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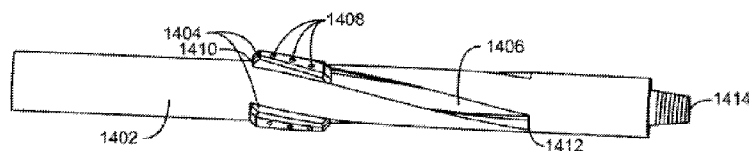


FIG. 14A

(57) Abstract: A stabilizer design for improving the likelihood of recovery of a drill string when obstructions are encountered in a wellbore is disclosed herein. The stabilizer includes a tubular body, a track, and a stabilizer blade. The track is disposed along the tubular body. The stabilizer blade is operatively coupled to the track and is configured to slide along the track from a first position to a second position.

DRILL STRING STABILIZER RECOVERY IMPROVEMENT FEATURES

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Patent Application No. 61/728,708, filed November 20, 2012, the disclosure of which is hereby incorporated by reference.

FIELD OF THE INVENTION

[0002] The present invention relates to devices for down hole drilling operations. More particularly, systems and methods for reducing the likelihood of permanently sticking the drill string are described.

BACKGROUND OF THE INVENTION

[0003] This section is intended to introduce various aspects of the art, which may be associated with exemplary embodiments of the present invention. This discussion is believed to assist in providing a framework to facilitate a better understanding of particular aspects of the present invention. Accordingly, it should be understood that this section should be read in this light, and not necessarily as admissions of prior art.

[0004] A stabilizer is an implementation used in downhole drilling operations to hold a drill string essentially concentrically in place. A stabilizer can be composed of a cylindrical body and a set of stabilizer blades that form an effective diameter similar to that of the drill string's drill bit which is nominally the same diameter as the wellbore (or borehole) when initially drilled. The stabilizer blades can help keep the drill string aligned so as to avoid unintentional sidetracking or vibrations and to reduce the contact area between the drill string and the wellbore during the drilling operation.

[0005] However, when pulling the drill string out of a wellbore after the drilling operation, the blades of a stabilizer can be at risk of being caught on an obstruction such as a debris build-up or a cuttings bed or formation ledge, which would subject the stabilizer to a downward axial force. These occurrences can cause damage to or loss of the drilling tools. Additionally, it may take several days and millions of dollars in order to safely remove a stuck drill string or in many instances, part of the drill string is permanently lost (unrecoverable) and a new wellbore must be drilled.

[0006] Several patents and pieces of literature discuss systems in which stabilizer blades can be extended or retracted. U.S. Patent No. 5,931,239 discusses a drill

string carrying a stabilizer sub above a drill bit for steering or directing drilling. The stabilizer body is rotatably carried by the stabilizer sub such that the stabilizer body remains substantially stationary relative to the borehole as the drill string rotates. At least one stabilizer blade is carried by the stabilizer body, with the stabilizer blade being radially extendable from the stabilizer body and into engagement with the sidewall of a borehole. Each stabilizer blade is extendable and retractable from the stabilizer body independently of the others. The stabilizer blades are coupled to the stabilizer body such that the stabilizer blades are capable of collapsing to a minimum radial extension if the stabilizer assembly becomes stuck in the borehole.

[0007] U.S. Patent No. 4,491,187 discusses a surface controlled blade stabilizer apparatus, in which surface control is achieved by the alteration of internal drill string pressure to move a piston carrying an actuator for expanding stabilizer blades. The stabilizer blades are spring biased inwardly when not forced outwardly by the actuator. A barrel cam controls and guides the actuator to downward, upward, and intermediate positions, such that the blades may be expanded, retracted, or held expanded when drill string pressure is reduced. The apparatus has a full open passage to allow passage of the drilling fluid (or mud) which is not interfered with by operation of the apparatus.

[0008] U.S. Patent No. 4,754,821 discusses a locking device for use in an adjustable drill string stabilizer that comprises a fluid reservoir provided in a first body member. The reservoir is divided into two chambers by a sealing piston secured on a second body member that is moveable relative to the first body member. The chambers of the reservoir are in fluid communication through a valve which is actuatable to close said fluid communication between the chambers, thus preventing relative movement of the body members.

[0009] U.S. Patent No. 5,293,945 discusses a downhole adjustable stabilizer and method for use in a wellbore and along a drill string having a bit at its lower end. A plurality of stabilizer blades are radially moveable with respect to the stabilizer body, with outward movement of each stabilizer blade being in response to a radially moveable piston positioned inwardly of a corresponding blade and subject to the pressure differential between the interior of the stabilizer and the wellbore. A locking member is axially moveable from an unlocked position to a locked position, such that the stabilizer blades may be locked in either their retracted or expanded positions. In the preferred embodiment of the invention, the stabilizer may be sequenced from a

stabilizer blade expanded position to a stabilizer blade retracted position by turning on and off a mud pump at the surface. The stabilizer position may be detected by monitoring the back pressure of the mud at the surface, since the axial position of the locking sleeve preferably alters the flow restriction at the lower end of the stabilizer. High radially outward forces may be exerted on each stabilizer blade by one or more radially moveable pistons responsive to the differential pressure across the stabilizer, and the stabilizer is presumed to be highly reliable and has few force-transmitting components.

[0010] U.S. Patent No. 5,311,953 discusses a trajectory control sub for steering a drill bit that contains a lower part adjustable relative to an upper part to produce an axial bend to angularly offset the drill bit so that drilling proceeds along a curved path. Adjustable stabilizer blades are mounted on the sub and are moveable between extended positions and retracted positions. An actuator is provided which selectively maintains the drill bit in axial alignment with the section of borehole being drilled, and which is actuated to move the stabilizer blades into their retracted positions and subsequently, with the stabilizer blades in their retracted positions, to effect tilting of the lower part relative to the upper part to produce the axial bend leading to tilting of the drill bit.

[0011] These references disclose extending and retracting stabilizer blades with the use of hydraulics, an actuator, or pistons. However, at present, there is not a known uniaxial, mechanical-only stabilizer with retractable stabilizer blades in the oilfield or wellbore drilling industry.

SUMMARY OF THE INVENTION

[0012] An exemplary embodiment provides a stabilizer. The stabilizer includes a tubular body, a track, and a stabilizer blade. The track is disposed along the tubular body. The stabilizer blade is operatively coupled to the track, wherein the track allows the stabilizer blade to slide from a first position to a second position.

[0013] Another exemplary embodiment provides a method for stabilizing a drill string in a wellbore. The method includes advancing the drill string into the wellbore. The method also includes centering the drill string with a plurality of stabilizer blades disposed along the drill string, wherein each of the plurality of stabilizer blades remains at a first position on a track as the drill string is advanced into the wellbore. The method also includes retracting the drill string in the wellbore, wherein a

stabilizer blade will slide to a second position along the track in response to being caught on an obstruction in the wellbore.

Another exemplary embodiment provides a stabilizer. The stabilizer includes a stabilizer blade operatively coupled to a track, wherein if the stabilizer blade encounters an obstruction in the wellbore as the drill string is being retracted in the well, the stabilizer blade slides on the track.

[0014] Another exemplary embodiment provides a method of minimizing sticking between a stabilizer blade and an obstruction in a wellbore. The method includes rotating a stabilizer blade with a drill string while the stabilizer blade remains in a first position on the drill string. The method also includes establishing contact with an obstruction as the drill string is pulled. The method also includes sliding along a track until a second position is reached. The method further includes moving to the first position as the drill string moves down for drilling.

[0015] Another exemplary embodiment provides a system for improving the probability of recovery of a drill string in a well. The system includes a drill string. The system also includes a stabilizer that includes a stabilizer blade. The stabilizer blade is operatively coupled to a track. If the stabilizer blade encounters an obstruction in the well, the stabilizer blade slides on the track. Another feature that is provided is a fluid circulation port(s) or nozzle(s) that is opened when the stabilizer blade is shifted due to the obstruction. Drilling fluid can be pumped through the port(s) to help clear the debris causing the obstruction. The port(s) or nozzle(s) may provide a relatively high pressure drop to provide a jetting action or relatively lower pressure drop to facilitate high rate circulation and turbulence, or even a relatively further reduced pressure drop merely to establish hole cleaning circulation rates to facilitate drilling fluid and cuttings circulation and removal. The circulation port(s) or nozzle(s) may be referred to herein collectively and broadly as hydraulic jet nozzle(s), regardless of the amount of pressure drop or jetting energy provided by such port(s) or nozzle(s), as many embodiments will provide at least some energized jetting action. Such nozzles may be selectively operable, such as via use of a rupture disk or valve assembly or operable any time the port is opened such as by shifting of a stabilizer blade or other component, or selectively operable independent of the position of the blade or other component.

[0016] The foregoing summary has outlined rather broadly the features and technical advantages of embodiments in order that the detailed description of the

invention that follows may be better understood. Additional features and advantages of the invention will be described hereinafter which form the subject of the claims of the invention. It should be appreciated by those skilled in the art that the conception and specific embodiment disclosed may be readily utilized as a basis for modifying or designing other structures for carrying out the same purposes of the present invention. It should also be realized by those skilled in the art that such equivalent constructions do not depart from the spirit and scope of the invention as set forth in the appended claims. The novel features which are believed to be characteristic of the invention, both as to its organization and method of operation, together with further objects and advantages will be better understood from the following description when considered in connection with the accompanying figures. It is to be expressly understood, however, that each of the figures is provided for the purpose of illustration and description only and is not intended as a definition of the limits of the present invention.

DESCRIPTION OF THE DRAWINGS

[0017] The foregoing and other advantages of the present invention may become apparent upon reviewing the following detailed description and drawings of non-limiting examples of embodiments in which:

[0018] **Fig. 1** is an illustration of a system for downhole drilling;

[0019] **Fig. 2** is an illustration of a drill string in a wellbore showing the binding or undesirable contact of stabilizers on an obstruction;

[0020] **Figs. 3A** and **3B** are side views of a four-blade stabilizer with blades extended and retracted, respectively, with **Fig. 3C** showing an embodiment with a fluid jet nozzle;

[0021] **Figs. 4A** and **4B** are front views of a four-blade stabilizer with blades extended and retracted, respectively;

[0022] **Fig. 5** is a perspective view of a stabilizer track configured to hold a stabilizer blade;

[0023] **Fig. 6** is a perspective view of a blade;

[0024] **Figs. 7A** and **7B** are side views of a three-blade stabilizer with blades extended and retracted, respectively, with **Fig. 7C** showing an embodiment with a fluid jet nozzle;

[0025] **Figs. 8A** and **8B** are front views of a three-blade stabilizer with blades extended and retracted, respectively;

[0026] **Figs. 9A and 9B** are perspective views of a three-blade two-piece stabilizer with blades extended and retracted, respectively, with **Fig. 9C** showing an embodiment with a fluid jet nozzle;

[0027] **Figs. 10A and 10B** are overhead and front views of a two-piece stabilizer track with blades retracted;

[0028] **Figs. 11A and 11B** are side and perspective views of a two-piece blade;

[0029] **Figs. 12A and 12B** are perspective views of a three-blade sleeve stabilizer with the sleeve in its original and sheared positions, with **Fig. 12C** showing an embodiment with a fluid jet nozzle;

[0030] **Fig. 13** is a front view of a three-blade sleeve stabilizer; and

[0031] **Figs. 14A and 14B** are side views of a three-blade spiral stabilizer with blades extended and retracted, with **Fig. 14C** showing an embodiment with a fluid jet nozzle; **Fig. 15** is a process flow chart of a method of minimizing drill string sticking between a stabilizer and an obstruction in a well.

[0032] It should be noted that the figures are merely exemplary of several embodiments of the present invention and no limitations on the scope of the present invention are intended thereby. Further, the figures are generally not drawn to scale, but are drafted for purposes of convenience and clarity in illustrating various aspects of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0033] In the following detailed description section, the specific embodiments of the present invention are described in connection with preferred embodiments. However, to the extent that the following description is specific to a particular embodiment or a particular use of the present invention, this is intended to be for exemplary purposes only and simply provides a description of the exemplary embodiments. Accordingly, the invention is not limited to the specific embodiments described below, but rather, it includes all alternatives, modifications, and equivalents falling within the true spirit and scope of the appended claims.

[0034] At the outset, and for ease of reference, certain terms used in this application and their meanings as used in this context are set forth. To the extent a term used herein is not defined below, it should be given the broadest definition persons in the pertinent art have given that term as reflected in at least one printed publication or issued patent. Further, the present techniques are not limited by the usage of the terms shown below, as all equivalents, synonyms, new developments,

and terms or techniques that serve the same or a similar purpose are considered to be within the scope of the present claims.

[0035] "Blade" and "blades" may be used in this application to include, but are not limited to, various types of projections extending outwardly from a wellbore tool. Such wellbore tools may have generally cylindrical bodies with associated blades extending radially therefrom. Blades formed in accordance with teachings of the present disclosure may have a wide variety of configurations including, but not limited to, helical, spiraling, tapered, converging, diverging, symmetrical, and/or asymmetrical. Such blades may also be used on wellbore tools which do not have a generally cylindrical body.

[0036] "Drilling" as used herein may include, but is not limited to, rotational drilling, slide drilling, directional drilling, non-directional (straight or linear) drilling, deviated drilling, geosteering, horizontal drilling, and the like. The drilling method may be the same or different for the offset and uncased intervals of the wells. Rotational drilling may involve rotation of the entire drill string, or local rotation downhole using a drilling mud motor, where by pumping mud through the mud motor, the bit turns while the drillstring does not rotate or turns at a reduced rate, allowing the bit to drill in the direction it points.

[0037] A "drill string" is understood to include a collection or assembly of joined tubular members, such as casing, tubing, jointed drill pipe, metal coiled tubing, composite coiled tubing, drill collars, subs and other drill or tool members, extending between the surface and on the lower end of the work string, is connected to a tool normally utilized in wellbore operations called a drill bit. The drill bit is used to cut or crush the formation rocks to form a wellbore (or borehole). A drill string may be used for drilling and be a drill string or an installation means. It should be appreciated that the work or drill string may be made of steel, a steel alloy, a composite, fiberglass, or other suitable material.

[0038] A "sleeve" is a tubular part designed to fit over another tubular part. The inner and outer surfaces of the sleeve may be circular or non-circular in cross-section profile. The inner and outer surfaces may generally have different geometries, i.e. the outer surface may be cylindrical with circular cross-section, whereas the inner surface may have an elliptical or other non-circular cross-section. Alternatively, the outer surface may be elliptical and the inner surface circular, or some other combination. More generally, a sleeve may be considered to be a

generalized hollow cylinder with one or more radii or varying cross-sectional profiles along the axial length of the cylinder.

[0039] A "tubular" is used herein to include oil country tubular goods and accessory equipment such as drill string, liner hangers, casing nipples, landing nipples and cross connects associated with completion of oil and gas wells. Tubulars also include any pipe of any size or any description and is not limited to only tubular members associated with oil and gas wells. Further, the term "tubular" is not restricted to flow spaces with a cylindrical shape (i.e., with a generally circular axial cross-section), but is instead intended to encompass enclosed flow spaces of any other desired cross-sectional shape, such as rectangular, hexagonal, oval, annular, non-symmetrical, etc. In addition, the term tubular also contemplates enclosed flow spaces whose cross-sectional shape or size varies along the length of the tube.

[0040] A "well" refers to holes drilled vertically, at least in part, and may also refer to holes drilled with deviated, highly deviated, and/or horizontal sections of the wellbore. The term also includes wellhead equipment, surface casing, intermediate casing, and the like, typically associated with oil and gas wells.

[0041] According to embodiments described herein, a stabilizer on a drill string is configured to reduce the contact area between the drill string and the wellbore and to minimize drill string sticking or drag. The improved stabilizer may be incorporated into method and systems for improving the probability of recovery of a drill string in a wellbore or mitigate potential sticking of a drillstring within a wellbore.

[0042] Multiple stabilizers can be used to help achieve a specified directional path for the wellbore as well as reduce the overall drag on the drill string. The stabilizer may include one or more stabilizer blades that form an effective diameter that is substantially the same as the drill bit to keep the drill string in place to avoid unintentional sidetracking or vibrations during operation. After operation, the drill string is pulled out of the wellbore. If a stabilizer blade encounters an obstruction in the well, the stabilizer blade can slide along a track on the stabilizer. In some embodiments, the stabilizer blade slides into recessed areas on the stabilizer body, so as to allow the stabilizer to slip past the obstruction. In other embodiments, the drill string is shifted downward and pulled upward while the stabilizer blade is stuck in order to attempt to dislodge the obstruction.

[0043] In some embodiments, the stabilizer blade is secured in place by a shearable device such as a shear pin, screw, or detent that can release the stabilizer blade only when a pre-determined axial force threshold is met. The stabilizer may contain mechanical stops to prevent the stabilizer blade from sliding upward or downward past a certain point. If the drill string is to go back down for further drilling operations, the stabilizer blade can return to its original position. The stabilizer blade may be aligned with the axis of the drill string, or it may be aligned at an angle from the axis of the drill string so as to make a spiral pattern.

[0044] Another feature that may be included is a fluid circulation port(s) or nozzle(s) (collectively also referred to herein as a hydraulic jet nozzle) that is opened when the stabilizer blade is shifted due to the obstruction. Drilling fluid can be pumped through the port(s) to help clear the debris causing the obstruction. The port(s) or nozzle(s) may provide a relatively high pressure drop to provide a jetting action or relatively lower pressure drop to facilitate high rate circulation and turbulence, or even a relatively further reduced pressure drop merely to establish hole cleaning circulation rates to facilitate drilling fluid and cuttings circulation and removal. The circulation port(s) or nozzle(s) may be referred to herein collectively and broadly as hydraulic jet nozzle(s), regardless of the amount of pressure drop or jetting energy provided by such port(s) or nozzle(s), as many embodiments will provide at least some energized jetting action. Such nozzles may be selectively operable, such as via use of a rupture disk or valve assembly or operable any time the port is opened such as by shifting of a stabilizer blade or other component, or selectively operable independent of the position of the blade or other component.

[0045] In some embodiments, a hydraulic jet nozzle may be included on the track to release a drilling fluid, for example, after the stabilizer blade has moved aside, leaving the nozzle open. As used herein, "open" means that the nozzle allows unimpeded flow of a fluid into the wellbore. The nozzle may be an aperture, a port, a hydraulic jet, a slot, an insert, or an orifice, or combinations thereof. The nozzle may also include a gasket, valve, check valve, other flow control device, or combinations thereof. The released drilling fluid can act as a lubricant or help displace, hydrate, dislodge, unpack, or re-suspend portions of the obstructive debris within the wellbore annulus. Such actions may aid recovery of a drill string or prevent sticking the drill string. In some embodiments, a sealing mechanism such as a gasket, valve, check valve, or other flow control device may be in place to block the nozzle, e.g., to

prevent the drilling fluid from flowing or leaking out when the stabilizer blade is positioned over the hydraulic jet nozzle.

[0046] **Fig. 1** is an illustration of a system for downhole drilling. The system **100** includes a drill string **102** operating in a wellbore **104**. The drill string **102** can be operatively coupled to a motor **106** configured to rotate, push, and pull the drill string **102**. The drill string **102** can include a drill bit **108** and a multiple drill string segments **110** that can be removed and replaced. Stabilizers **112**, placed along the drill string **102**, can keep the drill bit **108** in line with the wellbore **104**, preventing undesirable deviations and also reducing the contact area between the drill string and the wellbore. The motor **106** can operate the drill string **102** from the top of a surface **114**. The wellbore **104** can be a hole cutting through overburden **116** into a reservoir **118**. The stabilizer blades are designed to rotate in fixed engagement with the rotation of the drill string to mechanically agitate the drilled cuttings and aid in the removal of these cuttings from the wellbore. Furthermore, field testing has shown that generally a rotating stabilizer induces less axial and rotational drag than a static (non-rotating) stabilizer which is a significant benefit in long-reach directional wells.

[0047] **Fig. 2** is an illustration of a drill string in a wellbore showing the binding or undesirable contact of stabilizers on an obstruction. The drill string **200** can operate in a wellbore **202**, and may be composed of alternating segments of drill pipe, drill collars **204**, stabilizers **206**, and a drill bit **208**. The stabilizers **206** can help keep the drill string in place during drilling operation. When the drill string is pulled up towards the surface, the stabilizers **206** run the risk of being stuck on an obstruction **210** in the wellbore **202**.

[0048] The drill bit **208** is configured to drill the wellbore **202**. The drill collars **204** may be heavy, thick-walled sections of the drill string **200** that provide weight to the drill bit **208**. Obstructions **210** in the wellbore that can impede the stabilizer blades **206** may include loose or unstable formations or rock cuttings that remain after drilling. After drilling the wellbore using the drill string and stabilizer, hydrocarbons such as oil or gas may be produced from the wellbore or recovered from other wellbore in the field as a direct or indirect result of operations utilizing the wellbore.

[0049] In some embodiments, the stabilizer blades **206** are configured to slide if they are impeded. The stabilizer blades **206** can be composed of one or two pieces. In some embodiments, the stabilizer blades **206** are coupled to a sleeve that retains its effective diameter.

[0050] **Figs. 3A and 3B** are side views of a four-blade stabilizer with blades extended and retracted. The four-blade stabilizer **300** can have a stabilizer body **302** with four one-piece stabilizer blades **304**, each contained in a stabilizer blade slot **306**, which may be angled inward. The one-piece stabilizer blades **304** may be held in place by shearable devices **308** such as shear pins, screws, or ball detents. The stabilizer blade slots **306** may each contain an upper mechanical stop **310** and a lower mechanical stop **312** that serve to prevent the one-piece stabilizer blades **304** from sliding past a certain point. The four-blade stabilizer **300** can be inserted into a drill string by a drill string connection **314**, which can be a conventional pin or box thread. The drill string connection **314** may point towards the drill bit of the drill string.

[0051] **Fig. 3A** represents the four-blade stabilizer **300** during drilling operation in a well, when the one-piece stabilizer blades **304** are in an extended position, and held in place by the shearable devices **308** and the upper mechanical stop **310**. When the drill string is pulled upwards, one or more of the one-piece stabilizer blades **304** may encounter an obstruction in the well.

[0052] If enough force is applied onto the stabilizer blade **304**, the shearable devices **308** can release the one-piece stabilizer blade **304**, allowing it to slide down the stabilizer blade slot **306** until reaching the lower mechanical stop **312**, revealing shearing pin holes **316**. In many embodiments the stabilizer blade is a one-piece element, but in other embodiments the blade may comprise two or more integrated or cooperating elements. The shearable devices **308** may include shear pins that break when a force exceeds a set point. For example, the total shear force may be set to allow the stabilizer blade **304** to move when a force is applied to the stabilizer blade **304** of about 20,000 lbs (about 9100 kg), about 30,000 lbs (about 14000 kg), about 40,000 lbs (about 18,000 kg), or about 50,000 lbs (about 23,000 kg), or otherwise as appropriate for the use conditions. It can be noted that this force is measured at the stabilizer blade **304**, and is above any force needed to pull the drill string from the wellbore. Further, this force can be divided among a number of shearable devices **308**. For example, if three shear pins are used, each shear pin can be set to break at about 10,000 lbs (about 4500 kg), for a total force of about 30,000 lbs (about 14000 kg). The shearable devices **308** are not limited to shear pins, but can also include detents (such as spring-loaded spheres or hemispheres) that lock the stabilizer blades **304** into place at the forces described.

[0053] The shearing holes **316** correspond to where the shearable devices **308** were originally held in place. If the stabilizer blade slot **306** is angled into the drill pipe, the one-piece stabilizer blade **304** can retract into the four-blade stabilizer **300** as shown in **Fig. 3B**. In some embodiments, retracting the one-piece stabilizer blade **304** can expose the fluid jet nozzle **318** (as seen in **Fig. 2C**), which can release a drilling fluid **320** into the wellbore annulus.

[0054] If drilling is to be resumed, the drill string may be pushed downward, and the one-piece stabilizer blade **304** can slide back to its original position at the upper mechanical stop **310**. If detents are used, the stabilizer blade **304** may return to a locked condition if the drill string is again advanced into the wellbore.

[0055] **Figs. 4A** and **4B** are front views of a four-blade stabilizer with blades extended and retracted. The four-blade stabilizer **400** can have a stabilizer body **402**, four one-piece stabilizer blades **404**, and a center annulus **406** through which drilling fluid or mud can pass through. During drilling operation in a well, the one-piece stabilizer blades **404** are extended outward to form a larger effective diameter, e.g., to match the diameter of the drill bit, as shown in **Fig. 4A**. The larger effective diameter helps keep a drill string stable when drilling. As the drill string is pulled upward, if a one-piece stabilizer blades **404** is caught by an obstruction in the well, the one-piece stabilizer blades **404** break free and slide along the track, retracting into a recessed area and reducing the effect diameter so that the stabilizer can bypass the obstruction, as shown in **Fig. 4B**.

[0056] **Fig. 5** is a perspective view of a stabilizer track configured to hold a stabilizer blade. The stabilizer track **500** can include one or more shearing holes **502**, a pair of mechanical stops **504**, and one or more blade retention slots **506**. The shearing holes **502** are holders for shearable devices (such as pins or ball detents) that can hold a stabilizer blade in place during drilling operation. If enough force is applied to the stabilizer blade, the shearable devices can release the stabilizer blade (or blades), allowing it to slide within the stabilizer track **500**. The mechanical stops **504** constrain the axial movement of the stabilizer blade. The blade retention slot **506** can be configured to prevent stabilizer blade circumferential movement relative to the stabilizer body. The blade retention slot **506** can also ensure that the stabilizer blade does not become detached from the stabilizer body. In some embodiments, the stabilizer track **500** is angled into the stabilizer body such that when the stabilizer blade slides away from its starting position, the stabilizer blade retracts inward so as

to reduce the effective diameter formed. In some embodiments, the stabilizer track **500** also contains a hydraulic jet nozzle **508** that can release a drilling fluid **510** into the wellbore annulus.

[0057] **Fig. 6** is a perspective view of a stabilizer blade. The stabilizer blade **600** is configured to extend outward from a stabilizer on a drill string so as to increase the stabilizer's effective diameter during drilling operation, and slide on a track on the stabilizer when an obstruction is encountered. The stabilizer blade **600** can contain one or more shearing holes **602** and one or more retention blades **604**. The shearing holes **602** are holders for shearable devices (such as pins or detents) that can hold the blade **600** in place during drilling operations. The retention blade **604** is a ridge that engages in a blade retention slot on the track to prevent the blade **600** from separating from the stabilizer.

[0058] **Figs. 7A and 7B** are side views of a three-blade stabilizer with blades extended and retracted. The three-blade stabilizer **700** can have a stabilizer body **702** with three one-piece stabilizer blades **704**, each contained in a stabilizer blade slot **706**, which may be angled inward. The one-piece stabilizer blades **704** may be held in place by shearable devices **708** such as shear pins or ball detents. The stabilizer blade slots **706** may each contain an upper mechanical stop **710** and a lower mechanical stop **712** that serve to prevent the one-piece stabilizer blades **704** from sliding past a certain point. The three-blade stabilizer **700** can be inserted into a drill string by a drill string connection **714**, which can be a conventional pin or box thread. The drill string connection **714** may point towards the drill bit of the drill string.

[0059] **Fig. 7A** represents the three-blade stabilizer **700** during drilling operation in a well, when the one-piece stabilizer blades **704** are extended outward, and held in place by the shearable devices **708** and the upper mechanical stop **710**. When the drill string is pulled upwards, one or more of the one-piece stabilizer blades **704** may encounter an obstruction in the well. If enough force is applied onto the one-piece stabilizer blade **704**, the shearable devices **708** can release the one-piece stabilizer blade **704**, allowing it to slide down the stabilizer blade slot **706** until reaching the lower mechanical stop **712**, revealing shearing holes **716**. The shearing holes **716** correspond to where the shearable devices **708** were originally held in place. If the stabilizer blade slot **706** is angled inward, the one-piece stabilizer blade **704** can retract into the three-blade stabilizer **700** as shown in **Fig.**

7B. In some embodiments, retracting the one-piece stabilizer blade **704** can expose the fluid jet nozzle **718** (as seen in **Fig. 7C**), which can release a drilling fluid **720** into the wellbore annulus. If drilling is to be resumed, the drill string may be pushed downward, and the one-piece stabilizer blade **704** can slide back to its original position at the upper mechanical stop **710**.

[0060] **Figs. 8A** and **8B** are front views of a three-blade stabilizer with blades extended and retracted. The three-blade stabilizer **800** can have a stabilizer body **802**, three one-piece stabilizer blades **804**, and a central annulus **806** through which drilling fluid or mud can pass through. During drilling operation in a well, the one-piece stabilizer blades **804** are extended outward to form a larger effective diameter, as shown in **Fig. 8A**. The larger effective diameter helps keep a drill string stable when drilling. When the drill string is pulled upward and the one-piece stabilizer blades **804** are caught by obstructions in the well, the one-piece stabilizer blades **804** retract inward to reduce the effect diameter so that the stabilizer can bypass the obstruction, as shown in **Fig. 8B**.

[0061] **Figs. 9A** and **9B** are perspective views of a three-blade two-piece stabilizer with blades extended and retracted. The three-blade two-piece stabilizer **900** can have a stabilizer body **902** with three two-piece stabilizer blades **904**, each contained in a stabilizer blade slot **906**, which may be angled inward. The two-piece stabilizer blades **904** can be composed of an upper piece and lower piece, and may be held in place by shearable devices **908** such as shear pins or ball detents. The stabilizer blade slots **906** may each contain an upper mechanical stop **910** and a lower mechanical stop **912** that serve to prevent the two-piece stabilizer blades **904** from sliding past a certain point. The three-blade two-piece stabilizer **900** can be inserted into a drill string by a drill string connection **914**, which can be a conventional pin or box thread. The drill string connection **914** may point towards the drill bit of the drill string. The novelty of a two-piece stabilizer is that the effective diameter can be reduced incrementally depending on the amount of axial force subjected onto the stabilizer.

[0062] **Fig. 9A** represents the three-blade two-piece stabilizer **900** during drilling operation in a well, when the two-piece stabilizer blades **904** are extended outward, and held in place by the shearable devices **908** and the upper mechanical stop **910**. When the drill string is pulled upwards, one or more of the two-piece stabilizer blades **904** may encounter an obstruction in the well. If a predetermined amount of force is

applied onto the two-piece stabilizer blade **904**, the shearable devices **908** can release the two-piece stabilizer blade **904**, allowing the upper piece to slide down along the lower piece. If a greater amount of force is applied or if the wellbore is more restricted, then both the upper piece and the lower piece can slide down the stabilizer blade slot **906** until reaching the lower mechanical stop **912**, revealing shearing holes **916**. The shearing holes **916** correspond to where the shearable devices **908** were originally held in place. If the stabilizer blade slot **906** is angled inward, the two-piece stabilizer blade **904** can retract into the three-blade two-piece stabilizer **900** as shown in **Fig. 9B**. In some embodiments, retracting the two-piece stabilizer blade **904** can expose the fluid jet nozzle **918** (as seen in **Fig. 9C**), which can release a drilling fluid **920** into the wellbore annulus. If drilling is to be resumed, the drill string may be pushed downward, and the two-piece stabilizer blade **904** can slide back to its original position at the upper mechanical stop **910**.

[0063] **Figs. 10A and 10B** are overhead and front views of a two-piece stabilizer track with blades retracted. The two-piece stabilizer track **1000** can include one or more shearing holes **1002** and a pair of mechanical stops **1004**. The shearing holes **1002** are holders for shearable devices (such as pins or detents) that can hold a stabilizer blade in place during drilling operation. If enough force is applied to the stabilizer blade, the shearable devices can release the stabilizer blade, allowing it to slide within the stabilizer track **1000**. The mechanical stops **1004** constrain the lateral movement of the stabilizer blade. The two-piece stabilizer track **1000** can be configured such that both an upper piece **1006** and a lower piece **1008** of a two-piece stabilizer can fit separated within the track. The two-piece stabilizer track **1000** can be angled or tapered into the stabilizer body such that when the stabilizer blade slides away from its starting position, the stabilizer blade retracts inward so as to reduce the effective diameter formed. In some embodiments, the two-piece stabilizer track **1000** also contains a hydraulic jet nozzle **1010** that can release a drilling fluid **1012** into the wellbore annulus.

[0064] **Figs. 11A and 11B** are side and perspective views of a two-piece blade. The two-piece blade **1100** is configured to extend outward from a stabilizer on a drill string so as to increase the stabilizer's effective diameter during drilling operation, as shown in **Fig. 11A**. The two-piece blade **1100** can include an upper piece **1102** and a lower piece **1104** that are tapered with respect to one another. The upper piece **1102** can be coupled to a track on the lower piece **1104**. When the two-piece blade

1100 is subjected to an external force of a predetermined magnitude, the lower piece **1104** can slide axially along the tapered track of the stabilizer body such that the effective diameter of the stabilizer is somewhat reduced. If the stabilizer is subjected to a greater force or if the wellbore is more restricted, the upper piece **1102** can slide along a track on the lower piece **1104** (**Fig. 11B**), thus reducing the effective diameter even further. The two-piece blade **1100** can contain one or more shearing holes **1106** and one or more retention blades **1108**. The shearing holes **1106** are holders for shearable devices (such as pins or detents) that can hold the upper piece **1102** and the lower piece **1104** in place during drilling operation. The retention blade **1108** is a ridge that engages in a blade retention slot on the track on the stabilizer to prevent the two-piece blade **1100** from separating from the stabilizer.

[0065] **Figs. 12A and 12B** are perspective views of a three-blade sleeve stabilizer with the sleeve in its original and sheared positions. The three-blade sleeve stabilizer **1200** can have a stabilizer body **1202** with stabilizer blades **1204**, all of which can be connected to a cylindrical sleeve **1205**, which can be operatively coupled to a stabilizer track **1206** on the stabilizer body **1202**. The stabilizer blades **1204** on the cylindrical sleeve **1205** may be held in place by shearable devices **1208** such as shear pins or ball detents. The stabilizer track **1206** may contain an upper mechanical stop **1210** and a lower mechanical stop **1212** that serve to prevent the cylindrical sleeve **1205** from sliding past a certain point. The three-blade sleeve stabilizer **1200** can be inserted into a drill string by a drill string connection **1214**, which can be a conventional pin or box thread. The drill string connection **1214** may point towards the drill bit of the drill string.

[0066] **Fig. 12A** represents another embodiment of the three-blade sleeve stabilizer **1200** during drilling operation in a well, when the cylindrical sleeve **1205** and the stabilizer blades **1204** are in their original position, and held in place by the shearable devices **1208** and the upper mechanical stop **1210**. This embodiment does not employ tapered surfaces as described previously so the effective diameter of the stabilizer does not change. When the drill string is pulled upwards, one or more of the stabilizer blades **1204** may encounter an obstruction in the well.

[0067] If enough force is applied onto the stabilizer blade **1204**, the shearable devices **1208** can release cylindrical sleeve **1205**, allowing it to slide down the stabilizer track **1206** until reaching the lower mechanical stop **1212**, revealing shearing holes **1216**, as shown in **Fig. 12B**. This allows a jarring or hammering

action to occur which may dislodge the obstruction. In many embodiments the stabilizer blade **1204** is a one-piece element, but in other embodiments the stabilizer sleeve **1205** may encompass more than one stabilizer blade **1204**. The shearable devices **308** may include shear pins that break when a force exceeds a set point. The force required to release the stabilizer sleeve **1205** can fall in a range from the minimum force required to break the shear pins on a single stabilizer blade **1204**, for example, as discussed with respect to **Fig. 3**, to the total force required to break the shear pins of all of the stabilizer blades **1204** coupled to the stabilizer sleeve **1205**. For example, if three shear pins are used per blade for a three blade sleeve, each shear pin can be set to break at about 10,000 lbs (about 4500 kg), for a total force of about 90,000 lbs (about 41000 kg). The force required to release the stabilizer sleeve **1205** may fall between 10,000 lbs (about 4500 kg) and 30,000 lbs (about 1400 kg). The shearable devices **308** are not limited to shear pins, but can also include detents that lock the stabilizer blades **304** into place until the forces described are reached.

[0068] The shearing holes **1216** correspond to where the shearable devices **1208** were originally held in place. In some embodiments, retracting the cylindrical sleeve **1205** can expose the fluid jet nozzle **1218** (as seen in **Fig. 12C**), which can release a drilling fluid **1220** into the wellbore annulus.

[0069] In some embodiments, a hydraulic jet nozzle is included on the stabilizer track **1206** to release a drilling fluid into the wellbore annulus as the cylindrical sleeve **1205** slides or when the stabilizer blades are shifted downwards **Fig 14B**. The released drilling fluid can act as a lubricant or help displace some of the obstructive debris. If drilling is to be resumed, the drill string may be pushed downward, and the cylindrical sleeve **1205** can slide back to its original position at the upper mechanical stop **1210**.

[0070] **Fig. 13** is a front view of a three-blade sleeve stabilizer. The three-blade sleeve stabilizer **1300** can have a stabilizer body **1302**, three stabilizer blades **1304** connected to a cylindrical sleeve **1305**, and a central annulus **1306** through which drilling fluid or mud can pass through. The stabilizer blades **1304** are extended outward to form a larger effective diameter, as shown in **Fig. 13**. The larger effective diameter helps keep a drill string stable when drilling. When the drill string is pulled upward and the stabilizer blades **1304** are caught by obstructions in the well, the stabilizer blades **1304** retain the effective diameter. The drill string can be pushed

and pulled repeatedly in order to use the stabilizer blades **1304** as a hammer to dislodge the obstructions.

[0071] **Figs. 14A** and **14B** are side views of a three-blade spiral stabilizer with blades extended and retracted. The three-blade spiral stabilizer **1400** can have a stabilizer body **1402** with three one-piece stabilizer blades **1404**, each contained in a stabilizer blade slot **1406**, which may be angled inward. Each stabilizer blade slot **1406** is aligned at an angle to the axis of the drill string. The one-piece stabilizer blades **1404** may be held in place by shearable devices **1408** such as shear pins or ball detents. The stabilizer blade slots **1406** may each contain an upper mechanical stop **1410** and a lower mechanical stop **1412** that serve to prevent the one-piece stabilizer blades **1404** from sliding past a certain point. The three-blade stabilizer **1400** can be inserted into a drill string by a drill string connection **1414**, which can be a conventional pin or box thread. The drill string connection **1414** may point towards the drill bit of the drill string.

[0072] **Fig. 14A** represents the three-blade stabilizer **1400** during drilling operation in a well, when the one-piece stabilizer blades **1404** are extended outward, and held in place by the shearable devices **1408** and the upper mechanical stop **1410**. When the drill string is pulled upwards, one or more of the one-piece stabilizer blades **1404** may encounter an obstruction in the well. If enough force is applied onto the one-piece stabilizer blade **1404**, the shearable devices **1408** can release the one-piece stabilizer blade **1404**, allowing it to slide down the stabilizer blade slot **1406** until reaching the lower mechanical stop **1412**. The amount of force required for the shearable devices **1408** to release the one-piece stabilizer blade **1404** of a spiral stabilizer may be similar to the force required to release a stabilizer blade of a straight stabilizer. If the stabilizer blade slot **1406** is angled inward, the one-piece stabilizer blade **1404** can retract into the three-blade stabilizer **1400** as shown in **Fig. 14B**. Because the stabilizer blade slot **1406** is at an angle to the axis of the drill string, the one-piece stabilizer blade **1404** moves around the stabilizer body **1402** in a spiral-like path, revealing shearing holes **1416**. The shearing holes **1416** correspond to where the shearable devices **1408** were originally held in place. If the stabilizer blade slot **1406** is angled into the drill pipe, the one-piece stabilizer blade **1404** can retract into the three-blade stabilizer as shown in **Fig. 14B**. In some embodiments, retracting the one-piece stabilizer blade **1404** can expose the fluid jet nozzle **1418** (as seen in **Fig. 14C**), which can release a drilling fluid **1420** into the

wellbore annulus. If drilling is to be resumed, the drill string may be pushed downward, and the one-piece stabilizer blade **1404** can slide back to its original position at the upper mechanical stop **1410**.

[0073] **Fig. 15** is a process flow chart of a method of minimizing drill string sticking between a stabilizer and an obstruction in a well. The method **1500** can be performed by the embodiments discussed above, or any stabilizer that includes a stabilizer blade operatively coupled to a track.

[0074] At block **1502**, the stabilizer blade rotates along with a drill string during drilling operation. At this stage, the stabilizer blade remains static at a first position along the axis of the drill string. In some embodiments, the stabilizer blade can be held in place by an upper mechanical stop to prevent it from sliding up the drill string's axis, or by one or more shearable devices such as shear pins or detents.

[0075] At block **1504**, the stabilizer blade can establish contact with an obstruction in the wellbore due to the larger effective diameter formed by the stabilizer blade. This event can occur after drilling operation has been completed, as the drill string is pulled upward towards the surface.

[0076] At block **1506**, the stabilizer blade slides downward along the track due to the force imposed by the obstruction. A lower mechanical stop may be included on the stabilizer to prevent the stabilizer blade from sliding past a certain point. In some embodiments, the stabilizer blade retracts into a tapered slot in the stabilizer, reducing the effective diameter and allowing the stabilizer to bypass the obstruction. In other embodiments, the stabilizer blade is coupled to a cylindrical sleeve, which retains its effective diameter. The sleeve can be used as a hammer to dislodge the obstruction as the drill string is pushed and pulled repeatedly. In some embodiments, the act of sliding the stabilizer blade also reveals (or unseals) a hydraulic jet nozzle configured to release a drilling fluid into the wellbore annulus to assist in bypassing or dislodging the obstruction.

[0077] At block **1508**, the stabilizer blade can slide into the first position if the drill string is lowered. This stage can occur if drilling operation is to resume once more.

[0078] While the present invention may be susceptible to various modifications and alternative forms, the exemplary embodiments discussed above have been shown only by way of example. However, it should again be understood that the invention is not intended to be limited to the particular embodiments disclosed

herein. Indeed, the present invention includes all alternatives, modifications, and equivalents falling within the true spirit and scope of the appended claims.

CLAIMS

What is claimed is:

1. A stabilizer comprising:
a track disposed along a tubular body; and
a stabilizer blade operatively coupled to the track, wherein the track allows the stabilizer blade to slide from a first position to a second position.
2. The stabilizer of claim 1, comprising a shearable device configured to hold the stabilizer blade in the first position along the track.
3. The stabilizer of claim 2, wherein the shearable device is configured to allow the stabilizer blade to move from the first position in response to a particular force differential between the stabilizer blade and the tubular.
4. The stabilizer of claim 3, wherein the particular force differential is at least about 10,000 kg.
5. The stabilizer of claim 3, wherein each stabilizer blade is configured to move independently of other stabilizer blades.
6. The stabilizer of claim 3, comprising a detent mechanism configured to hold the stabilizer blade in the first position along the track.
7. The stabilizer of claim 6, wherein the detent mechanism is configured to reengage the stabilizer blade upon the return of the stabilizer blade to the first position.
8. The stabilizer of claim 1, comprising a mechanical stop configured to prevent the stabilizer blade from sliding past the second position on the track.
9. The stabilizer of claim 1, comprising an angled track configured to move the stabilizer blade into a recessed position along the tubular body.

10. The stabilizer of claim 1, wherein the track is aligned along with the axis of the tubular body.

11. The stabilizer of claim 1, wherein the track is aligned at an angle to the axis of the tubular body.

12. The stabilizer of claim 1, wherein the stabilizer blade comprises a first piece and a second piece, the first piece configured to slide along a slot on the second piece.

13. The stabilizer of claim 1, wherein the stabilizer blade is mounted on a stabilizer sleeve.

14. The stabilizer of claim 1, comprising a hydraulic jet nozzle on the track, wherein the hydraulic jet nozzle is configured to release fluid into the annulus of the tubular body.

15. The stabilizer of claim 14, wherein the hydraulic jet nozzle is blocked when the stabilizer blade is in the first position.

16. The stabilizer of claim 14, wherein the hydraulic jet nozzle is exposed when the stabilizer blade is in the second position.

17. A method for stabilizing a drill string in a wellbore, comprising:
advancing the drill string into the wellbore;
centering the drill string with a plurality of stabilizer blades disposed along the drill string, wherein each of the plurality of stabilizer blades remains at a first position on a track as the drill string is advanced into the wellbore; and
retracting the drill string in the wellbore, wherein a stabilizer blade will slide to a second position along the track in response to being caught on an obstruction in the wellbore.

18. The method of claim 17, comprising releasing a fluid from a hydraulic jet nozzle on the track into the annulus of the wellbore.

19. The method of claim 17, comprising retracting the stabilizer blade to a smaller effective diameter when the stabilizer blade slides to the second position.

20. The method of claim 17, comprising moving the drill string axially to dislodge the obstruction.

21. A stabilizer comprising a stabilizer blade operatively coupled to a track, wherein if the stabilizer blade encounters an obstruction in a wellbore as the drill string is being retracted in the wellbore, the stabilizer blade slides on the track.

22. The stabilizer of claim 21, comprising a shearable device holding the stabilizer blade in a single position on the track, the shearable device configured to release the stabilizer blade at a preset axial force.

23. The stabilizer of claim 21, wherein the track comprises a mechanical stop to prevent the stabilizer blade from moving past a point on the drill string.

24. The stabilizer of claim 21, comprising an angled or tapered track that is configured to allow the stabilizer blade to retract to a smaller effective diameter when sliding.

25. The stabilizer of claim 21, wherein the stabilizer blade can return to its original position on the drill string.

26. The stabilizer of claim 21, wherein the stabilizer blade is aligned along with the axis of the drill string.

27. The stabilizer of claim 21, wherein the stabilizer blade is aligned at an angle to the axis of the drill string.

28. The stabilizer of claim 21, wherein the stabilizer blade comprises two pieces, wherein a first piece slides along a slot on a second piece.

29. The stabilizer of claim 28, wherein the first piece slides at a different force than the second piece.

30. The stabilizer of claim 21, wherein the stabilizer blade is coupled with a stabilizer sleeve that retains its effective diameter when sliding.

31. The stabilizer of claim 21, comprising a hydraulic jet nozzle to release fluid into the annulus of the wellbore.

32. A method of minimizing drill string sticking between a stabilizer blade and an obstruction in a wellbore, comprising:

- rotating a stabilizer blade with a drill string while the stabilizer blade remains in a first position on the drill string;
- establishing contact with an obstruction as the drill string is pulled;
- sliding along a track until a second position is reached; and
- moving to the first position as the drill string moves down for drilling.

33. The method of claim 32, comprising retracting the stabilizer blade to a smaller effective diameter when the stabilizer blade slides to the second position.

34. The method of claim 32, comprising releasing fluid from a hydraulic jet nozzle into the wellbore.

35. A system for improving the probability of recovery of a drill string in a wellbore:

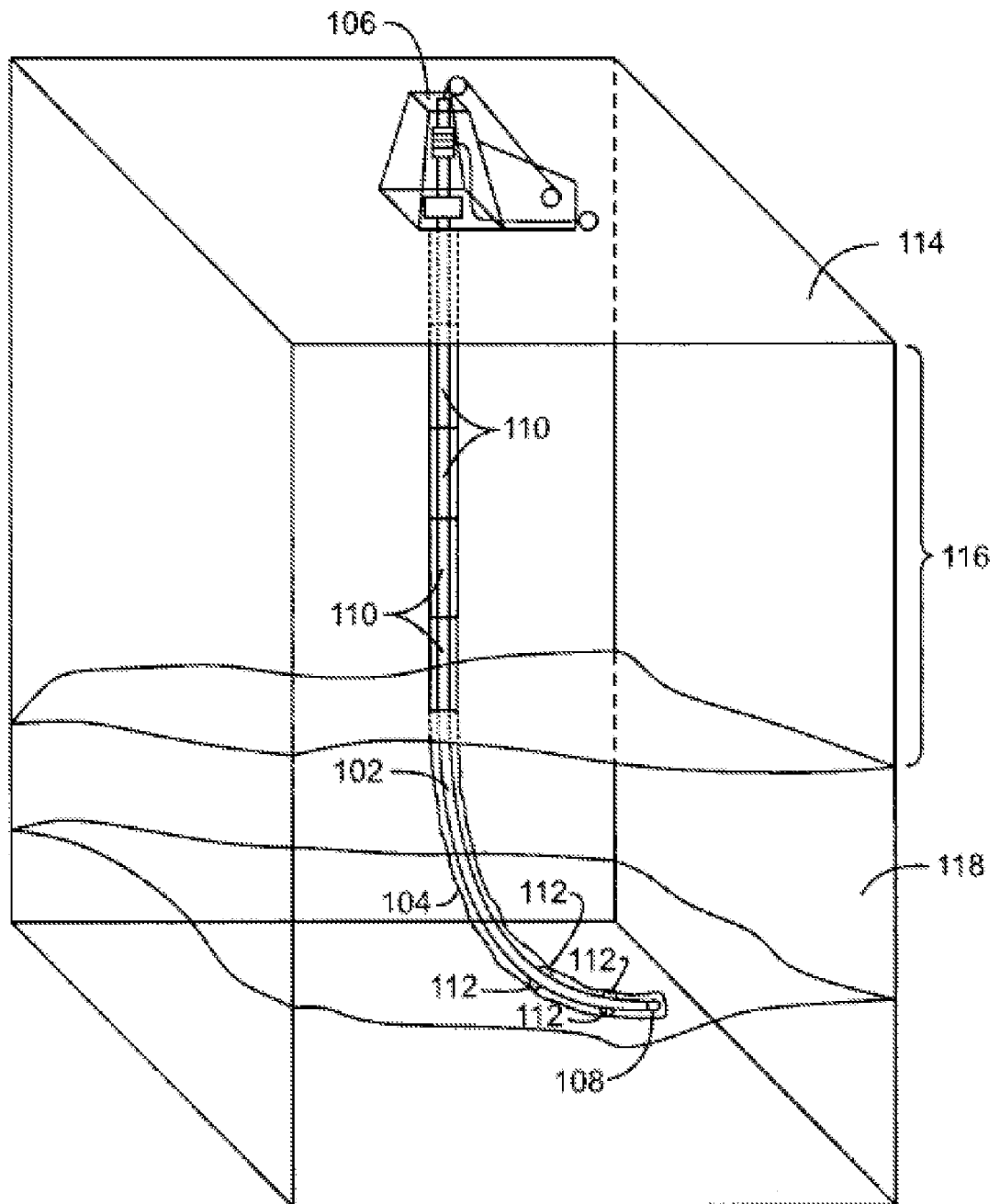
- a drill string; and
- a stabilizer comprising a stabilizer blade, wherein:
 - the stabilizer blade is operatively coupled to a track; and
 - if the stabilizer blade encounters an obstruction in the wellbore, the stabilizer blade slides on the track.

36. The system of claim 35, wherein the stabilizer blade comprises two pieces, wherein a first piece slides along a slot on a second piece.

37. The system of claim 35, wherein the stabilizer blade is coupled with a stabilizer sleeve that retains its effective diameter when sliding.

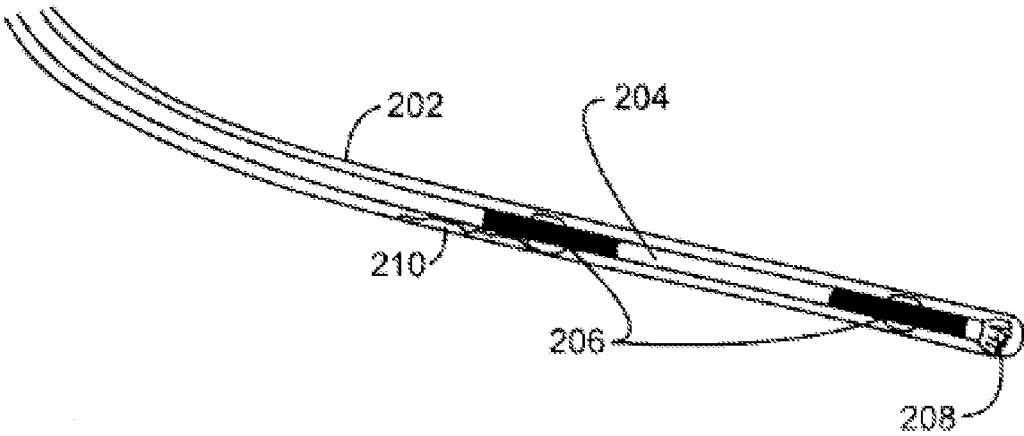
38. The system of claim 35, further comprising a wellbore drilled using the drillstring and stabilizer and hydrocarbons recovered from hydrocarbon recovery operations utilizing the wellbore.

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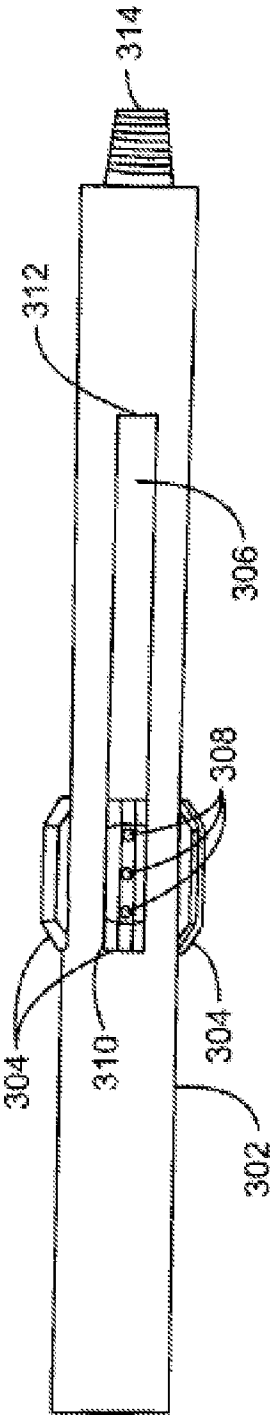


100
FIG. 1

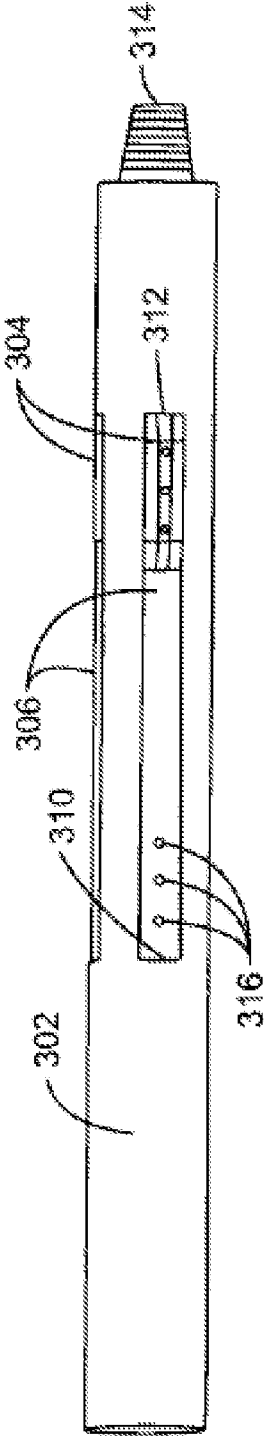
2/20



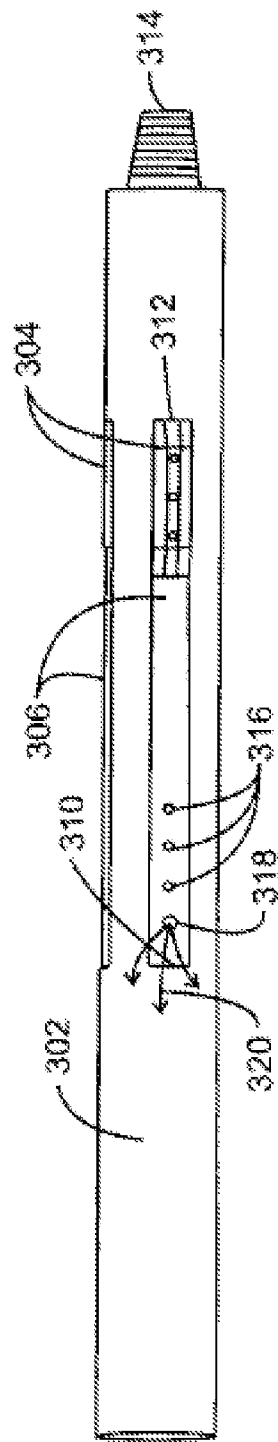
200
FIG. 2



300
FIG. 3A

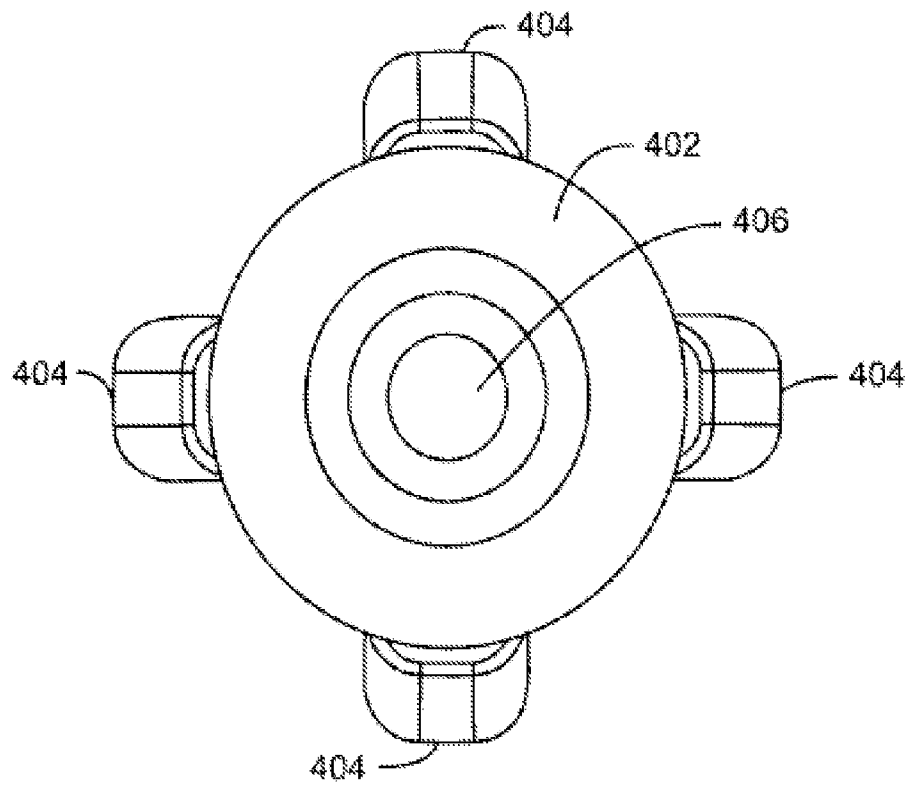


300
FIG. 3B

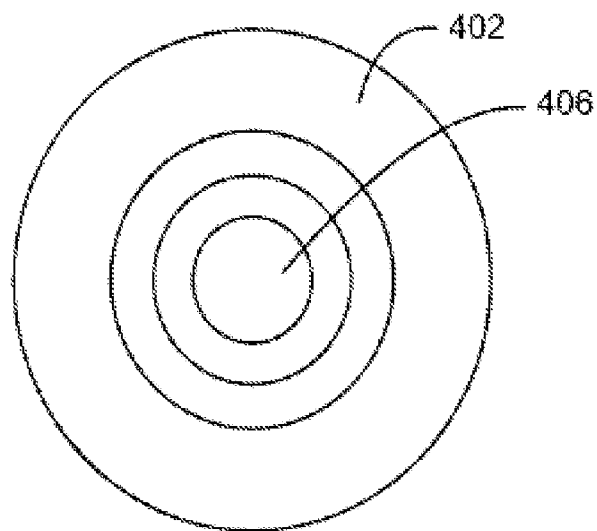


300
FIG. 3C

5/20

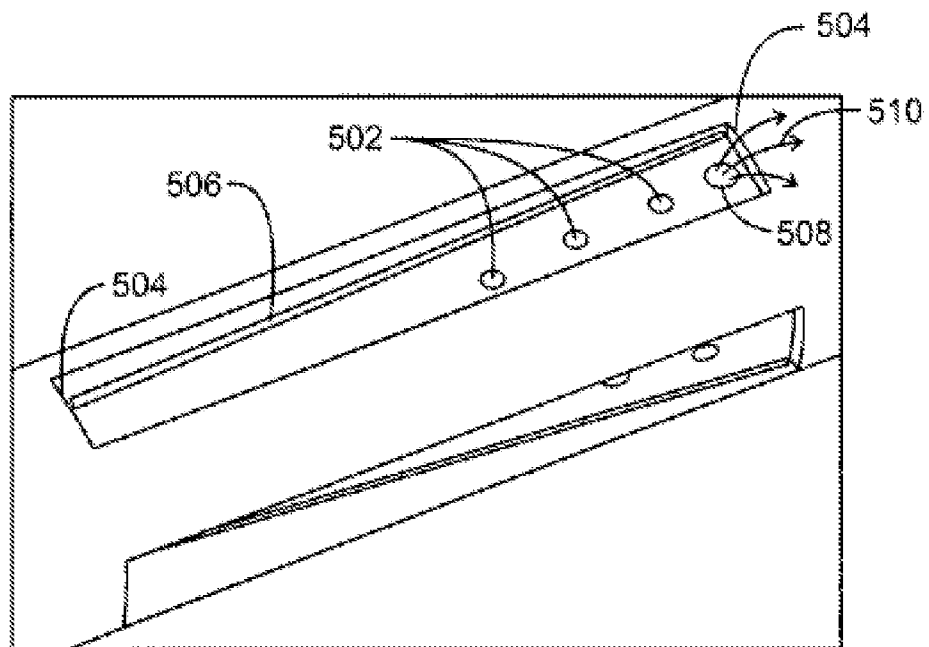


400
FIG. 4A



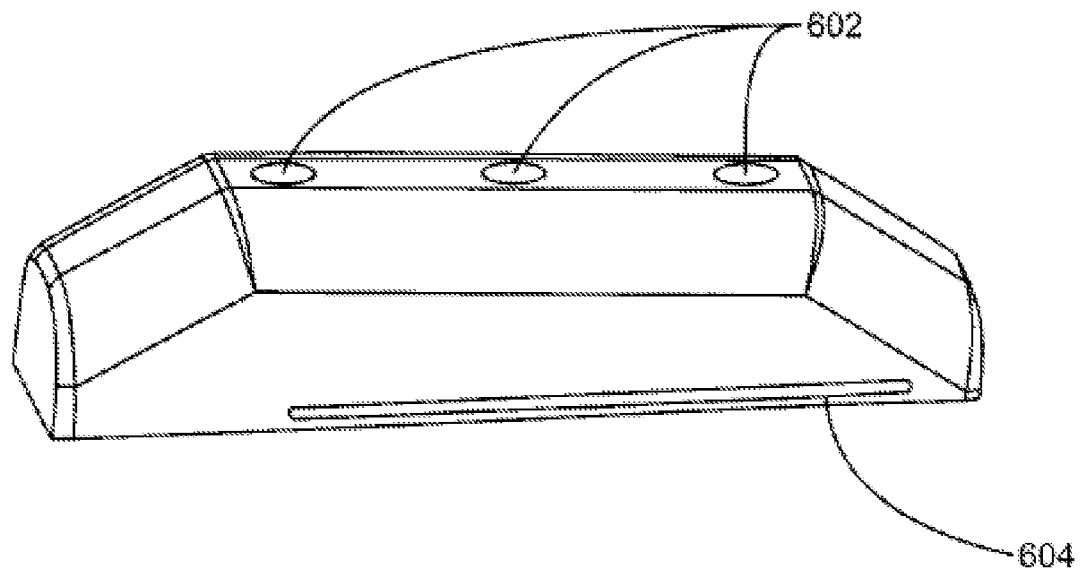
400
FIG. 4B

6/20

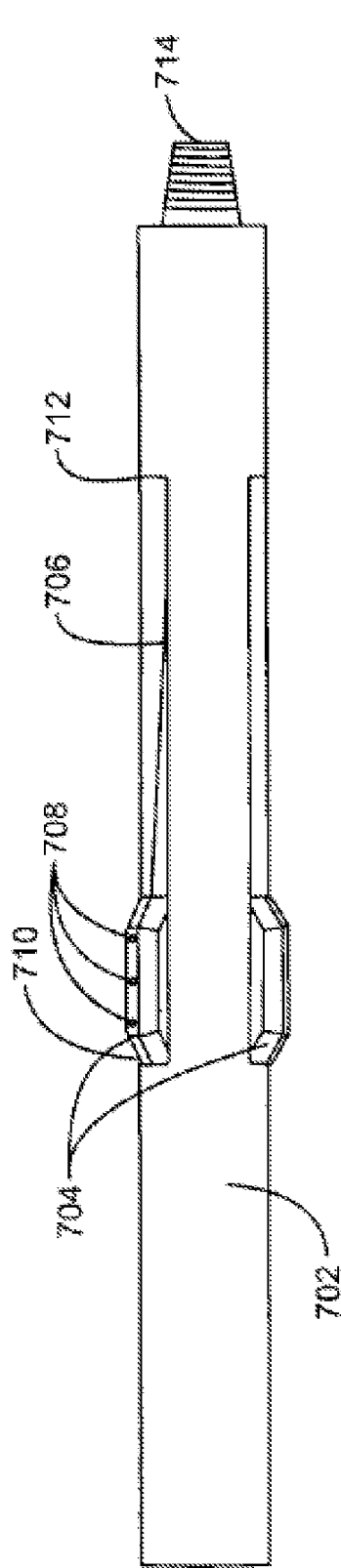


500
FIG. 5

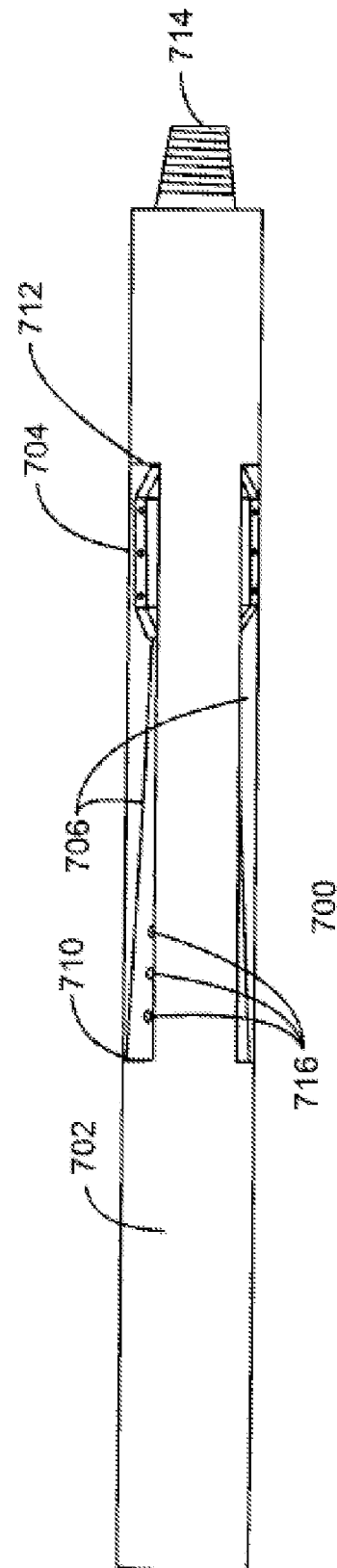
7/20



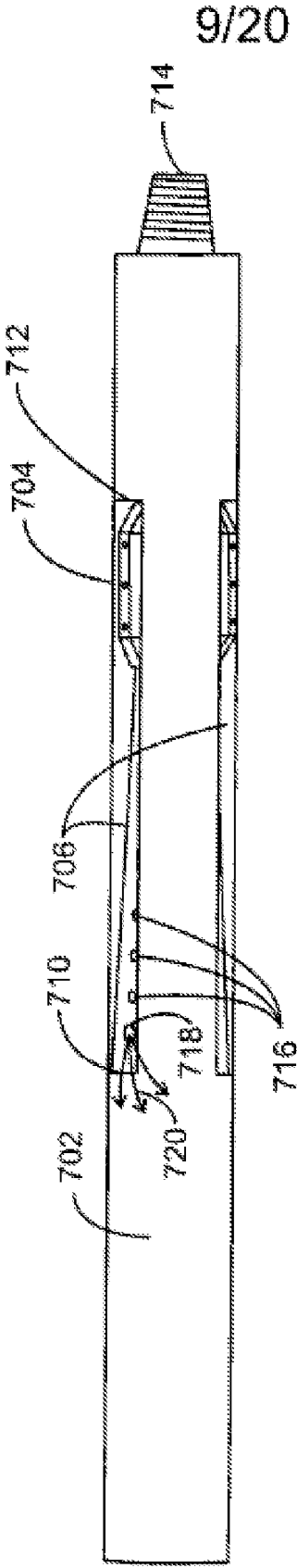
600
FIG. 6



700
FIG. 7A

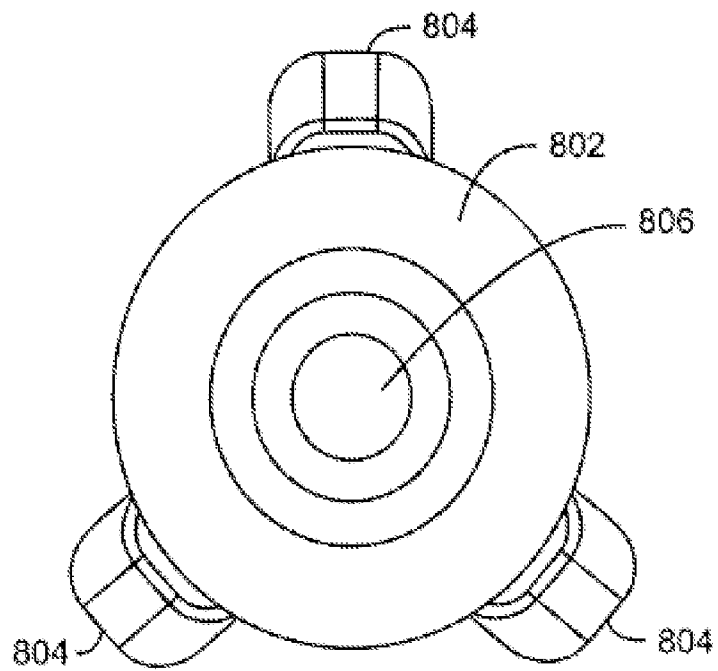


700
FIG. 7B

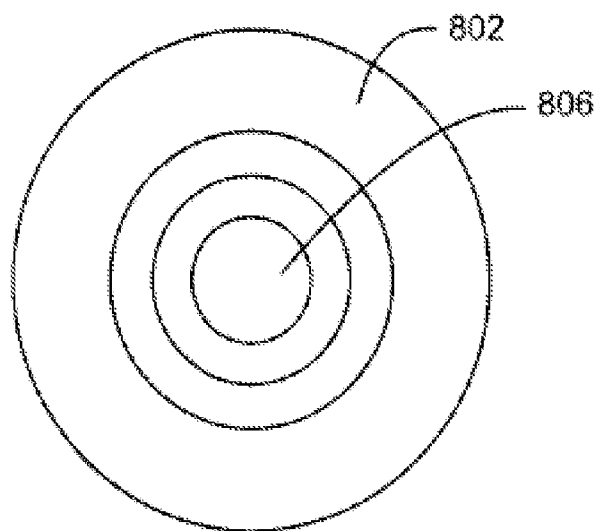


700
FIG. 7C

10/20

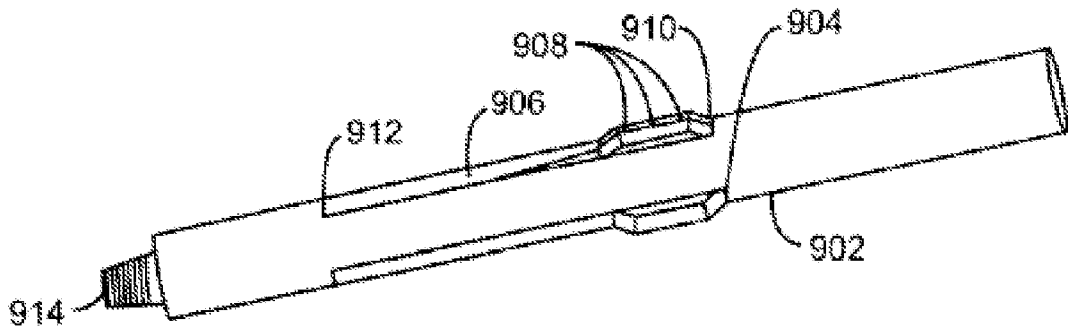


800
FIG. 8A

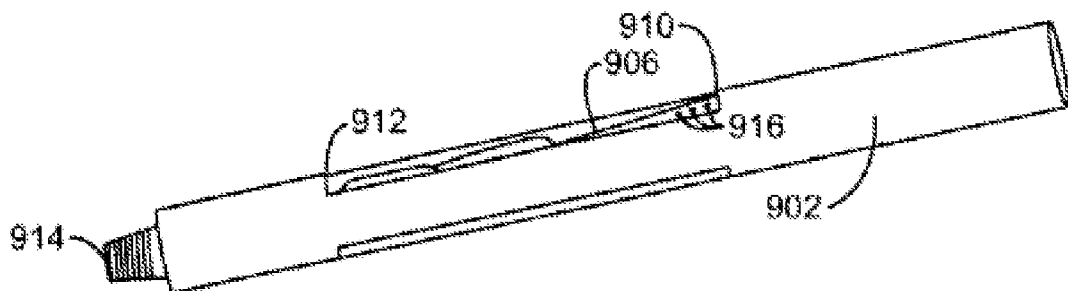


800
FIG. 8B

11/20

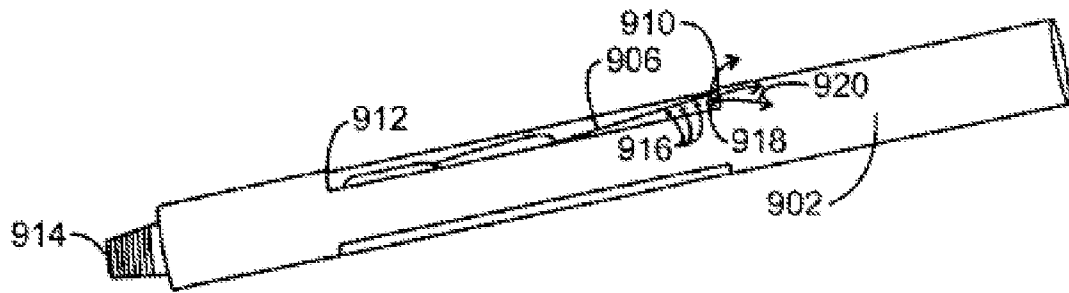


900
FIG. 9A



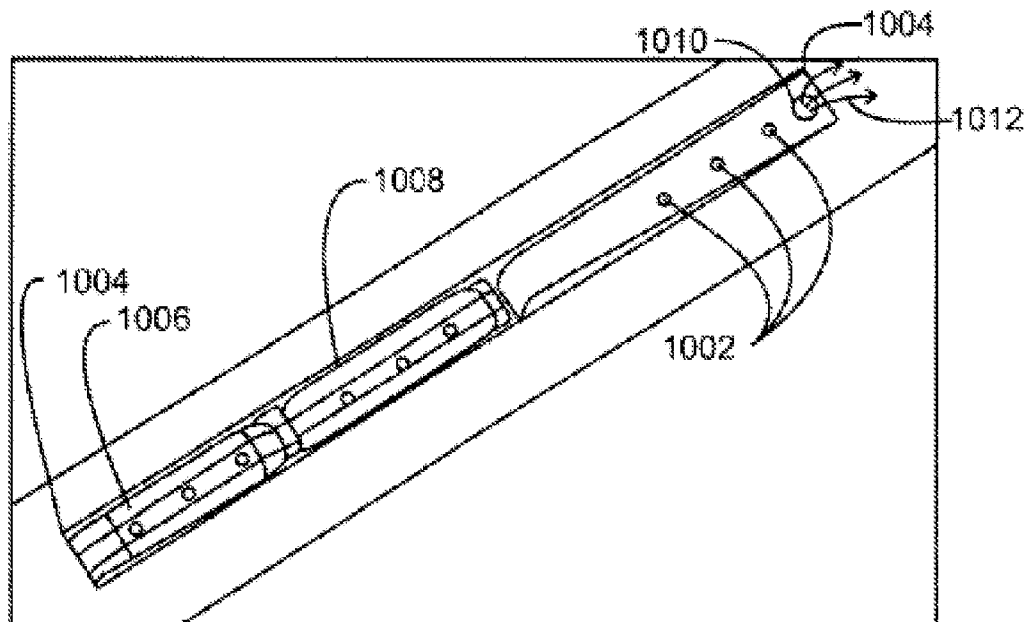
900
FIG. 9B

12/20

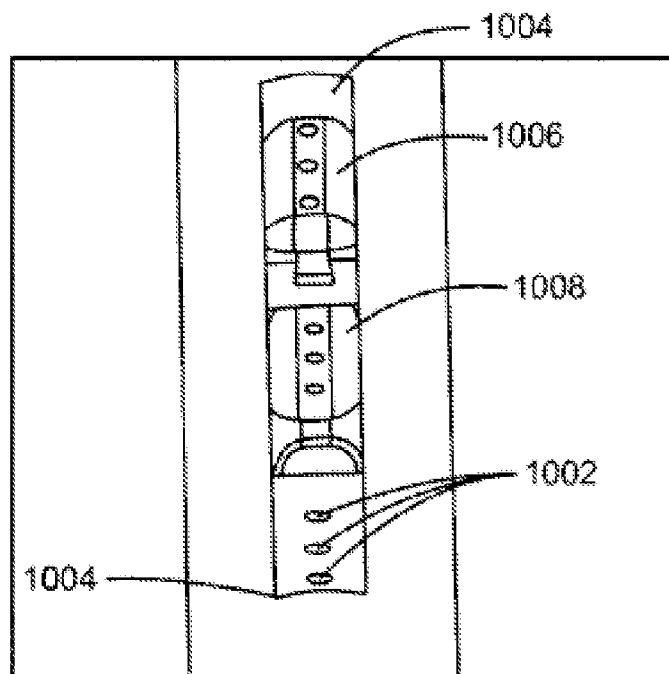


900
FIG. 9C

13/20

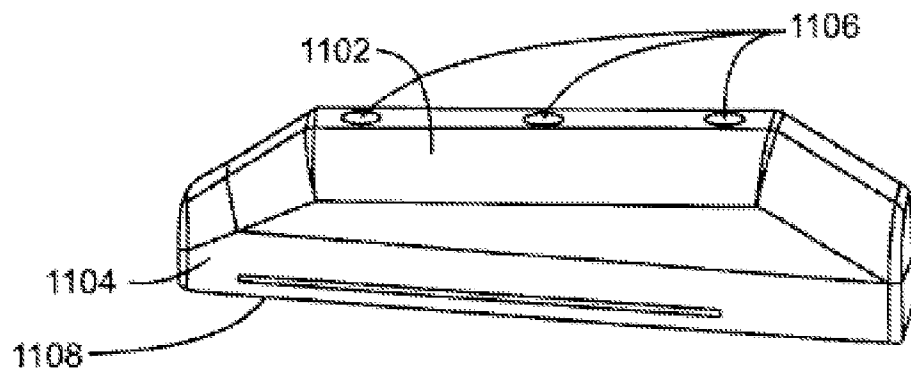


1000
FIG. 10A

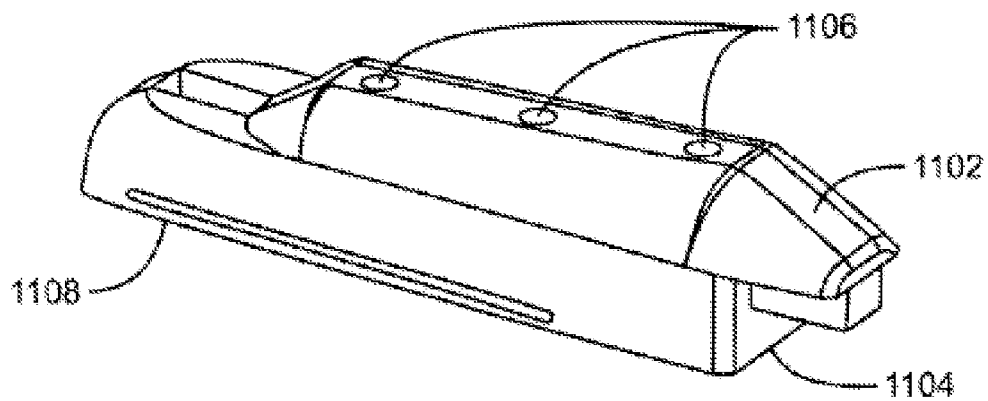


1000
FIG. 10B

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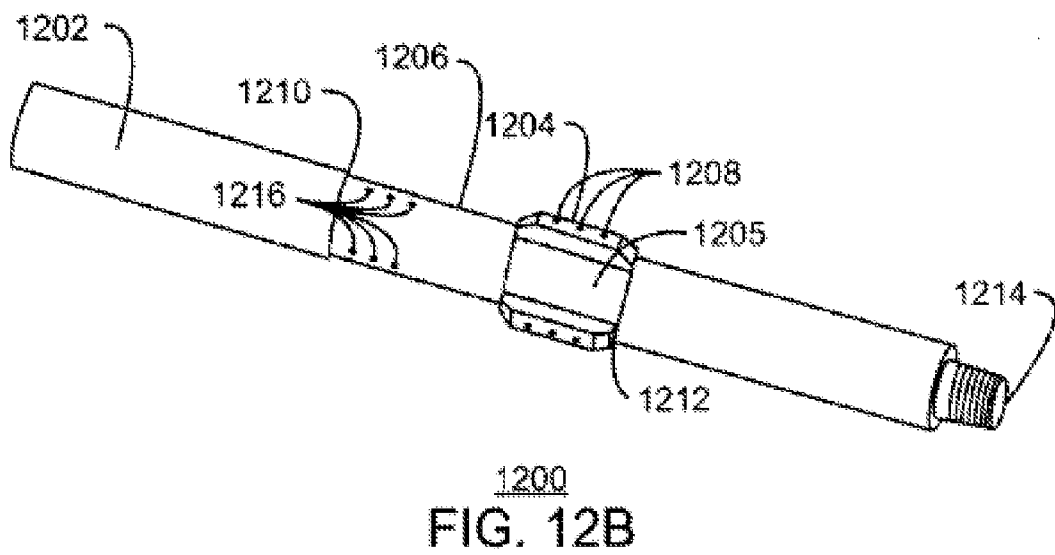
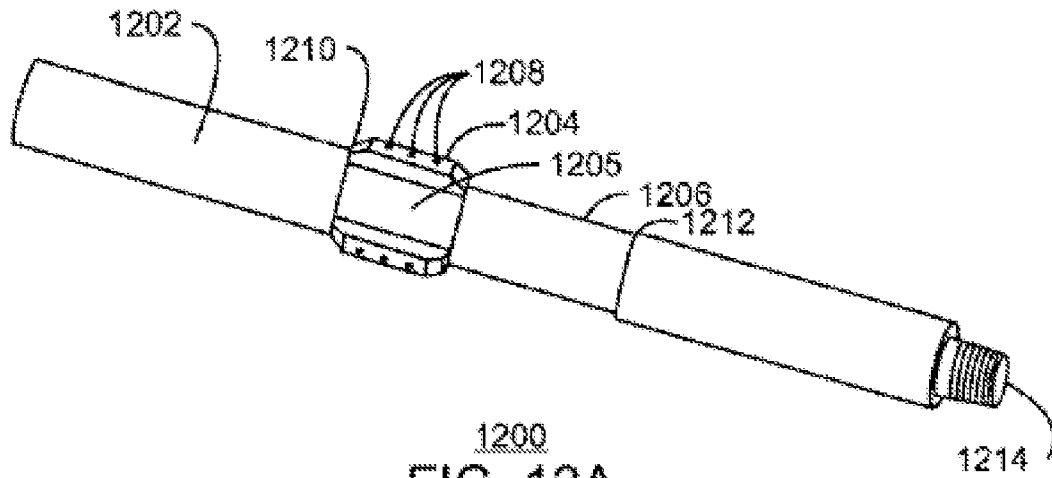


1100
FIG. 11A

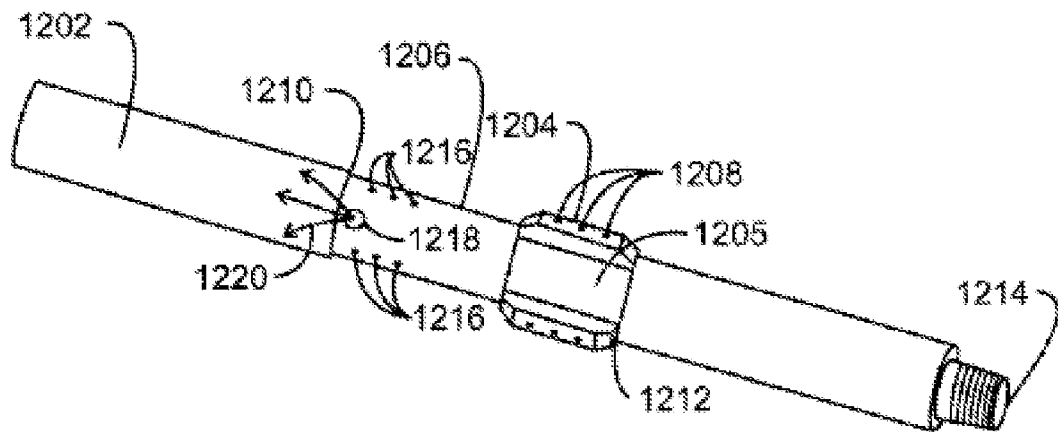


1100
FIG. 11B

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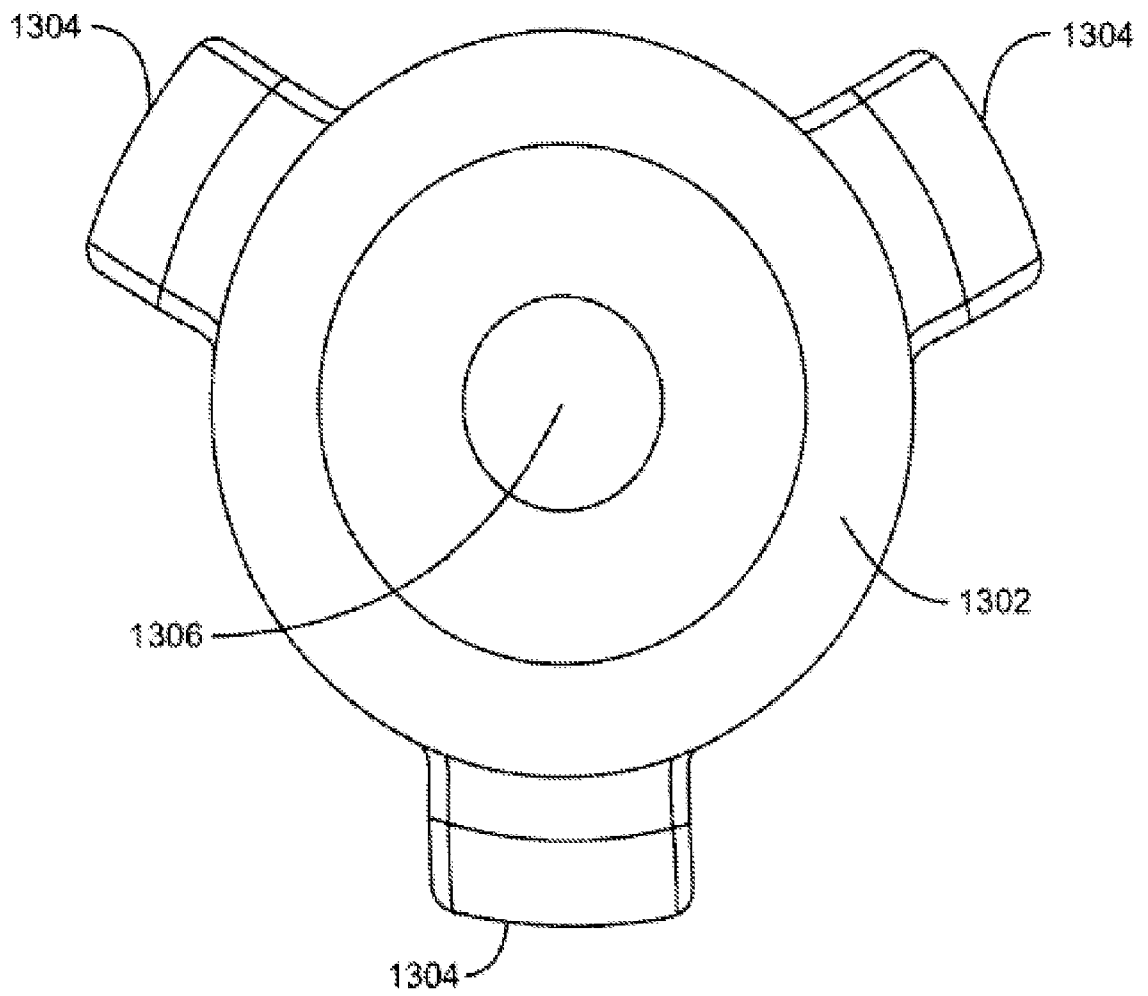


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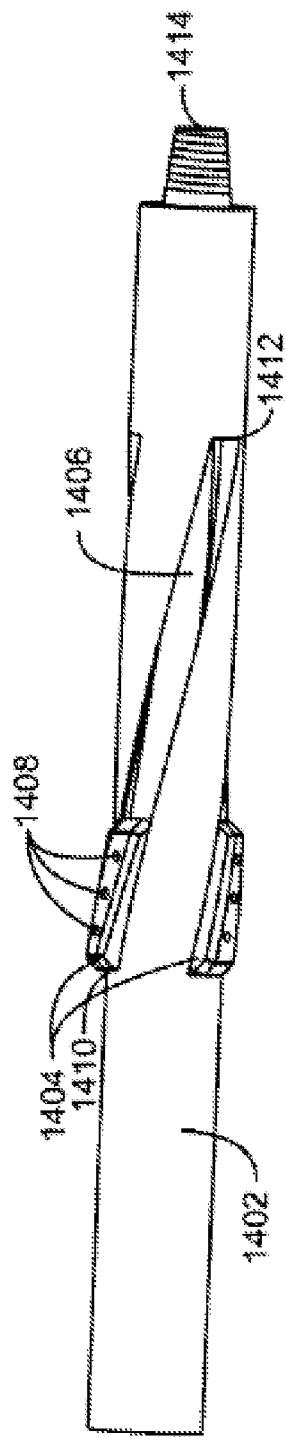


1200
FIG. 12C

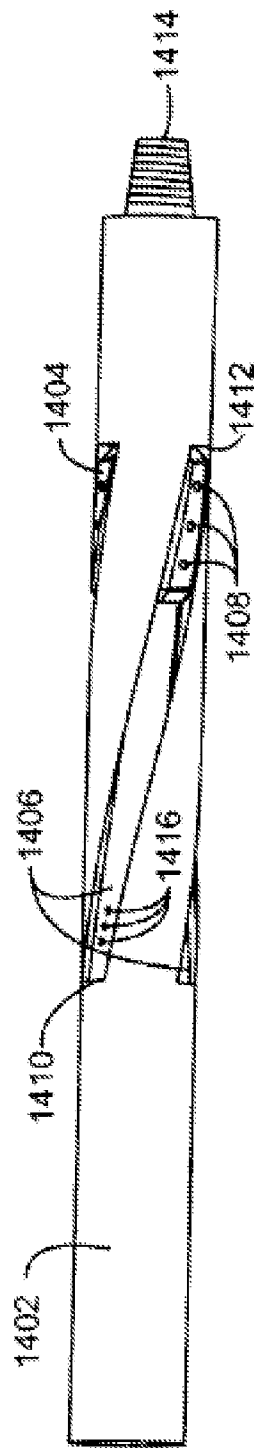
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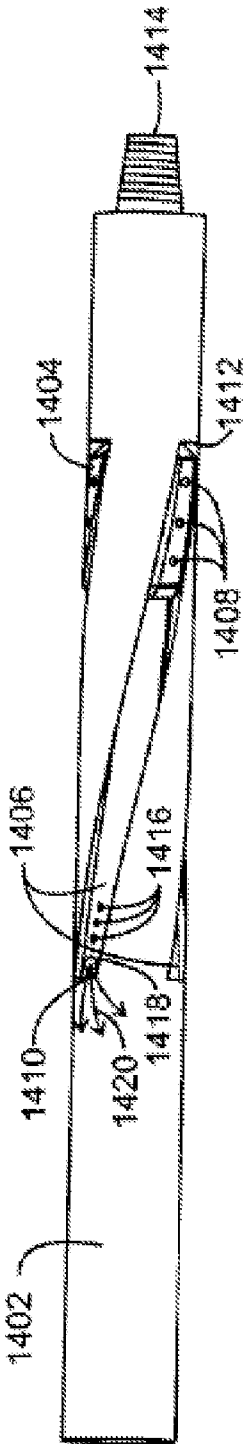
1300
FIG. 13



1400
FIG. 14A

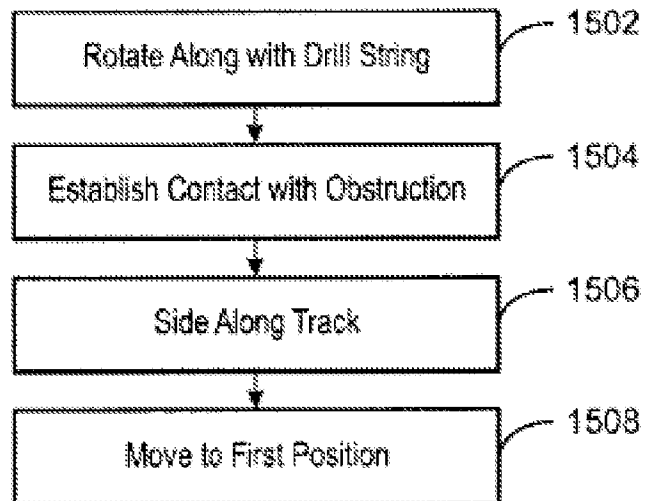


1400
FIG. 14B



1400
FIG. 14C

20/20



1500
FIG. 15

INTERNATIONAL SEARCH REPORT

PCT/US13/62300 24.02.2014

International application No.

PCT/US13/62300

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - E21B 7/28, 10/26, 10/32 (2014.01)

USPC - 175/57, 265, 268

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)

IPC(8) Classification(s): E21B 7/00, 7/28, 10/26, 10/28, 10/32 (2014.01)

USPC Classification(s): 76/108.4; 175/57, 263, 265, 268

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

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

MicroPatent (US Granted, US Applications, EP-A, EP-B, WO, JP, DE-G, DE-A, DE-T, DE-U, GB-A, FR-A); ProQuest; Google; GoogleScholar; KEYWORDS: drill string*, well*bore*, stabilizer*, reamer*, blade*, wing*, track*, slide*, Exxonmobil

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2008/0128169 A1 (RADFORD, S et al.) June 5, 2008; figures 2, 4, 12; paragraphs [0002]-[0003], [0028], [0030]-[0032], [0038]-[0039], [0044]-[0050]	1-4, 6-14, 16-19, 21-28, 30-38
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Y		5
Y	WO 2010/127450 A1 (HARVEY, M) November 11, 2010; figures 1, 2; page 2, lines 14-26; page 8, lines 4-13	5
A	US 2009/0266614 A1 (MEISTER, M) October 29, 2009; entire document	1-38
A	US 2013/0256034 A1 (POTEET III, C) October 3, 2013; entire document	1-38

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"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

11 February 2014 (11.02.2014)

Date of mailing of the international search report

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