1104, the upper biasing mechanism 1132 may have a greater outer diameter than the upper biasing mechanism 132 of the tool 100.

[0079] Returning to Figure 1, in another implementation, the lower valve assembly 160 may be assembled in the pressure pulse generating tool 100 without the upper valve assembly 120. In order to operate the tool 100, the upper valve assembly 120 may be pumped down to activate the tool.

[0080] In yet another implementation, a pressure pulse generating tool may be similar to that of the tool 100, with the exception of the shape of the upper valve body 130. In such an implementation, the upper valve assembly 120 may have an upper valve body 130 that does not include a head section 136. Instead, an open area (not shown) of the upper valve body 130 may protrude into a bypass bore 144 of the upper valve housing 122. In order to close the open area, and thus increase a fluid pressure differential across the upper valve body 130, a dart or ball may be delivered downhole and configured to form a seal against the open area. At this point, the tool may operate in a similar manner to that of the tool 100.

[0081] In yet another implementation, the pressure pulse generating tool 100 may be configured such that upper valve assembly 120 may remain in its “closed” state during the operation of tool 100. In particular, after the upper valve assembly 120 initially transitions from its “open” state to its “closed” state, the lower valve body 161 may cyclically separate from the lower valve seat 124 and re-create its lower valve restriction 163 while the upper valve assembly 120 may remain in its “closed” state. In such an implementation, the tool 100 may use one or more latches (not shown) in conjunction with the upper valve assembly 120, one or more nozzle configurations (not shown) throughout the tool 100, or any other configuration known to those skilled in the art to keep the upper valve assembly 120 in its “closed” state during the operation of tool 100.

[0082] In some implementations, various configurations of a lower valve assembly may be used. For example, returning to Figure 1, the mass of the lower valve body 161 may be increased to increase a magnitude of the pressure pulses generated by the tool. The increased mass may also create an increased jarring upon impact of the impact section 166 with the downhole end portion of the upper valve cylinder 106.

[0083] In another implementation, one or more springs may be placed between the downhole end portion of the upper valve cylinder 106 and the uphole side portion of the impact section 166. The lower valve assembly 166 may thus behave as a mass oscillator.

[0084] In yet another implementation, as illustrated in Figures 13 and 14, the pressure pulse generating tool 100 may have a downhole end portion of the lower valve assembly 160 coupled to a structural element of the drill string or tubular, thereby producing a direct movement of the drill string or tubular upon operation of the tool 100. Figures 13 and 14 illustrate cross-sectional views of a pressure pulse generating tool 100 in accordance with implementations of various techniques disclosed herein. As shown, the downhole end portion of the lower valve body 161 may be coupled to a spring mandrel 1310, which may be coupled to a lower portion 1320 of the drill string or tubular.

[0085] As shown in Figure 13, the spring mandrel 1310 and the lower portion 1320 may be positioned at their most uphole positions when the lower valve body 161 forms the lower valve restriction 163 with the lower valve seat 124. Accordingly, the upper valve assembly 120 may be in its “open” state, as previously described. Conversely, as shown in Figure 14, the spring mandrel 1310 and the lower portion 1320 may be positioned at their most downhole positions when the lower valve body 161 separates from the lower valve seat 124. Accordingly, the upper valve assembly 120 may be in its “closed” state, as previously described.

[0086] In another implementation, a magnitude of pressure pulses generated by a pressure pulse generating tool 1500 may be increased through the use of a checked restriction to a lower valve assembly 1560. Figures 15 through 22 illustrate cross-sectional views of a pressure pulse generating tool 1500 in accordance with implementations of various techniques disclosed herein. The pressure pulse generating tool 1500 may be similar to the pressure pulse generating tool 100. However, an impact section 1566 of a lower valve body 1561 may include a detent ring 1567 disposed about the impact section 1566. As shown in Figure 15, the detent ring 1567 makes an initial metal-to-metal seal with a shoulder 1568 disposed on an inner surface of lower valve cylinder 1508. In particular, the shoulder 1568 of lower valve cylinder 1508 may provide a smaller inner bore diameter than the inner bore diameter of other portions of the lower valve cylinder 1508.

[0087] As shown in Figures 15 and 16, with the initial metal-to-metal seal with the shoulder 1568, a fluid flow may be restricted from passing from one side of the impact section 1566 to the other. As long as the detent ring 1567 engages the shoulder 1568, the fluid flow may initially be restricted from flowing across the impact section 1566, even as the lower valve body 1561 may move in a downhole direction 1501. Accordingly, an initial fluid pressure may be higher in a bore of the upper valve cylinder 1506 proximate to the lower valve body 1561 than when compared to the configuration of tool 100. In addition, a lower valve restriction 1563 may be formed between the lower valve body 1561 and the lower valve seat 1524.

[0088] As shown in Figures 17 and 18, the lower valve body 1561 may move downhole such that the detent ring 1567 may no longer engage the shoulder 1568. Accordingly, the fluid flow may no longer be restricted from passing from one side of the impact section 1566 to the other. As shown in Figures 19 and 20, the lower valve body 1561 may move in the uphole direction 1503 while the detent ring 1567 remains disengaged from the shoulder 1568.

[0089] As shown in Figures 21 and 22, as the lower valve body 1561 returns to re-form the lower valve restriction 1563 with the lower valve seat 1524, the detent ring 1567 may again engage the shoulder 1568 and restart the cycle as described in Figures 15 through 22.

[0090] In one or more implementations of the pressure pulse generating tool, various configurations may be used to “activate” the tool, *i.e.*, transitioning an upper valve assembly to its “closed” state. As shown in Figures 23 through 27, rather than moving the upper valve body 130 using a pressure force from a fluid flow with a predetermined threshold flow rate, a drill string axial load may be lowered onto the upper valve body 130 in order to move the upper valve assembly 120 to a “closed” state. Figures 23 through 27 illustrate cross-sectional views of a pressure pulse generating tool 100 with an axial activation section 2300 in accordance with implementations of various techniques disclosed herein. As shown in Figure 23, an axial activation section 2300 may be placed uphole on a drill string relative to the pressure pulse generating tool 100.

[0091] Initially, as shown in Figures 24 through 25, a splined kelly mandrel 2310 may be positioned such that a push rod 2320 may be located downhole from the mandrel 2310. In addition, the push rod 2320 may be positioned proximate to, but away from, the upper valve body 130. As shown in Figure 26, as a force may be applied to the mandrel 2310, the mandrel 2310 may move in a downhole direction 2301. The mandrel 2310 may have a splined section which engages with a splined section of a cylinder which houses the mandrel. Further, the mandrel 2310 may compress a spring stack 2330 as it moves downhole.

[0092] As shown in Figure 27, as the mandrel 2310 travels downhole, the push rod 2320 may be forced to also move downhole. As a result, the push rod 2320 may engage the upper valve body 130, transitioning the upper valve assembly 120 into its “closed” state. In addition, a fluid flow may pass in the downhole direction 2301 from the axial activation section 2300 and may produce a pressure force against the lower valve assembly 160 (not shown). Upon removal of the force from the mandrel 2310, the spring state 2330 may move the mandrel 2310 and the push rod 2320 in an uphole direction 2303.

[0093] In another implementation, as shown in Figures 28 through 32, a torsional activation section 2800 may be placed uphole on a drill string relative to the pressure pulse generating tool 100. Figures 28 through 32 illustrate cross-sectional views of a pressure pulse generating tool 100 with a torsional activation section 2800 in accordance with implementations of various techniques disclosed herein. Similar to the implementation of Figures 23 through 27, as shown in Figures 28 through 30, a threaded kelly mandrel 2810 may be positioned such that a push rod 2820 may be located downhole from the mandrel 2810. In addition, the push rod 2820 may be positioned proximate to, but away from, the upper valve body 130.

[0094] As shown in Figure 30, as torque may be applied to the mandrel 2810, the mandrel 2810 may move in a downhole direction 2801. The mandrel 2810 may have a threaded section which engages with a threaded section of a cylinder which houses the mandrel 2810. Further, the mandrel 2810 may compress a spring stack 2830 as it threadedly moves downhole.

[0095] As shown in Figure 31, as the mandrel 2810 travels downhole, the push rod 2820 may be forced to also move downhole. As a result, the push rod 2820 may engage the upper valve body 130, transitioning the upper valve assembly 120 into its “closed” state. In addition, a fluid flow may pass in the downhole direction 2801 from the torsional activation section 2800 and may produce a pressure force against the lower valve assembly 160 (not shown). Upon removal of the force from the mandrel 2810, the spring state 2830 may move the mandrel 2810 and the push rod 2820 in an uphole direction 2303.

<u>Pressure Pulse Generating Tool Applications</u>

[0096] The pressure pulses generated by various implementations of the pressure pulse generating tool, as described previously with respect to Figures 1 through 31, may be applied to various tools. For example, the pressure pulse generating tool may be coupled with a shock sub. In one or more implementations, the pressure pulse generating tool and the shock sub may be placed in a drill string or other tubular for use in drilling a well, borehole or other subterranean bore. The pressure pulse generating tool and the shock sub may be oriented such that the shock sub is uphole relative to the pressure pulse generating tool. The upper sub of the pressure pulse generating tool may be coupled to a downhole end portion of the shock sub through the use of threads, bolts, welds, or any other coupling known to those skilled in the art.

[0097] As previously stated, the pressure pulses generated by the pressure pulse generating tool may travel through the upper sub. From the upper sub, the pressure pulses may be applied to a pump open area of the shock sub. In turn, the application of the pressure pulses to the pump open area may generate axial force pulses within the shock sub. The axial force pulses produced within the shock sub may cause an axial vibration which oscillates the drill string or other tubular coupled thereto to reduce friction.

[0098] In another implementation, the pressure pulse generating tool may be used without a shock sub in coil tubing applications. In such an implementation, the pressure pulses produced by the pressure pulse generating tool may generate a water hammering effect, such that the pressure pulses may cause an axial vibration which travels up and down a drill string. In turn, the axial vibration may oscillate the drill string or other tubular coupled thereto to reduce friction.

[0099] The pressure pulse tool may generate pressure pulses which vary in amplitude. The variance in amplitude depends on physical dimensions of components of the pressure pulse generating tool. In one or more implementations, the pressure pulse tool may be placed along or coupled within a drill string or other tubular in a vertical, horizontal, or directional orientation.

[00100] While the foregoing is directed to implementations of various techniques disclosed herein, other and further implementations may be devised without departing from the basic scope thereof. Although the subject matter has been described in language specific to structural features and/or methodological acts, it is

to be understood that the subject matter defined in the appended claims is not limited to the specific features or acts described above. Rather, the specific features and acts described above are disclosed as example forms of implementing the claims.

CLAIMS

What Is Claimed Is:

1. A pressure pulse generating tool, comprising:

a housing having a housing bore extending at least partially therethrough;

an upper valve assembly disposed within the housing bore, the upper valve assembly configured to permit fluid to flow through at least a portion of the upper valve assembly when in an open state and to at least partially restrict fluid from flowing through the upper valve assembly when in a closed state, thereby causing an increase in fluid pressure in an annulus within the housing bore; and

a lower valve assembly disposed within the housing bore, the lower valve assembly configured to receive any fluid flowing from the upper valve assembly, the lower valve assembly having at least a portion thereof that moves within the housing bore in response to the increase in fluid pressure in the annulus, thereby causing annular fluid to flow through at least a portion of the lower valve assembly and decreasing the fluid pressure in the annulus.

2. The pressure pulse generating tool of claim 1, wherein the upper valve assembly further comprises an upper valve body and an upper valve housing, at least a portion of the upper valve body configured to move downhole in order to transition the upper valve assembly from the open state to the closed state.

3. The pressure pulse generating tool of claim 2, further comprising at least one flow port disposed in the upper valve body, the at least one flow port configured to permit fluid flow when the upper valve assembly is in the open state.

4. The pressure pulse generating tool of claim 3, wherein, when the upper valve assembly is in the closed state, the at least one flow port is substantially covered by a portion of the upper valve housing thereby restricting fluid flow therethrough.

5. The pressure pulse generating tool of claim 2, further comprising an upper biasing mechanism coupled to upper valve body and biasing the upper valve body in an uphole direction.

6. The pressure pulse generating tool of claim 2, wherein the upper valve body comprises:

a head portion having at least one flow port permitting the fluid to flow from a bore of the upper valve housing to a bore of the upper valve body, the head portion forming a restriction with a portion of the upper valve housing; and

a base portion configured to releasably engage with a spring guide, the spring guide arranged and designed to permit fluid to flow from the bore of the upper valve body to a bore of the lower valve assembly.

7. The pressure pulse generating tool of claim 1, wherein the upper valve assembly is configured to transition from the open state to the closed state when a flow rate of the fluid is greater than or equal to a predetermined flow rate.

8. The pressure pulse generating tool of claim 1, wherein the annulus is defined between an inner diameter of the housing and an outer diameter of the upper valve assembly, the annulus receiving fluid when the upper valve assembly is in the closed state.

9. The pressure pulse generating tool of claim 1, wherein the upper valve assembly further includes a lower valve seat configured to form a lower valve restriction with an uphole end portion of the lower valve assembly.

10. The pressure pulse generating tool of claim 1, wherein the upper valve assembly further includes an upper valve housing defining a plurality of splines at an outer diameter thereof, the plurality of splines defining channels therebetween.

11. The pressure pulse generating tool of claim 1, further comprising a lower valve restriction formed by a portion of the lower valve assembly overlapping a downhole end portion of the upper valve assembly.

12. The pressure pulse generating tool of claim 1, wherein the at least a portion of the lower valve assembly is configured to move relative to the upper valve assembly by a predetermined distance.

13. A pressure pulse generating tool, comprising:

a housing having a housing bore extending at least partially therethrough;

an upper valve assembly disposed within the housing bore and including an upper valve housing and an upper valve body, the upper valve assembly configured to permit a fluid to flow through at least one flow port disposed in the upper valve body when in an open state and configured to restrict the at least one flow port from flowing fluid therethrough when in a closed state, thereby causing an increase in fluid pressure in an annulus defined between the upper valve assembly and the housing; and

a lower valve assembly disposed within the housing bore, the lower valve assembly configured to receive the fluid from the upper valve assembly when the upper valve assembly is in the open state and configured to separate from the upper valve assembly when the upper valve assembly is in the closed state in response to the increase in fluid pressure in the annulus, thereby causing annular fluid to flow through the lower valve assembly and decreasing fluid pressure in the annulus.

14. The pressure pulse generating tool of claim 13, wherein, when the upper valve assembly is in the open state, the fluid flows from a bypass bore of the upper valve housing through the at least one flow port.

15. The pressure pulse generating tool of claim 13, wherein, when the upper valve assembly is in the closed state, the at least one flow port is substantially covered by a portion of the upper valve housing.

16. The pressure pulse generating tool of claim 13, further comprising an upper biasing mechanism coupled to the upper valve body and biasing the upper valve body in an uphole direction to permit the fluid to flow through the at least one flow port.

17. The pressure pulse generating tool of claim 13, wherein the upper valve assembly oscillates between the open state and the closed state when a flow rate of the fluid is greater than or equal to a predetermined flow rate.

18. The pressure pulse generating tool of claim 13, wherein at least a portion of the upper valve body moves downhole in response to fluid pressure, thereby transitioning the upper valve body to the closed state.

19. The pressure pulse generating tool of claim 13, wherein the upper valve assembly diverts the fluid to the annulus when in the closed state.

20. The pressure pulse generating tool of claim 13, wherein the lower valve assembly further includes a lower biasing mechanism coupled to the lower valve assembly and biasing the lower valve assembly into a lower valve restriction with the upper valve assembly.

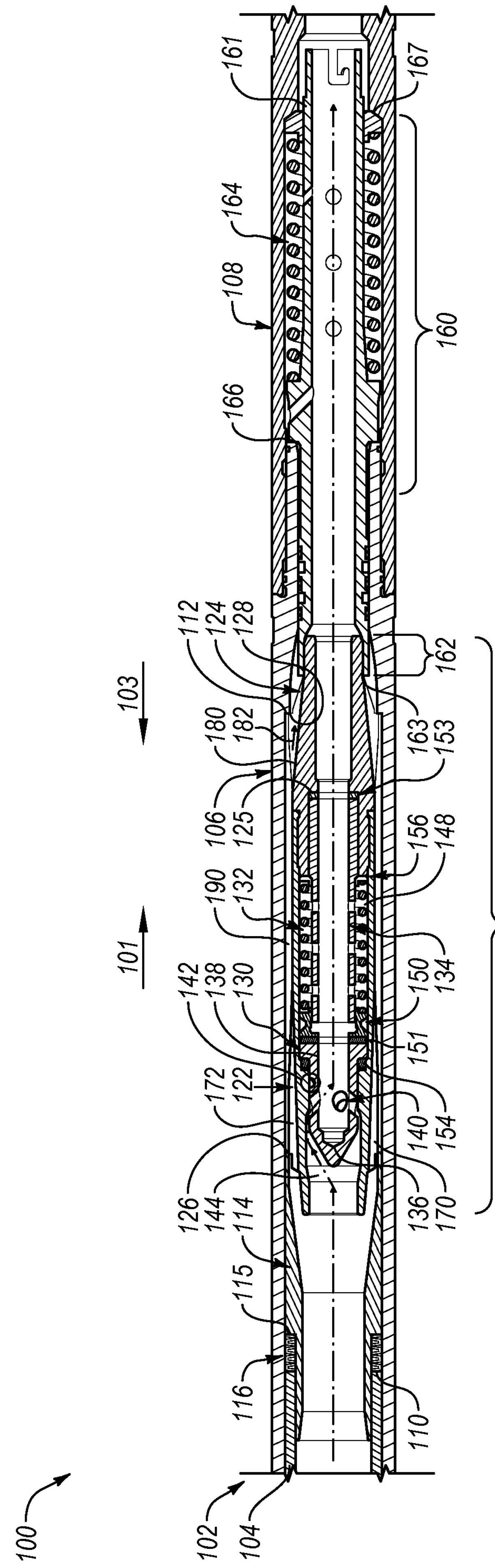
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FIG. 1

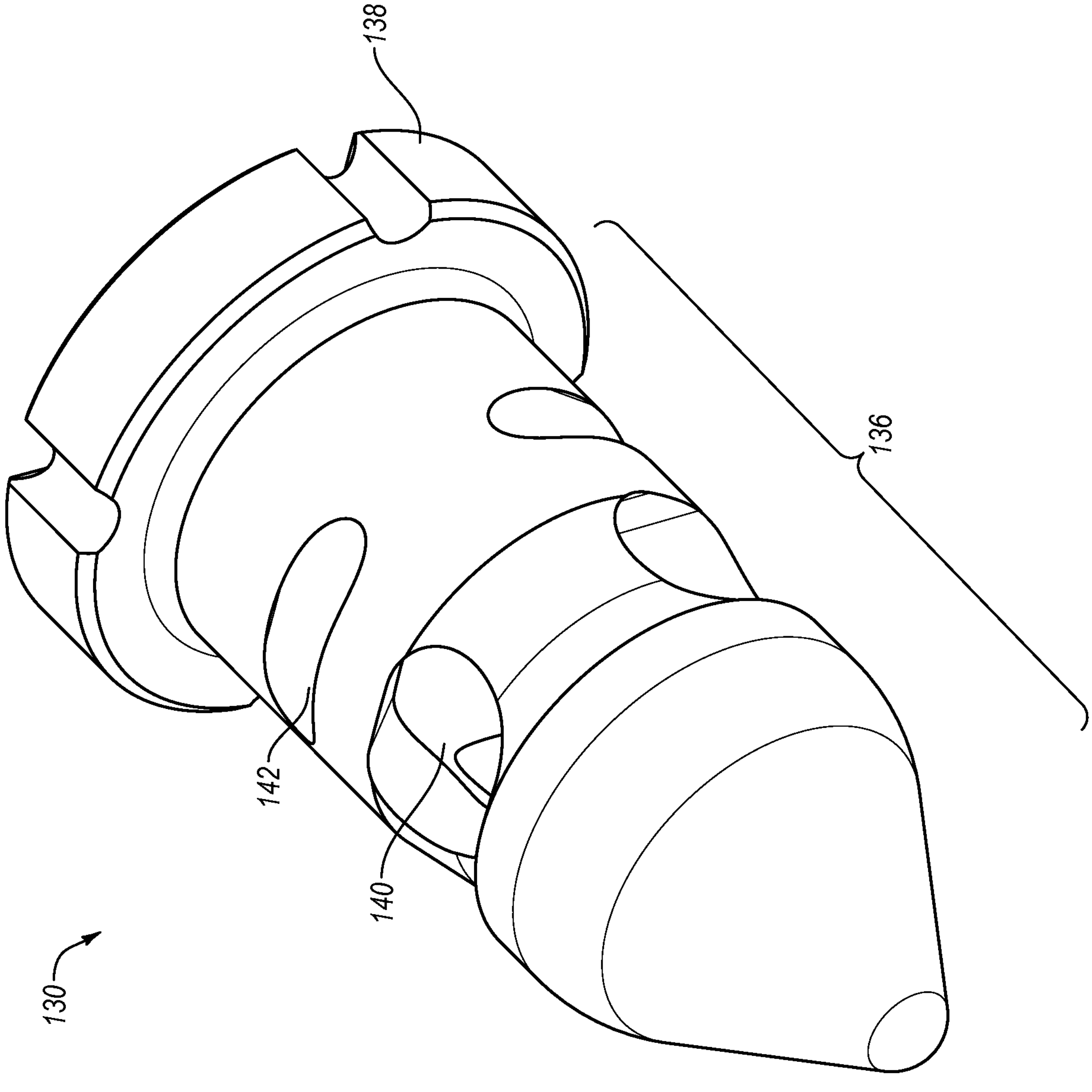

FIG. 2

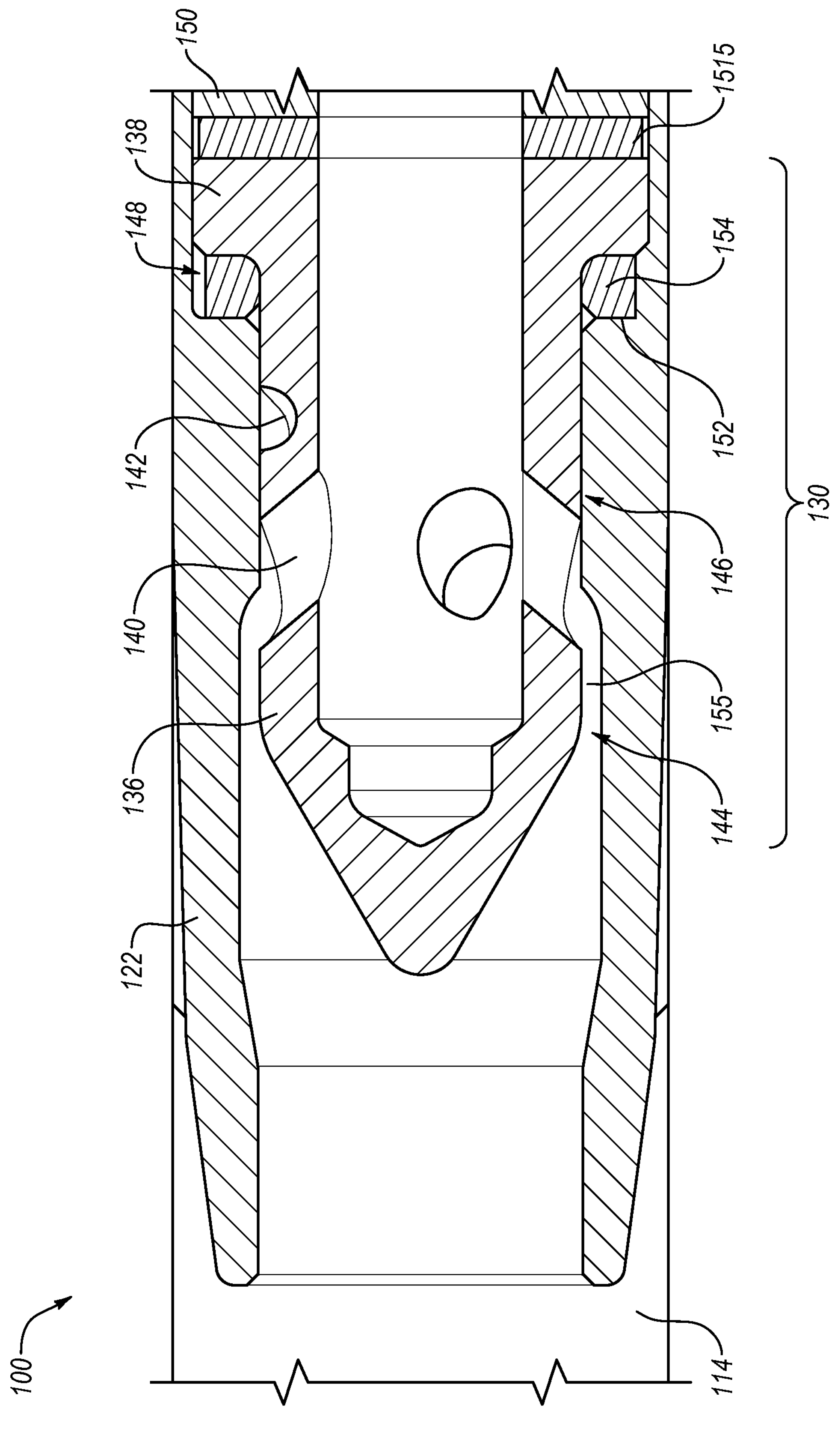

FIG. 3

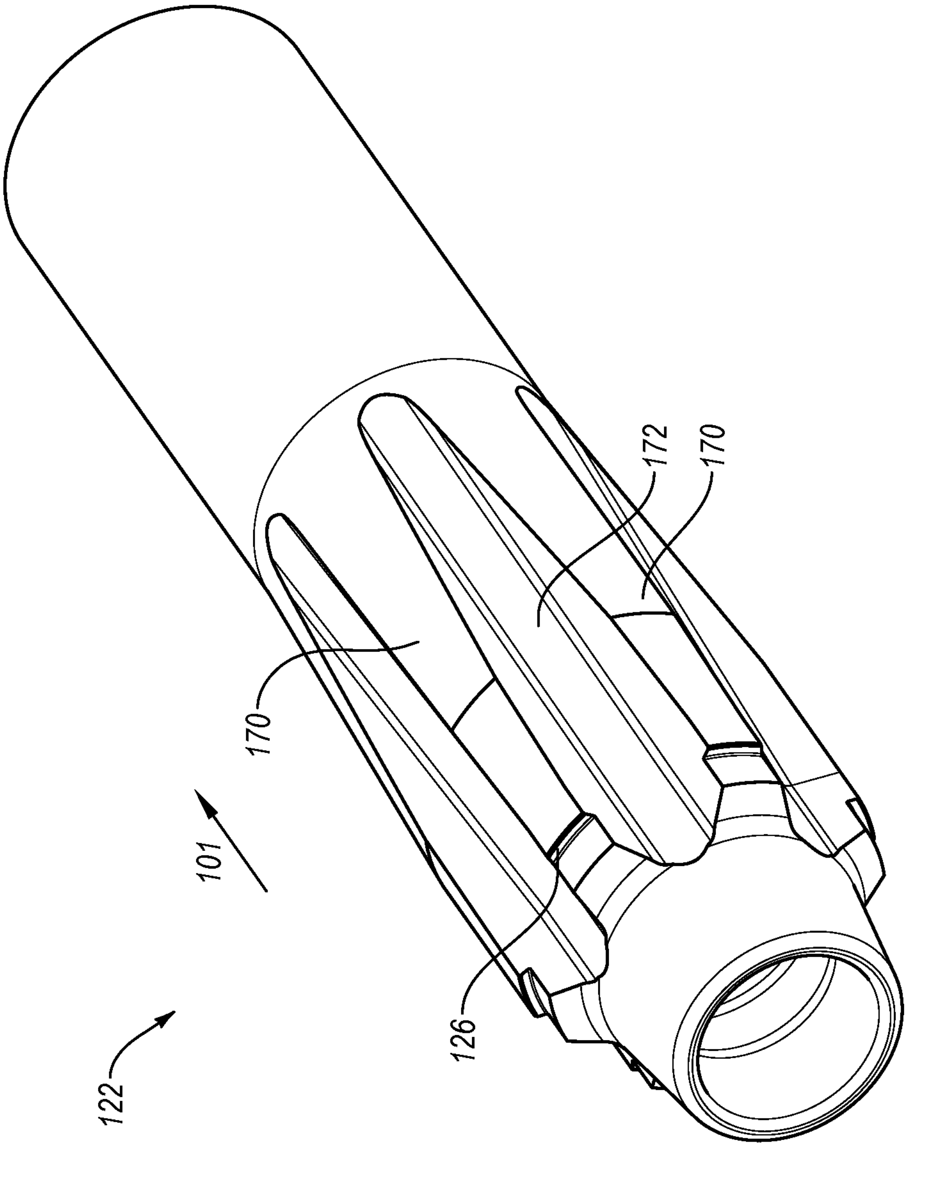

FIG. 4

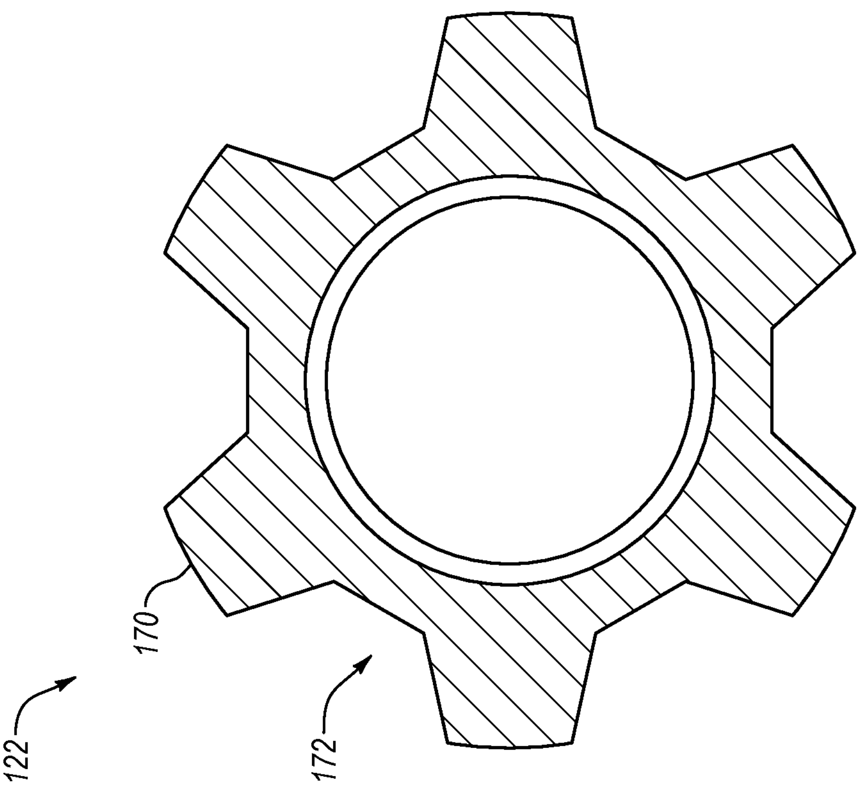

FIG. 5

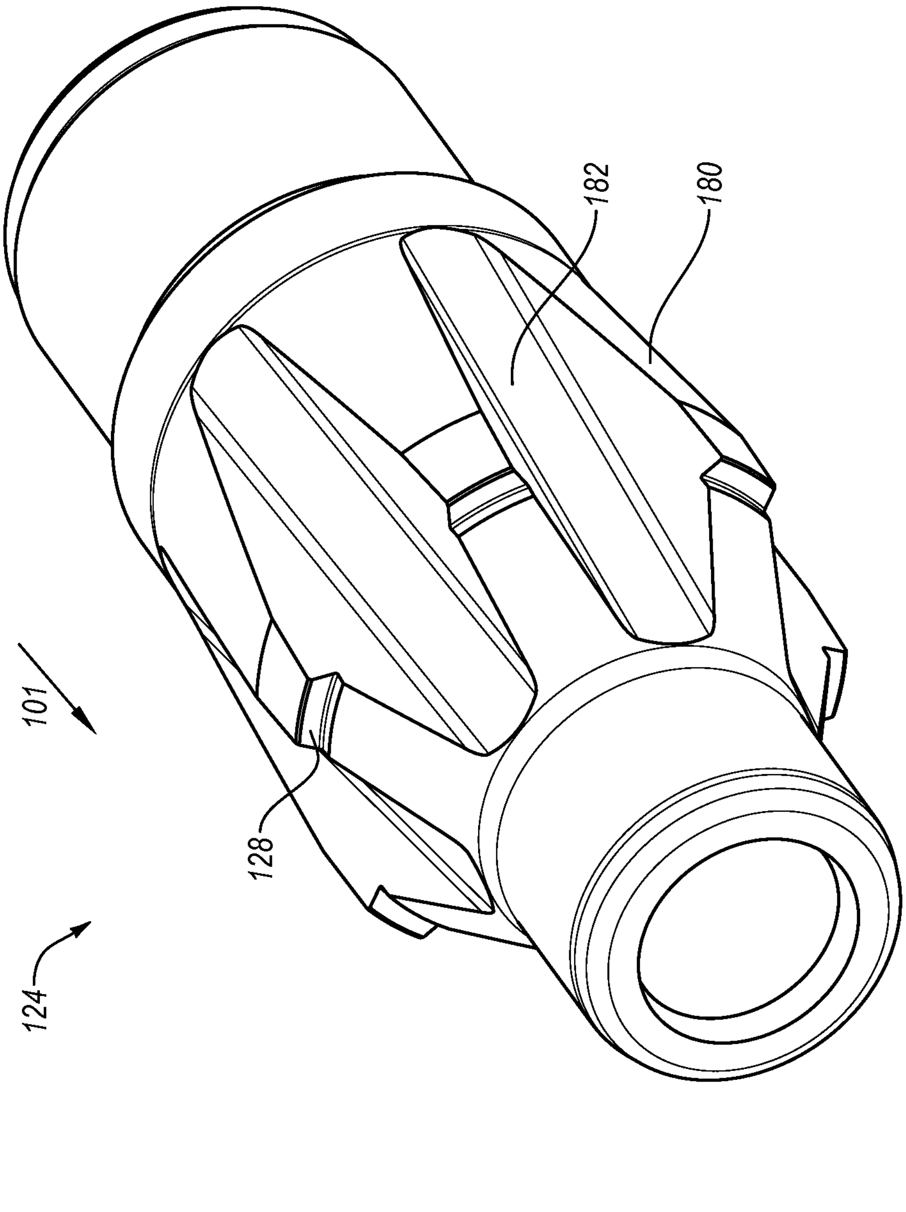

FIG. 6

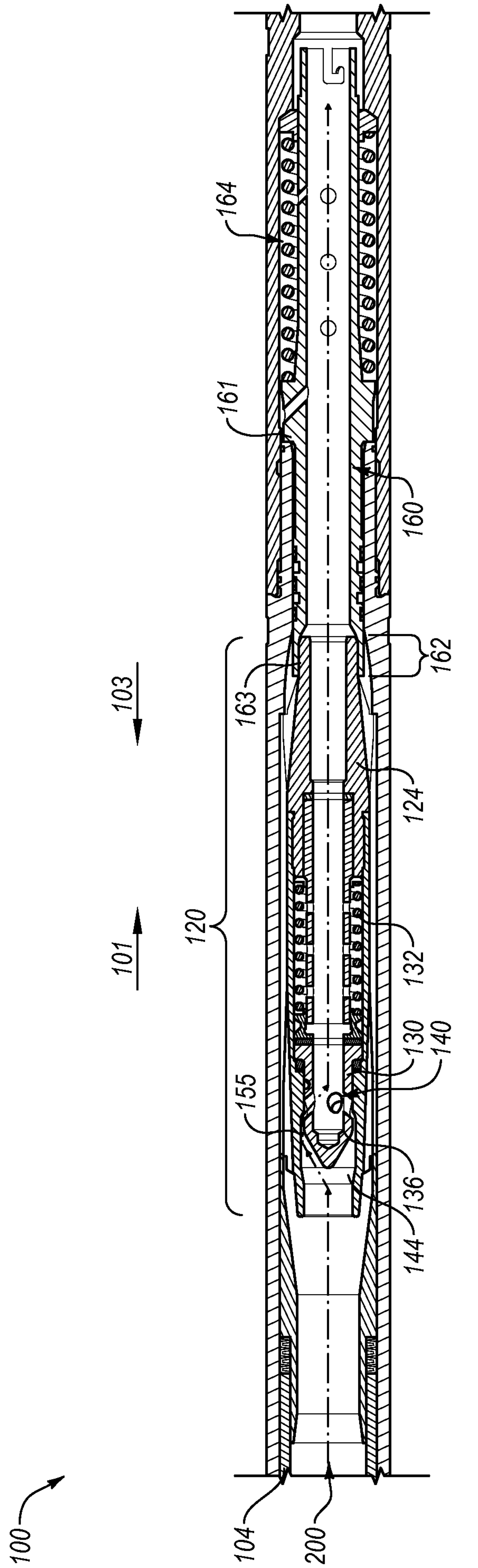
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FIG. 7

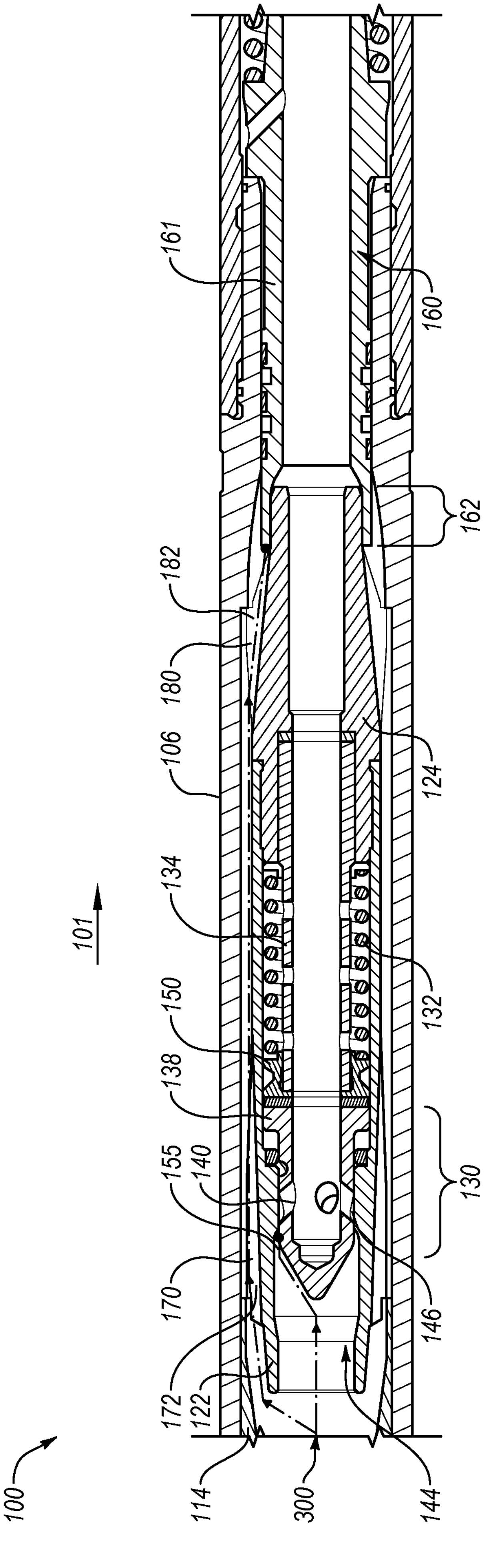
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FIG. 8

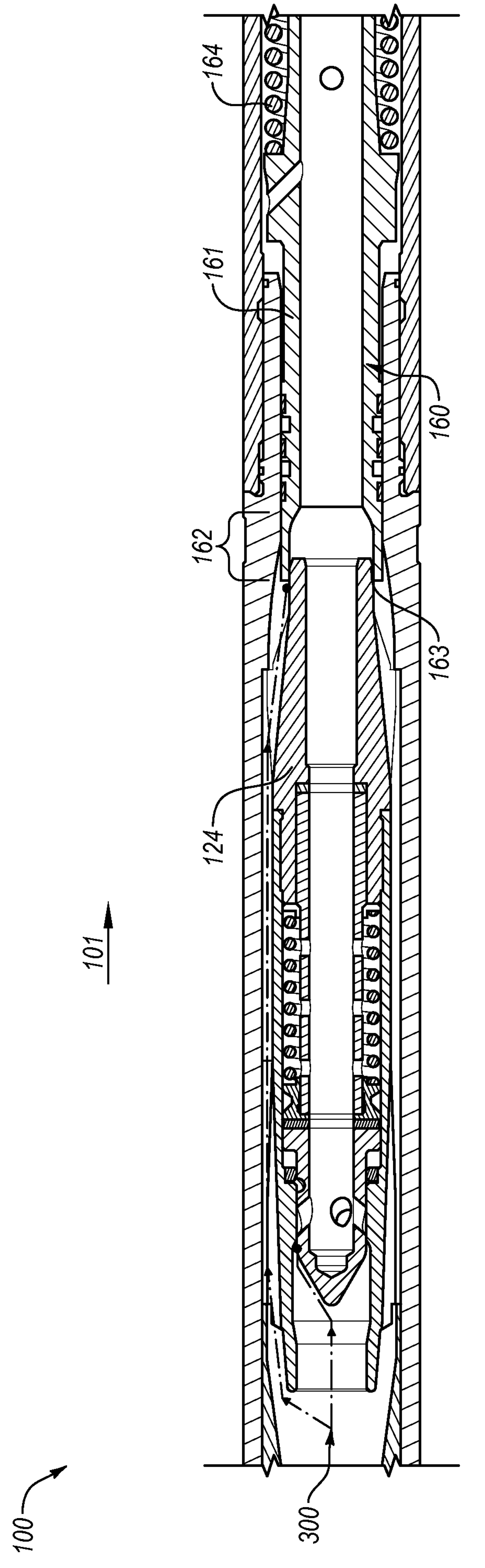

FIG. 9

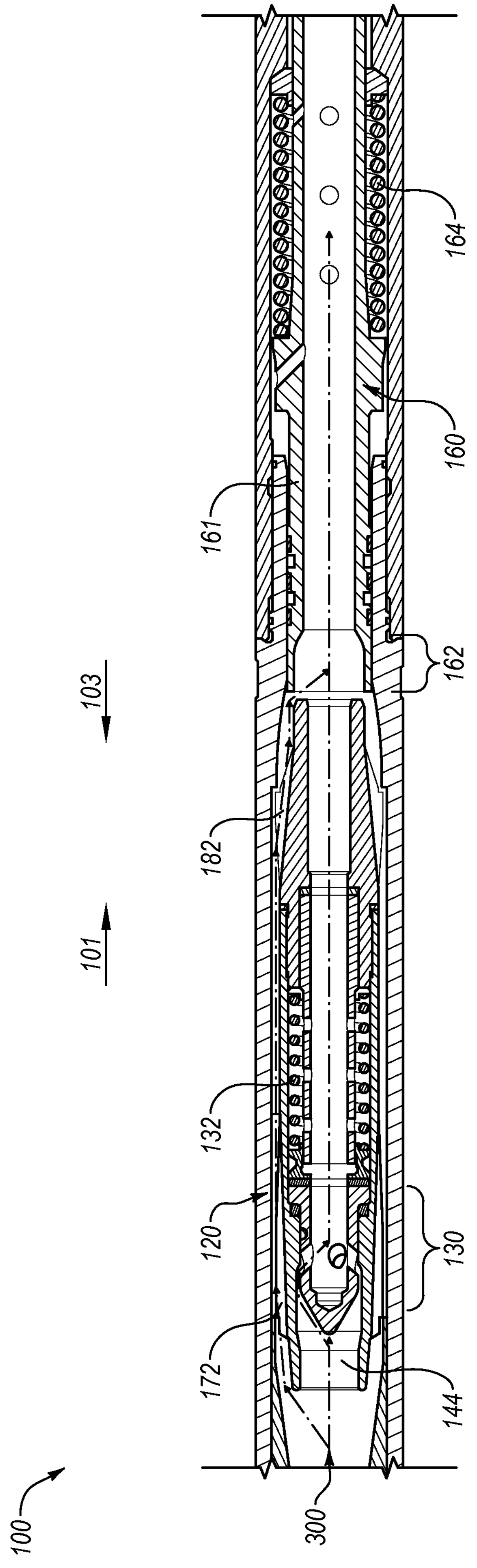

FIG. 10

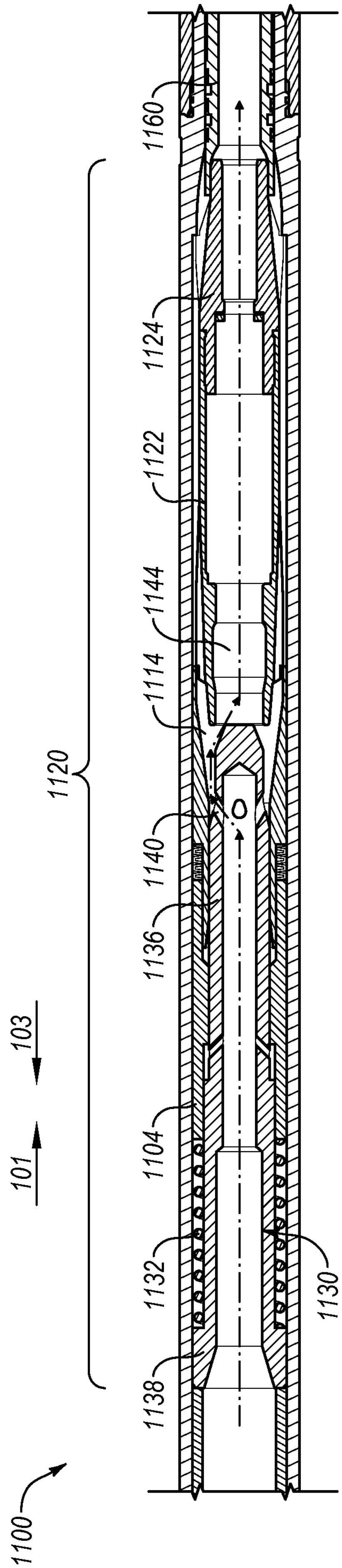
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FIG. 11

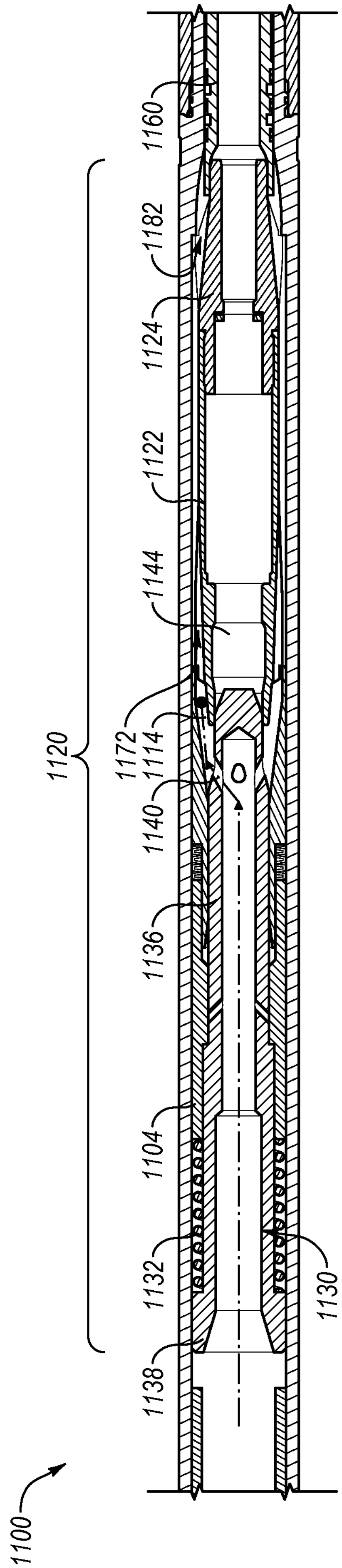
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FIG. 12

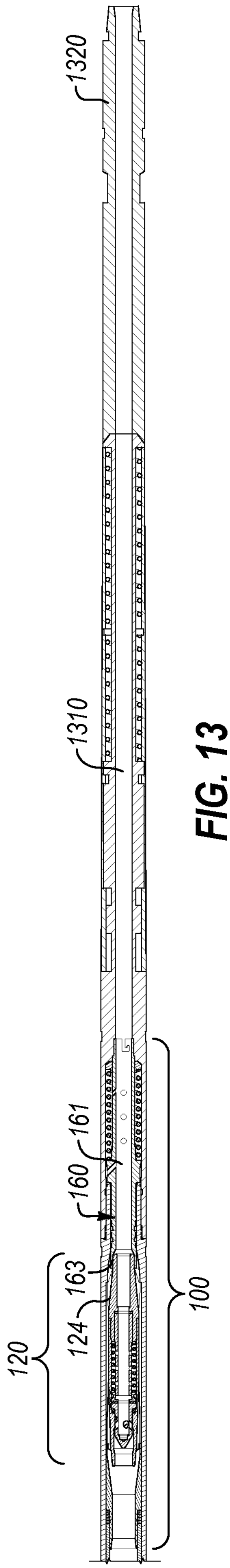

FIG. 13

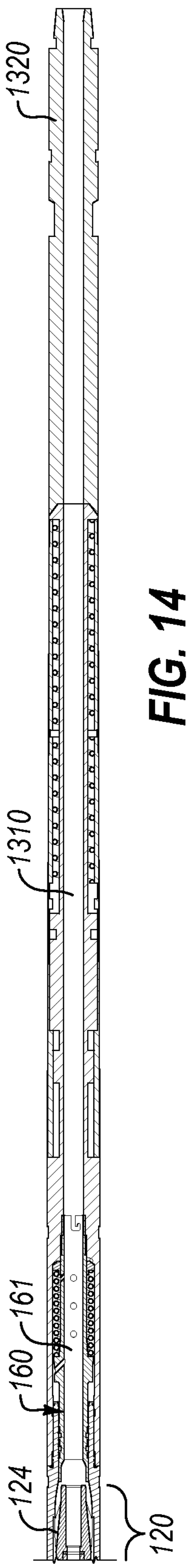

FIG. 14

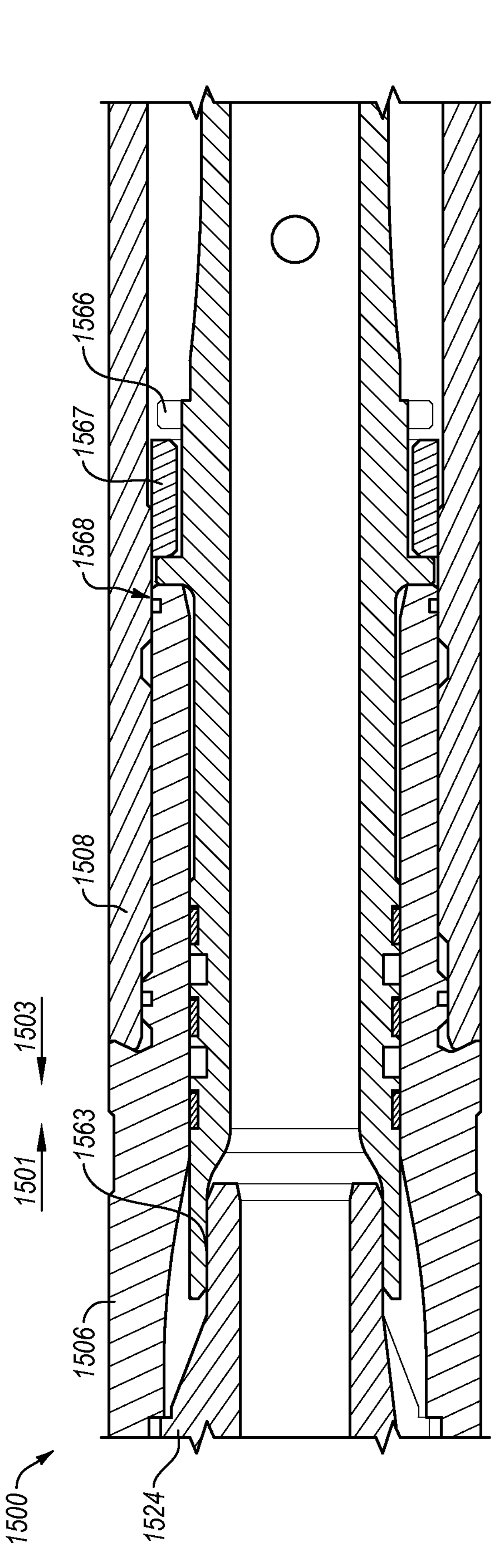
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FIG. 15

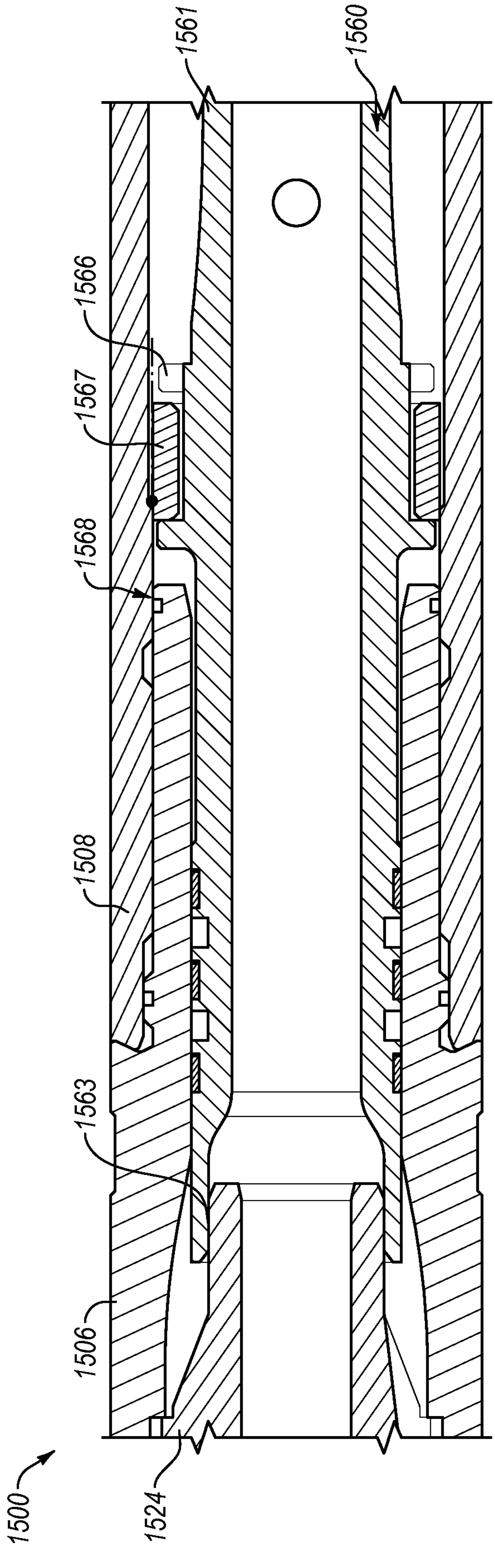
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FIG. 16

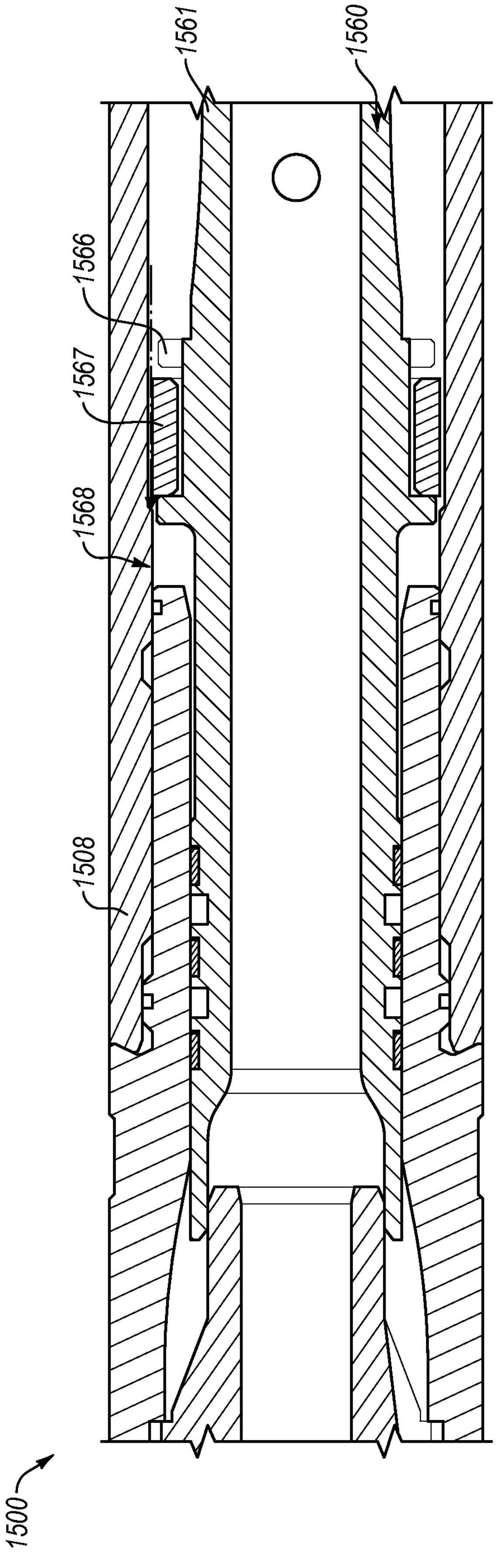
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FIG. 17

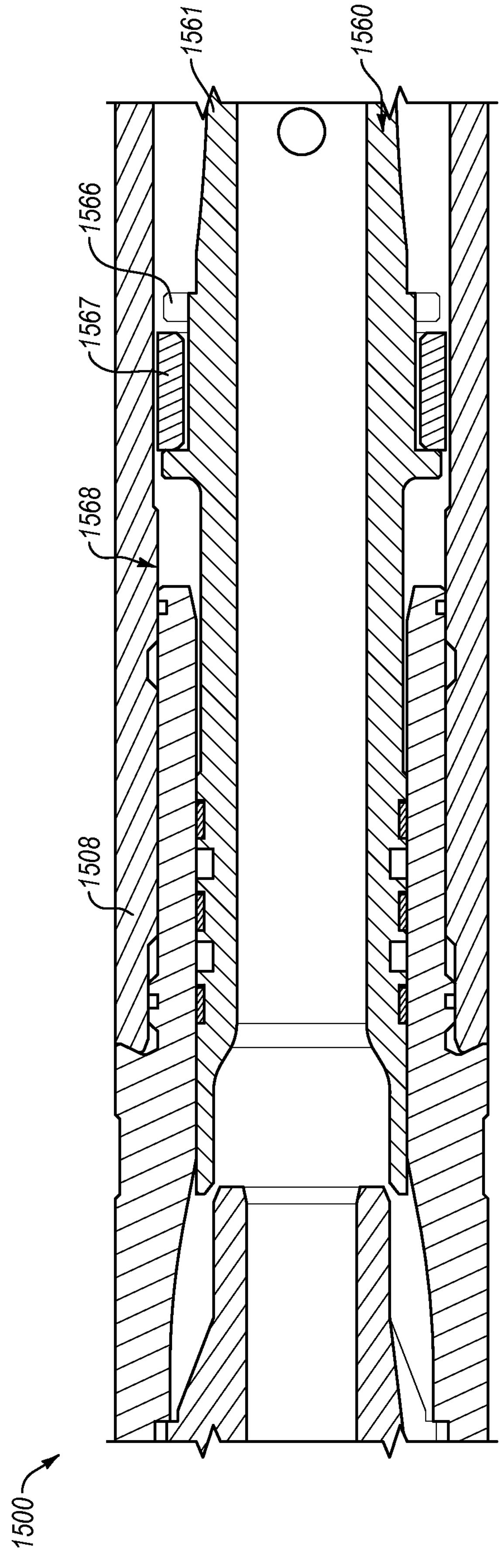
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FIG. 18

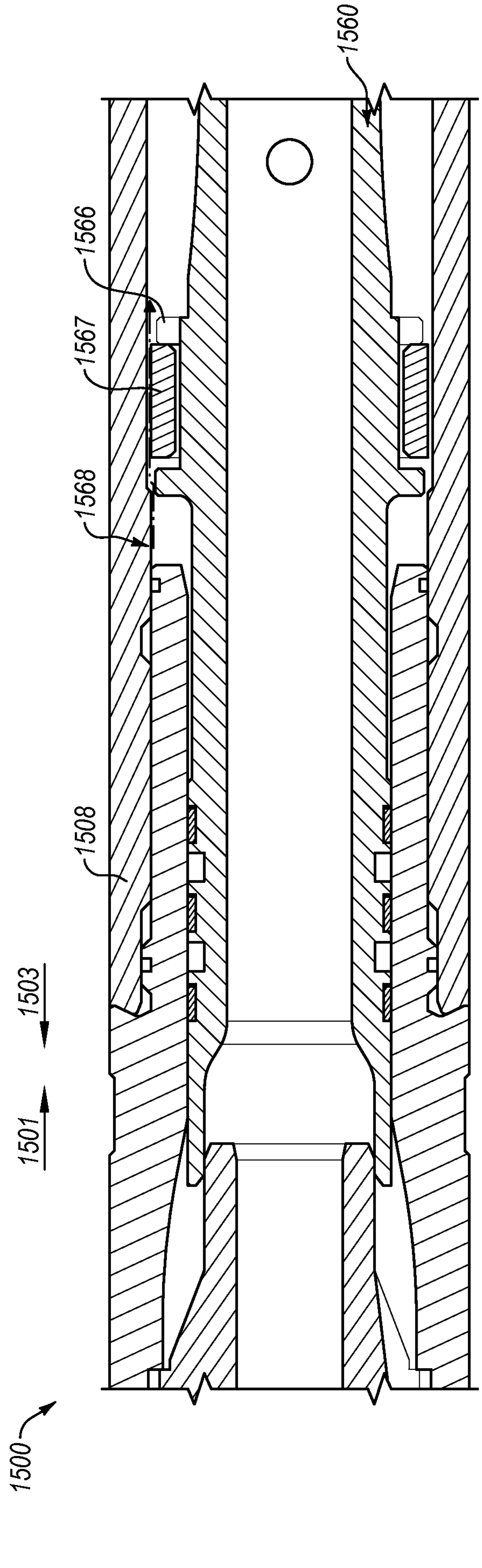
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FIG. 19

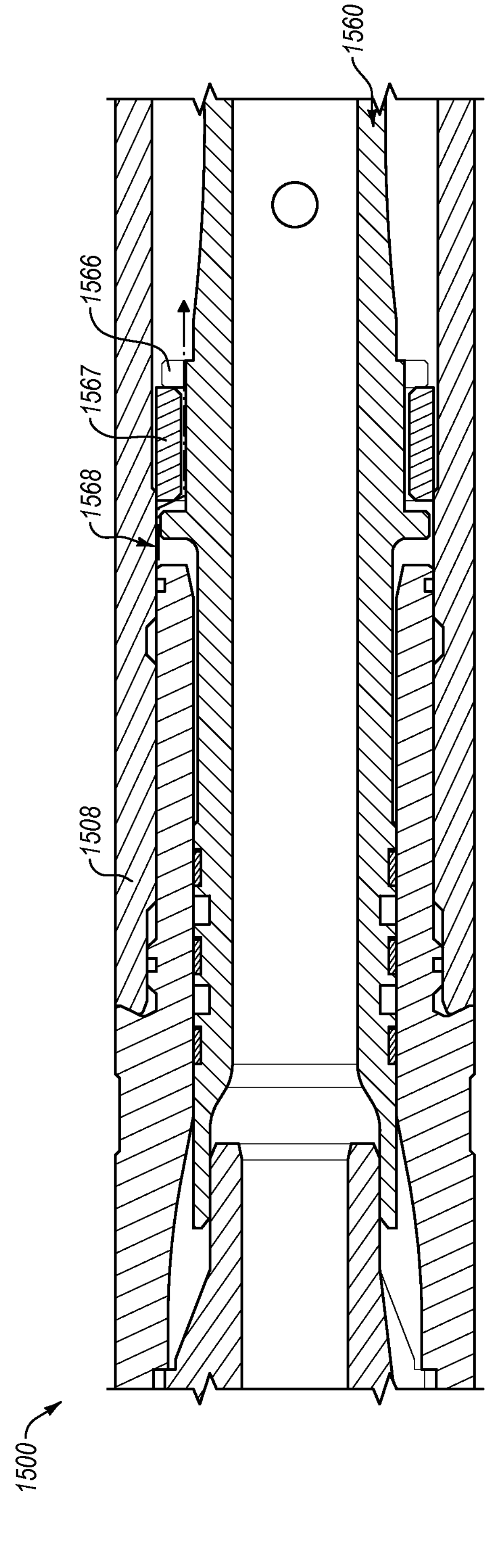
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FIG. 20

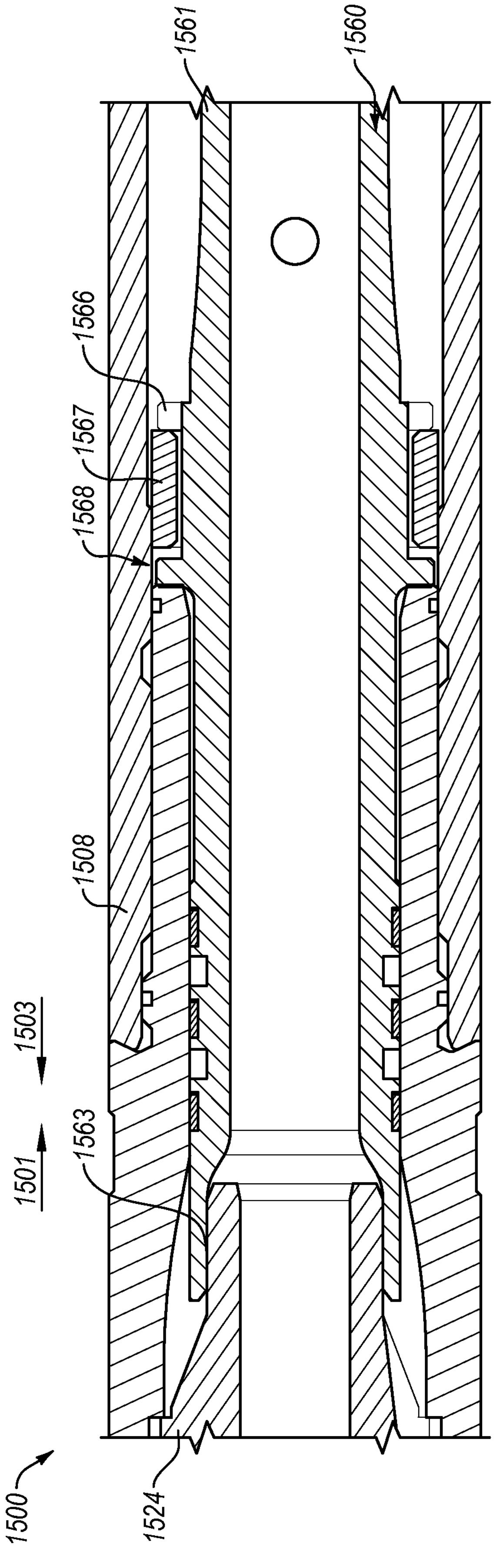
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FIG. 21

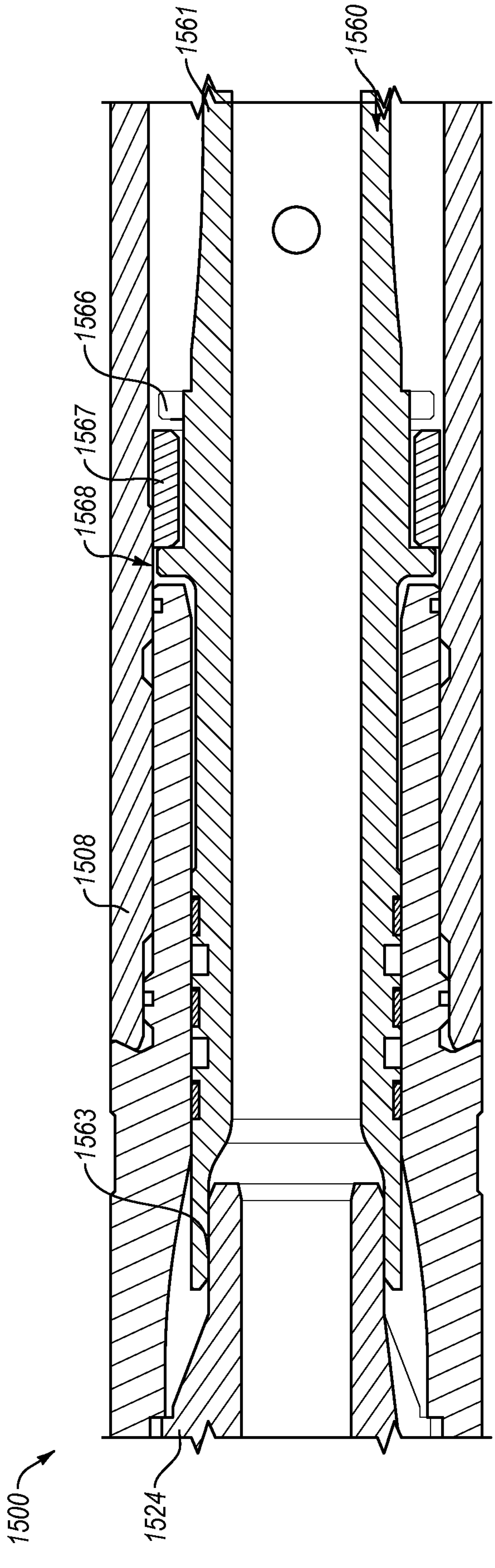
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FIG. 22

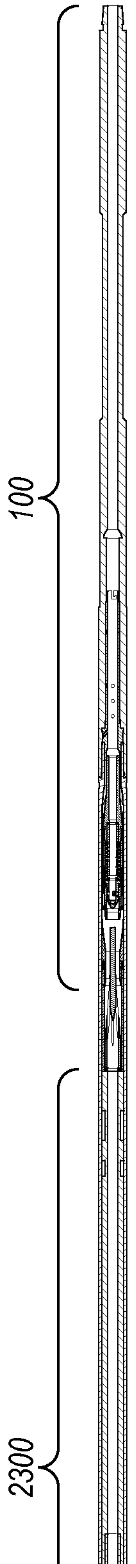

FIG. 23

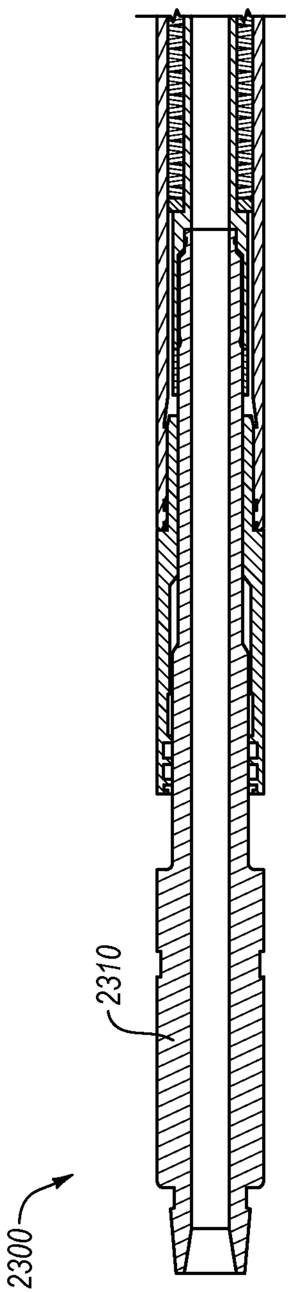

FIG. 24

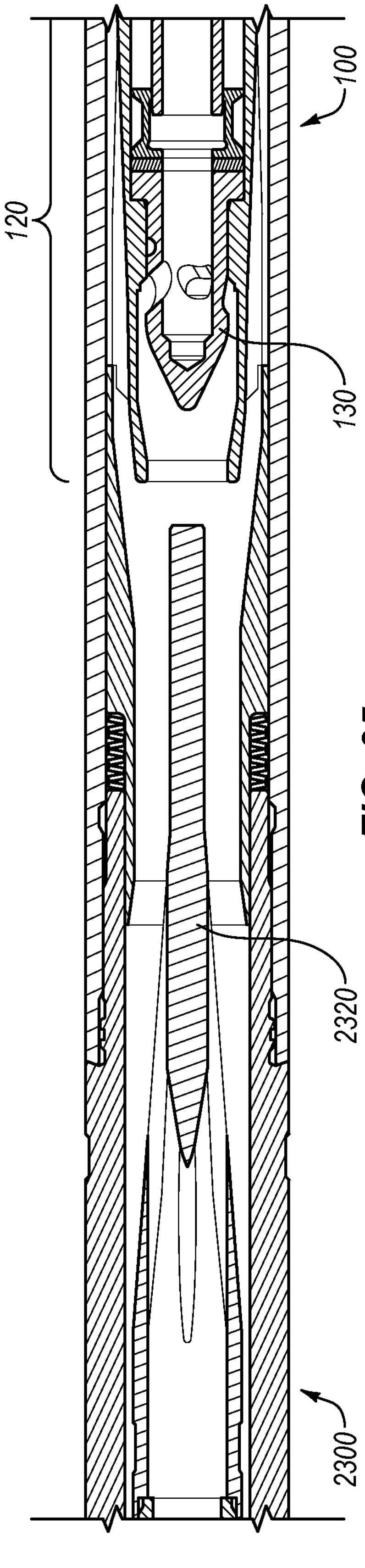

FIG. 25

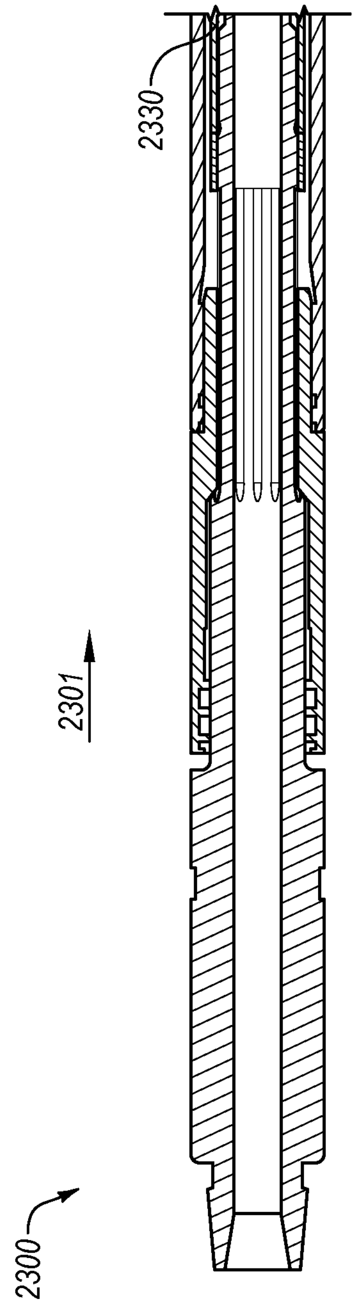

FIG. 26

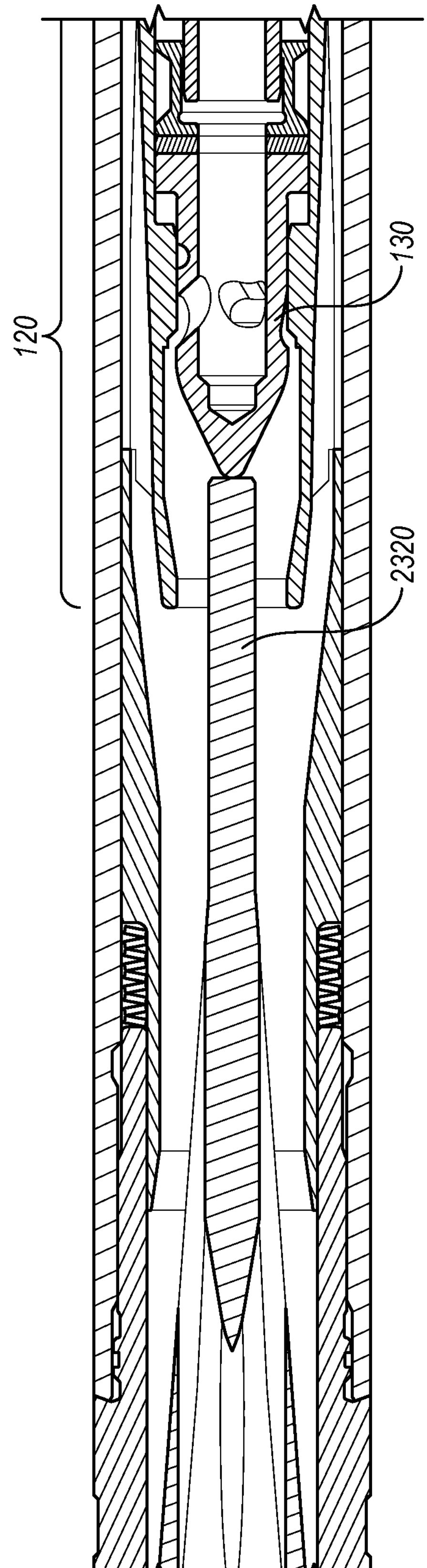

FIG. 27

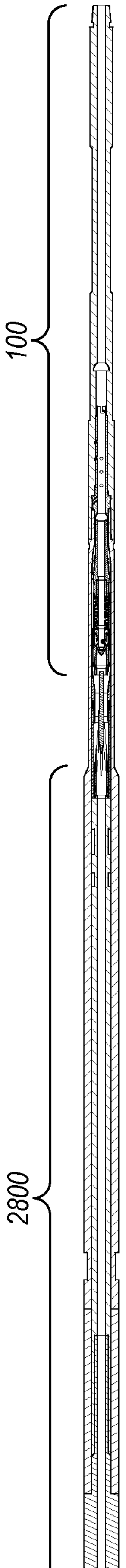

FIG. 28

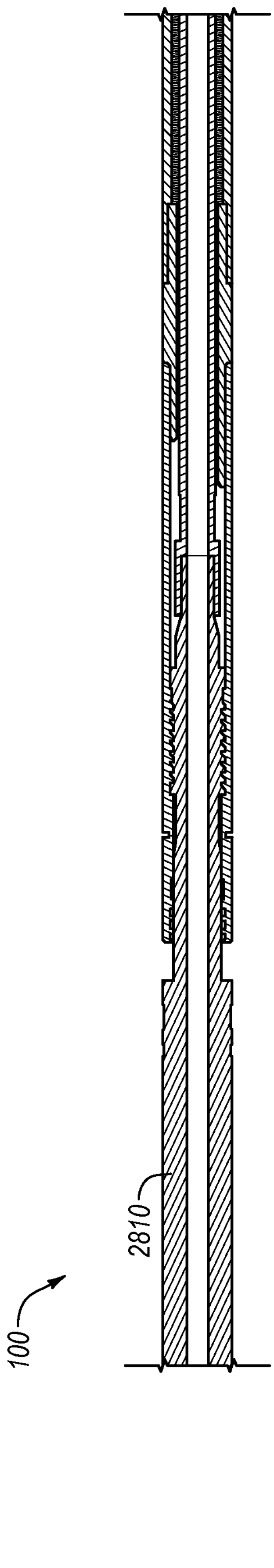

FIG. 29

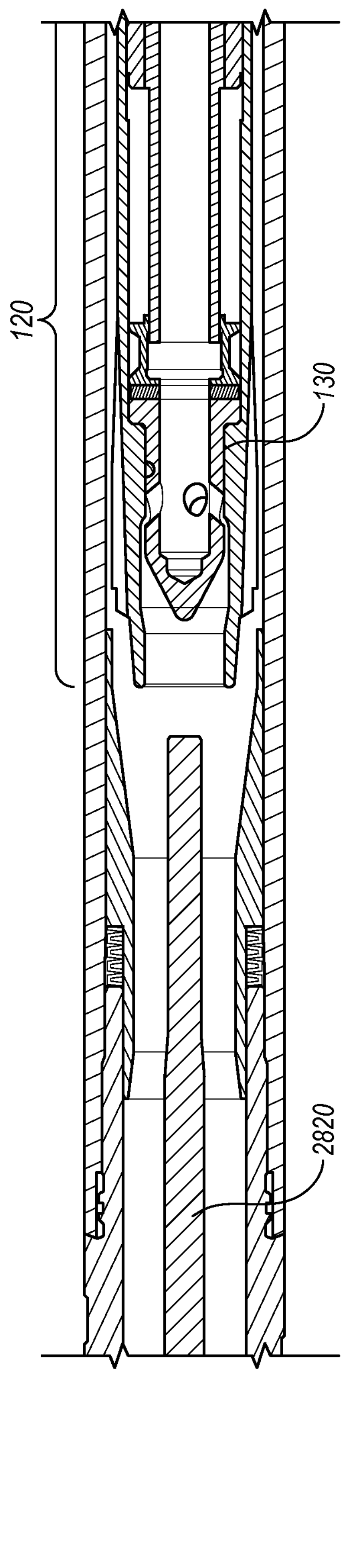

FIG. 30

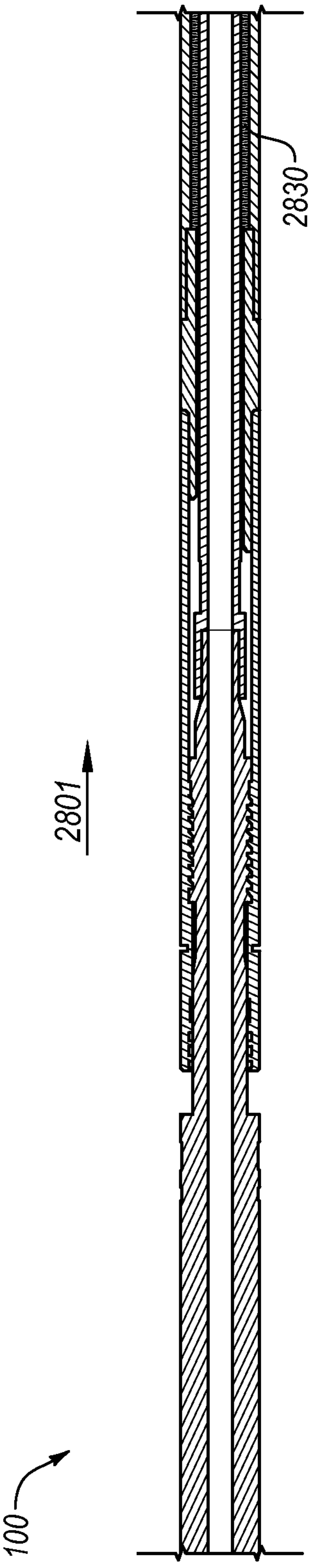

FIG. 31

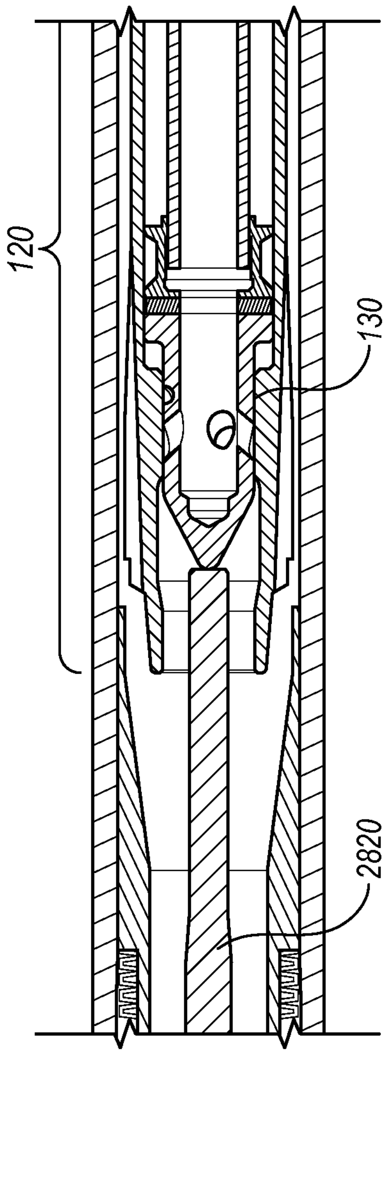

FIG. 32

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/065640

A. CLASSIFICATION OF SUBJECT MATTER

E21B 7/24(2006.01)i, E21B 17/00(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 7/24; E21B 34/00; E21B 47/022; E21B 47/18; E21B 43/26; E21B 17/00

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: pressure pulse, valve, flow, annulus, spring, and pressure differential

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4120097 A (JETER, JOHN DOISE) 17 October 1978 See abstract, column 3, line 63 - column 4, line 59.	1-20
A	US 2009-0016159 A1 (FRASER et al.) 15 January 2009 See abstract, paragraphs [0059]-[0061], and figure 1.	1-20
A	US 3983948 A (JETER, JOHN DOISE) 05 October 1976 See abstract, column 3, lines 32-39, and figure 1.	1-20
A	WO 02-059460 A1 (GEOLINK (UK) LTD.) 01 August 2002 See abstract, page 3, lines 16-24, and figure 2.	1-20
A	US 2013-0075099 A1 (KITZMAN, JEFFERY D.) 28 March 2013 See abstract, paragraph [0027], and figures 1-4.	1-20

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

☒ See patent family annex.

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"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
24 February 2015 (24.02.2015)	**24 February 2015 (24.02.2015)**

Name and mailing address of the ISA/KR
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Facsimile No. ++82 42 472 3473

Authorized officer
PARK, Tae Wook
Telephone No. +82-42-481-3405

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2014/065640

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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