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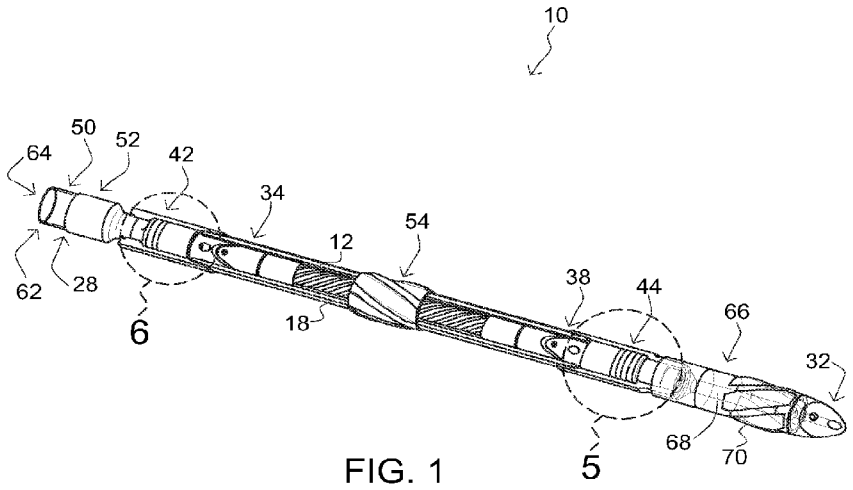

FIG. 1

(57) Abstract: A reaming assembly (10) having an inner mandrel (12) including spiral lobes disposed on an outer surface thereof. The inner mandrel (12) is hollow and is sized large enough to freely pass a standard drill bit therethrough. The reaming assembly (10) includes an outer mandrel (18) disposed around the inner mandrel (12) and includes spiral lobes disposed on an inner surface of the outer mandrel. The outer mandrel (18) has a number of spiral lobes equal to the number of spiral lobes of the inner mandrel (12) plus one. The reaming assembly includes a spacing between the outer surface of the inner mandrel (12) and the inner surface of the outer mandrel (18) through which fluid is pumped to generate torque therebetween; wherein at least one of the inner and outer mandrel is free to rotate.

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A REAMING SYSTEM, DEVICE, AND ASSEMBLY

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

The present invention relates to drilling, specifically to reaming systems, assemblies, and devices, including reaming assemblies associated to horizontal drilling.

DESCRIPTION OF THE RELATED ART

A reamer is a type of rotary cutting tool used to clean and/or enlarge the size of a previously formed hole, generally to leave the sides of the hole sufficiently smooth for later purposes. The process of so cleaning and/or enlarging the hole is called reaming. There are many different types of reamer and they may be designed for use as a hand tool or in a machine tool, such as a milling machine or drill press, in drilling system for drilling for oil, and/or in other earth drilling contexts, etc.

In the context of drilling for oil, once a hole is drilled, the hole so drilled will generally not maintain a clean, smooth profile. Drilling changes the fundamental characteristics of the surrounding and produces a void with respect to pressure, water content, and even chemical interactions may occur by exposing the materials surrounding the hole to the air. Further, natural layering, fissures, facture lines and etc. may react different to the hole than the surrounding material. Accordingly, such holes will often end up with discontinuities that make it difficult to operate the hole as desired. Thus, reaming systems/devices may be used to make the sides of the hole sufficiently smooth for continued operation. Also, it is often useful to follow the reaming with a pipe that then prevents further distortion of the surrounding material from intruding on the working portion of the hole.

Where a pipe follows the reaming device, it would be difficult and expensive to retrieve the reaming device since the pipe is literally right behind the device and the device must have a large enough profile to make room for the pipe. Accordingly, the reaming device is generally left in the hole at the bottom of the pipe. Wherein further drilling needs to occur, the drill will generally just drill through the reaming device on its way past.

Horizontal drilling includes added difficulties, especially including difficulties in sliding tools/mandrels/pipes/etc. inside the hole, since the weight of such will rest against the side of the hole. This makes it much more difficult to advance a drill or reamer during horizontal operation.

Some improvements have been made in the field. Examples of references related to the present invention are described below in their own words, and the supporting teachings of each reference are incorporated by reference herein:

U.S. Patent No.: 2,084,096, issued to Everett, discloses a self-supporting, self-guiding rotary oil well drilling, apparatus and "particularly to that type embodying two rotary drill bits, two rotary drill stems therefor and an operating block for operating the said rotary drill bits and stems, a-gatherer, container and retainer for drill bit cuttings, a propelling shaft therefor and differential gears for operating the said shaft, and electrically driven motors for operating the aforesaid mechanism, however, while the present invention is embodied in an apparatus of this type, there are certain features which may of course be utilized in rotary oil well drilling apparatus different from the specific form shown, and other means of power such as steam, hydraulic or compressed

air pressure may be utilized in actuating and rotating the drill bits and other mechanism in connection with the operation of the aforesaid rotary oil well drilling apparatus.

U.S. Patent No.: 7,823,657, issued to Zeni, discloses drilling assemblies, drilling reamer arm assemblies, and methods of drilling. In one implementation, a drilling assembly includes a cutting head apparatus configured to cut into earthen material as the cutting head apparatus is rotated. A drive shaft extends aft of and is configured to rotate the cutting head apparatus. A plurality of reamer arm assemblies projects radially outward of the drive shaft and are mounted for rotation therewith aft of the cutting head apparatus. Individual of the reamer arm assemblies include a radial inner portion extending radially outward of the drive shaft. A radial outer portion connects with and extends radially outward of the radial inner portion. The radial outer portion includes a cutter. At least one breakaway retainer fastens the radial inner and outer portions together and restrains the radial outer portion from moving relative to the radial inner portion towards the cutting head apparatus and the drive shaft. Other aspects are contemplated.

U.S. Patent No.: 7,938,204, issued to Buske, discloses a reamer bit for use in earth boring operations comprising a body, mounting elements on the bit body having rolling cutters, and nozzles configured to emit a cleaning spray that is angled with respect to the well bottom. The cleaning spray may be angled up to about 20.degree. with respect to the well bottom. The reamer may further include a pilot bit on a drill pipe extending downward from the reamer body.

U.S. Patent No.: 8,201,643, issued to Soby et al., discloses a system and method for enabling longitudinal and radial drilling in a wellbore is described. The system and method enable an operator to perforate the casing of a wellbore with an under-reamer at

the end of a drill string and, without removing the drill string from the wellbore, initiate and complete lateral jetting of the wellbore into the surrounding formation. The system utilizes a perforation tool having a ball seat, which upon seating a drop ball in the ball seat enables the perforation tool to move from a closed position to an open position thereby allowing access to the formation using a jetting tool. Prior to seating the drop ball, an under-reaming operation may be performed using a hydraulic pressure activated under-reaming tool.

U.S. Patent No.: 8,205,689, issued to Radford, discloses drilling systems and methods for enlarging a borehole that include at least one expandable reamer and at least one expandable stabilizer axially spaced therefrom in a tubular string, such as a drill string, the at least one expandable reamer and the at least one expandable stabilizer being independently actuatable by different-sized actuation devices. A relatively lower tool is actuatable by a smaller actuation device, such as a drop ball, which passes through a relatively higher tool in the drill string without triggering the higher tool.

The inventions heretofore known suffer from a number of disadvantages which include being limited in use, being expensive, not being powerful enough, failing to provide strong torque, being slow, resulting in slow reaming, not being scalable, failing to extend reach, failing to overcome obstructions, not allowing for an easy drill-through, failing to reduce the need for evacuation to push a casing, not being capable of drilling surface case and/or surface holes, not able to directionally drill surface holes, not allowing one to drill and run casing at the same time without rotating the entire casing, not allowing you to drill and run casing in a non-vertical hole, being unduly complex, being difficult to use, being limited in application, being limited in adaptability, being

limited in conversion, being limited in torque, having too slow a rotation, not being usable with a variety of shoes, and/or failing to prevent a shoe from falling off when drilling through the system.

What is needed is a reaming system, device and/or assembly that solves one or more of the problems described herein and/or one or more problems that may come to the attention of one skilled in the art upon becoming familiar with this specification.

SUMMARY OF THE INVENTION

The present invention has been developed in response to the present state of the art, and in particular, in response to the problems and needs in the art that have not yet been fully solved by currently available reaming systems. Accordingly, the present invention has been developed to provide an efficient and effective horizontal drilling and reaming assembly.

According to one embodiment of the invention, there is a reaming assembly that may include an inner mandrel that may have spiral lobes disposed on an outer surface thereof. The inner mandrel may be hollow. The hollow of the inner mandrel may be sized large enough to freely pass a standard drill bit therethrough.

The reaming assembly may include an outer mandrel that may be disposed around the inner mandrel and may have spiral lobes disposed on an inner surface of the outer mandrel. The outer mandrel may have a number of spiral lobes equal to the number of spiral lobes of the inner mandrel plus one. One of the inner and outer mandrel may be non-rotatably coupled to an end of a casing and the other may be non-rotatably coupled to a bit or shoe.

The reaming assembly may include a spacing that may be between the outer surface of the inner mandrel and the inner surface of the outer mandrel through which fluid may be pumped to generate torque therebetween; wherein at least one of the inner and outer mandrel may be free to rotate.

The reaming assembly may include an upper flow diverter that may divert fluid flow from a center region of the reaming assembly to the spacing between the inner and outer mandrels.

The reaming assembly may include a lower flow diverter that may divert fluid flow from the spacing between the inner and outer mandrels to a center region of the reaming assembly. The reaming assembly may include upper and lower bearing assemblies rotatably coupled between the inner and outer mandrels.

The reaming assembly may include an elongated tubular housing that may have a first end that may have a fluid inlet aperture. The elongated tubular housing may include a second end that may be disposed opposite the first end, and may have a fluid outlet aperture. The elongated tubular housing may include a coupling structure that may be at the first end of the housing that may be selectably mated with a bottom end of a casing tube.

The reaming assembly may include a reaming tool that may be functionally coupled to the inner or outer mandrel such that torque therefrom is transmitted to the reaming tool. The reaming assembly may include a casing tube that may be coupled to the housing.

Reference throughout this specification to features, advantages, or similar language does not imply that all of the features and advantages that may be realized with the present invention should be or are in any single embodiment of the invention. Rather, language referring to the features and advantages is understood to mean that a specific feature, advantage, or characteristic described in connection with an embodiment is included in at least one embodiment of the present invention. Thus, discussion of the features and advantages, and similar language, throughout this specification may, but do not necessarily, refer to the same embodiment.

Furthermore, the described features, advantages, and characteristics of the invention may be combined in any suitable manner in one or more embodiments. One skilled in the relevant art will recognize that the invention can be practiced without one or more of the specific features or advantages of a particular embodiment. In other instances, additional features and advantages may be recognized in certain embodiments that may not be present in all embodiments of the invention.

These features and advantages of the present invention will become more fully apparent from the following description and appended claims, or may be learned by the practice of the invention as set forth hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

In order for the advantages of the invention to be readily understood, a more particular description of the invention briefly described above will be rendered by reference to specific embodiments that are illustrated in the appended drawing(s). It is noted that the drawings of the invention are not to scale. The drawings are mere schematics representations, not intended to portray specific parameters of the invention. Understanding that these drawing(s) depict only typical embodiments of the invention and are not, therefore, to be considered to be limiting its scope, the invention will be described and explained with additional specificity and detail through the use of the accompanying drawing(s), in which:

Figure 1 is a perspective view of a reaming assembly with cutaway, according to one embodiment of the invention;

Figure 2 is a cross-sectional view of a an upper flow diverter of a reaming assembly, according to one embodiment of the invention;

Figure 3 is a perspective view of a reaming assembly with cut-away, according to one embodiment of the invention;

Figure 4 is a top plan cross-sectional view of an inner mandrel and an outer mandrel of a reaming assembly, according to one embodiment of the invention;

Figures 5 and 6 are perspective views of portions of a reaming assembly with cutaway, according to one embodiment of the invention; and

Figure 7 is a side elevational view of a reaming system, according to one embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

For the purposes of promoting an understanding of the principles of the invention, reference will now be made to the exemplary embodiments illustrated in the drawing(s), and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the invention is thereby intended. Any alterations and further modifications of the inventive features illustrated herein, and any additional applications of the principles of the invention as illustrated herein, which would occur to one skilled in the relevant art and having possession of this disclosure, are to be considered within the scope of the invention.

Reference throughout this specification to an "embodiment," an "example" or similar language means that a particular feature, structure, characteristic, or combinations thereof described in connection with the embodiment is included in at least one embodiment of the present invention. Thus, appearances of the phrases an "embodiment," an "example," and similar language throughout this specification may, but do not necessarily, all refer to the same embodiment, to different embodiments, or to one or more of the figures. Additionally, reference to the wording "embodiment," "example" or the like, for two or more features, elements, etc. does not mean that the features are necessarily related, dissimilar, the same, etc.

Each statement of an embodiment, or example, is to be considered independent of any other statement of an embodiment despite any use of similar or identical language characterizing each embodiment. Therefore, where one embodiment is identified as "another embodiment," the identified embodiment is independent of any other embodiments characterized by the language "another embodiment." The features,

functions, and the like described herein are considered to be able to be combined in whole or in part one with another as the claims and/or art may direct, either directly or indirectly, implicitly or explicitly.

As used herein, "comprising," "including," "containing," "is," "are," "characterized by," and grammatical equivalents thereof are inclusive or open-ended terms that do not exclude additional unrecited elements or method steps. "Comprising" is to be interpreted as including the more restrictive terms "consisting of" and "consisting essentially of."

Figure 1 is a perspective view of a reaming assembly with cutaway, according to one embodiment of the invention. There is shown a reaming assembly 10 including an outer mandrel 18 (partially cut-away) coupled to an upper and a lower flow diverters 34, 38 and an upper and lower bearing assemblies 42, 44, and an auger-like inner mandrel 12 disposed within the outer mandrel 18. Each of the two mandrels include spiral lobes facing towards each other (i.e. the lobes on the inner mandrel are on the outside, while the lobes of the out mandrel are on the inside, See Figure 4). The spiral lobes are mismatched such that they rotate against each other when fluid is pumped through the space between them and generate vibration (notation) as one rotates past the other.

According to one embodiment of the invention, there is a reaming assembly 10 for installing a casing 50 that generates sufficient torque to drill or ream through substantially any obstruction in a wellbore. The reaming assembly 10 agitates a drill string by generating a shock-wave due to the notation of a tool. This extends the reach of the casing 50 by creating agitation which in some extended reach wells (e.g. horizontal wells that are longer than the vertical section of the well) the assembly 10 could run the

casing 50 further than normally would be able to do without the need for extra hydraulic or mechanical evacuation. The strong torque allows the assembly 10 to drill with a casing bit. This is supposed to replace a jetting assembly in deep water operations. The power is generated by a long rotor/stator (generally, the longer the rotor, the more torque that will be generated). The external part of the whole tool rotates about the internal. There are two versions of the tool. In one, the inner mandrel (not shown) is the rotor (i.e. rotates) and the outer mandrel 18, as shown, is the stator (i.e. stays fixed relative to the casing). In the other, the outer mandrel 18 is the rotor (rotates) and the inner mandrel is the stator (does not rotate). The bit 32 at the front end is connected to whichever is the rotor so that the bit 32 turns as fluid is pumped through the assembly.

The rotor and stator or the inner and outer mandrels have spiral lobes that face each other and the lobes bouncing past each other during rotation is what causes the vibration/agitation. The inner mandrel may be hollow and sized so that a drill bit just passes through it and does not need to drill. The inner mandrel may also be of a drillable material so it may be drilled out. The version with the rotating outer mandrel 18, as shown, may be a more robust tool that may be appropriate for more challenging well types. The reaming assembly 10 will generally have one fewer lobes on the inner mandrel 12 as compared to the outer mandrel 18 and this allows for strong consistent torque.

This allows for better turning and prevents the lobes from matching and locking up. When making the assembly and putting the inner mandrel into the outer mandrel, the inner mandrel will turn into the outer mandrel so that the lobes match and it may fit. Whichever part, either the inner mandrel or the outer mandrel is connected to the casing

adapter 52, the shoe/bit 32 at the front is connected to the other, since that will be the one that rotates and the other may be fixedly coupled to the casing 50 which does not turn.

According to one embodiment of the invention, the reaming assembly 10 includes a casing 50, a casing adapter 52, an upper end cap, an upper bearing assembly 42, an upper flow diverter 34 (upper flow joint assembly), an inner mandrel, an outer mandrel 18, a centralizer 54, a lower flow diverter 38 (lower flow joint assembly), a lower bearing assembly 44, a lower cap, and a reamer shoe 32.

According to one embodiment of the invention, there is a casing 50, and a casing adapter 52 fixedly coupled to the casing 50 (casing mates into the casing adapter through a box connection) and to either the inner mandrel or the outer mandrel 18 and rotatably coupled to the other (could be via the upper cap) upper end cap (forces flow through the lobes and not through the hollow center of the inner mandrel) is fixedly connected to the outer mandrel and rotatably coupled to the upper bearing assembly. The upper bearing assembly is rotatably coupled between the inner mandrel and the outer mandrel. The upper flow diverter 34 (upper flow joint assembly) is in fluid connection between an interior of the casing 50 and the power section (the space between lobes that are facing each other) inner mandrel is disposed within the outer mandrel. The outer mandrel surrounds the inner mandrel. The centralizer is disposed around one or more of the casing adapter and the outer mandrel. The lower flow diverter 38 (lower flow joint assembly) is in fluid connection between the power section (the space between lobes that are facing each other) and the interior of the reamer shoe 32. The lower bearing assembly 44 is rotatably coupled between the inner mandrel and the outer mandrel. The lower cap (protects the lower bearing assembly) which is fixedly coupled to the outer

mandrel and either fixedly coupled to the shoe 32. If the outer mandrel is rotating or rotatably coupled to the shoe via a projection, if not the reamer shoe is fixedly coupled to the rotor (whichever one is rotating, i.e. inner or outer mandrel).

According to one embodiment of the invention, there is a hollow rotor having an external part of the tool which rotates along with the reamer shoe and the lobed power section. There may be a casing which may be any weight, size, strength, and/or grade. There may be a casing adapter to connect to a casing, which type may depend on the casing (e.g. box connection if the casing has a threaded end). There may be an upper end cap which may be sufficient to protect the bearing assembly and/or make any connections required at that region. There may be an upper bearing assembly, which may include but is not limited to ball bearings and friction bearings. There may be an upper flow diverter associated with or within an upper flow joint assembly. The upper flow diverter may be a drillable tube that diverts fluid flow from being central (i.e. how it is when it comes down the casing) to being medial (i.e. between the inner and outer mandrels).

There may be an internal/inner mandrel that may be hollow or not, may have continuous or discontinuous lobes, may have one fewer lobe than how many lobes are on an external/outer mandrel, and/or may consist essentially of a drillable material or not. There may be an external/outer mandrel that may generally comprise not drillable material which may generally be solid steel, may generally have one more lobe than an associated internal mandrel, and may generally include continuous or discontinuous lobes. There may be one or more centralizers that may be functionally coupled to an exterior surface of the assembly to help keep the assembly centered within a hole.

There may be a lower flow diverter that may be associated with or part of a lower flow joint assembly and may include a tube/channel that diverts flow from a medial region (i.e. between the inner and outer mandrels) to a more central region of the assembly (i.e. an interior cavity of a reaming shoe). There may be a lower bearing assembly similar to the upper bearing assembly. There may be a lower cap similar to an upper cap. There may be a reaming/reamer shoe such as but not limited to an eccentric nose reamer shoe or a casing bit.

The reaming assembly 10 includes an inner mandrel 12 that includes spiral lobes disposed on an outer surface thereof. The illustrated reaming assembly 10 includes an outer mandrel 18 disposed around the inner mandrel and has spiral lobes disposed on an inner/interior surface of the outer mandrel 18. One of the inner and outer mandrels are non-rotatably coupled to an end 28 of a casing 50 and the other is non-rotatably coupled to a bit or shoe 32. Thereby at least one of the inner and outer mandrel is free to rotate when fluid pumped through the space between the two lobed mandrels causes torque therebetween.

The illustrated reaming assembly 10 includes an upper flow diverter 34 to divert fluid flow from a center region, not shown in Figure 1, of the reaming assembly 10 to the spacing between the inner and outer mandrels. The reaming assembly 10 includes a lower flow diverter 38 to divert fluid flow from the spacing between the inner and outer mandrels to a center region of the reaming assembly 10. The illustrated reaming assembly 10 includes upper and lower bearing assemblies 42, 44 rotatably coupled between the inner and outer mandrels.

The casing 50 includes a first end 62 including a fluid inlet aperture 64 and a second end 66, disposed opposite the first end 62, and includes a fluid outlet aperture 68. The casing 50 includes a casing adapter 52 or a coupling structure that is at the first end 62 of the casing 50 that is selectably mated with a casing tube.

The reaming assembly 10 includes an auger 70 disposed within the casing and is functionally coupled to a lower bearing assembly 44 such that the auger may rotate with respect to an attached casing tube and including a rotation transmission structure that transfers rotation motion. The reaming assembly 10 includes a reaming tool, such as a bit or shoe 32 that is functionally coupled to the auger 70. The reaming assembly 10 includes a casing tube coupled to the casing 50.

Figure 2 is a cross-sectional view of a an upper flow diverter of a reaming assembly, according to one embodiment of the invention. There is shown an upper flow diverter 34 that diverts fluid flow from a center region 36 of the reaming assembly to a spacing 24 in between an inner mandrel 12 and an outer mandrel 18.

The illustrated upper flow diverter 34 that diverts fluid flow from a center region 36 of a reaming assembly to a spacing 24 between an inner mandrel 12 and an outer mandrel 18 of a reaming assembly. The inner mandrel 12 includes spiral lobes 14 disposed on an outer surface thereof. The inner mandrel 12 is hollow. The hollow of the inner mandrel 12 is sized large enough to freely pass a standard drill bit therethrough.

The outer mandrel 18 is disposed around the inner mandrel 12 and has spiral lobes 20 disposed on an inner surface of the outer mandrel 18. The outer mandrel 18 generally has a number of spiral lobes 20 equal to the number of spiral lobes 14 of the inner mandrel 12 plus one 26. The one-lobe difference between the inner and outer mandrels

has thus far been an optimum number of lobes to produce the best torque and notation within the reaming devices/assemblies/systems. One of the inner and outer mandrels are non-rotatably coupled to an end of a casing and the other is non-rotatably coupled to a bit or shoe.

The illustrated spacing 24 is between the outer surface of the inner mandrel 12 and the inner surface of the outer mandrel 18 through which fluid is pumped to generate torque therebetween; wherein at least one of the inner 12 and outer mandrels 18 is free to rotate. The upper flow diverter 34 diverts fluid flow from a center region of the reaming assembly to the spacing 24 between the inner and outer mandrels 12, 18. There is also a lower flow diverter, not shown in Figure 2, that diverts fluid flow from the spacing 24 between the inner and outer mandrels 12, 18 to a center region 36 of the reaming assembly.

Figure 3 is a perspective view of a reaming assembly with cutaway, according to one embodiment of the invention. There is shown a reaming assembly 10 including an outer mandrel 18, coupled to an upper and a lower flow diverters 34, 38 and an upper and lower bearing assemblies 42, 44.

The reaming assembly 10 includes an inner mandrel 12 that includes spiral lobes disposed on an outer surface thereof. The illustrated reaming assembly 10 includes an outer mandrel 18 disposed around the inner mandrel and has spiral lobes disposed on an inner surface of the outer mandrel 18, not shown in Figure 1. One of the inner and outer mandrels are non-rotatably coupled to an end 28 of a casing 50 and the other is non-rotatably coupled to a bit or shoe 32. At least one of the inner and outer mandrel is free to rotate.

The illustrated reaming assembly 10 includes an upper flow diverter 34 to divert fluid flow from a center region, not shown in Figure 1, of the reaming assembly 10 to the spacing between the inner and outer mandrels. The reaming assembly 10 includes a lower flow diverter 38 to divert fluid flow from the spacing between the inner and outer mandrels to a center region of the reaming assembly 10. The illustrated reaming assembly 10 includes upper and lower bearing assemblies 42, 44 rotatably coupled between the inner and outer mandrels.

The casing 50 includes a first end 62 including a fluid inlet aperture 64 and a second end 66, disposed opposite the first end 62, and includes a fluid outlet aperture 68. The casing 50 includes a casing adapter 52 or a coupling structure that is at the first end 62 of the casing 50 that is selectably mated with a casing tube.

The reaming assembly 10 includes an auger 70 disposed within the casing and is functionally coupled to a lower bearing assembly 44 such that the auger may rotate with respect to an attached casing tube and including a rotation transmission structure that transfers rotation motion. The reaming assembly 10 includes a reaming tool, such as a bit or shoe 32 that is functionally coupled to the auger 70. The reaming assembly 10 includes a casing tube coupled to the casing 50.

Figure 4 is a top plan cross-sectional view of an inner mandrel and an outer mandrel of a reaming assembly, according to one embodiment of the invention. An upper flow diverter diverts fluid flow from a center region of a reaming assembly to a spacing 24 in between the inner mandrel 12 and the outer mandrel 18.

The illustrated upper flow diverter 34 that diverts fluid flow from a center region 36 of a reaming assembly to a spacing 24 between an inner mandrel 12 and an outer

mandrel 18 of a reaming assembly. The inner mandrel 12 includes spiral lobes 14 disposed on an outer surface thereof. The inner mandrel 12 is hollow. The hollow of the inner mandrel 12 is sized large enough to freely pass a standard drill bit therethrough.

The outer mandrel 18 is disposed around the inner mandrel 12 and has spiral lobes 20 disposed on an inner surface of the outer mandrel 18. The outer mandrel 18 has a number of spiral lobes 20 equal to the number of spiral lobes 14 of the inner mandrel 12 plus one. In particular, the illustrated inner mandrel has nine lobes while the illustrated outer mandrel has ten lobes. One of the inner and outer mandrels are non-rotatably coupled to an end of a casing and the other is non-rotatably coupled to a bit or shoe.

The illustrated spacing 24 is between the outer surface of the inner mandrel 12 and the inner surface of the outer mandrel 18 through which fluid is pumped to generate torque therebetween; wherein at least one of the inner 12 and outer mandrels 18 is free to rotate. The upper flow diverter diverts fluid flow from a center region of the reaming assembly to the spacing 24 between the inner and outer mandrels 12, 18.

Figures 5 and 6 are partial cutaway views of lower and upper bearing assemblies (44 and 42) of Figure 1 respectively.

Each of the lower and upper bearing assemblies includes a port 41 and 21 that provides fluid connection between the center region and the spacing between the two mandrels, with the lower port 41 allowing for a return of the fluid to the central region after it flows between the two mandrels and the upper port allowing for the fluid to divert from the central region to then flow between the two mandrels towards the lower portion of the assembly 10 (See Figure 1). One of the inner and outer mandrels are non-rotatably coupled to an end of a casing and the other is non-rotatably coupled to a bit or shoe 32.

At least one of the inner and outer mandrel is free to rotate and by operation of lower and upper bearing packs 43 and 23 respectively.

The illustrated reaming assembly 10 includes an upper flow diverter 34 to divert fluid flow from a center region, not shown in Figure 1, of the reaming assembly 10 to the spacing between the inner and outer mandrels. The reaming assembly 10 includes a lower flow diverter 38 to divert fluid flow from the spacing between the inner and outer mandrels to a center region of the reaming assembly 10. The illustrated reaming assembly 10 includes upper and lower bearing assemblies 42, 44 rotatably coupled between the inner and outer mandrels.

The casing 50 includes a first end 62 including a fluid inlet aperture 64 and a second end 66, disposed opposite the first end 62, and includes a fluid outlet aperture 68. The casing 50 includes a casing adapter 52 or a coupling structure that is at the first end 62 of the casing 50 that is selectably mated with a casing tube.

The reaming assembly 10 includes an auger 70 disposed within the casing and is functionally coupled to a lower bearing assembly 44 such that the auger may rotate with respect to an attached casing tube and including a rotation transmission structure that transfers rotation motion. The reaming assembly 10 includes a reaming tool, such as a bit or shoe 32 that is functionally coupled to the auger 70. The reaming assembly 10 includes a casing tube coupled to the casing 50.

Figure 7 is a side elevational view of a reaming system, according to one embodiment of the invention. There is shown a reaming system 11 designed to cut the final size and finish of a horizontal drill hole. Generally, a reaming system, device, etc. will not make the original hole, but instead, enlarge and/or clean or otherwise make more

smooth the interior of a previously drilled or bored hole. The illustrated reaming system 11 includes a rig structure (derrick) 14 supporting a casing 13 lead by a mandrel assembly 38 that is disposed within a hole 39. The derrick 14 includes structure and devices to operate the mandrel assembly and to permit the addition of more casing sections as the mandrel assembly works its way down the hole. Accordingly, the reaming system 11 advantageously allows for a hole to be reamed and lined with a casing for future operations, such as but not limited to oil production. Similar reaming systems may be constructed for reaming in other contexts, wherein the derrick is replaced with appropriate support structure and/or wherein the casing may or may not be present.

The illustrated reaming system 11 includes a derrick 14 for supporting the components and parts of the reaming system 11 during use. A derrick is a lifting device generally including a guyed mast, as in a gin pole, which may be articulated over a load by adjusting its guys. The term derrick is also applied to the framework supporting a drilling apparatus in an oil rig.

The illustrated derrick includes a crown block 83. The illustrated crown block 83 is functionally coupled to a traveling block 82 that travels vertically within the derrick 14. A crown block is the stationary section of a block and tackle that contains a set of pulleys or sheaves through which the drill line (wire rope) is threaded and is opposite and above the traveling block. A traveling block is the freely moving section of a block and tackle that contains a set of pulleys or sheaves through which the drill line (wire rope) is threaded is opposite (and under) the crown block (the stationary section). The combination of the traveling block, crown block and wire rope drill line gives the ability

to lift weights in the hundreds of thousands of pounds. On larger drilling rigs, when raising and lowering the derrick, line tensions over a million pounds are not unusual.

The illustrated derrick 14 includes a motor 84 or other power source that may be used to operate one or more pumps, winches, drills, and/or the like and combinations thereof. The motor 84 may be used to pump fluid through the casing and thereby through the mandrel assembly to cause a shoe at a bottom portion of the mandrel assembly to rotate at high speeds and with strong torque to effectively ream the hole.

The illustrated derrick 14 also includes a blowout preventer 86 functionally coupled around a top of the hole 39. The blowout preventer 86 is generally a large, specialized valve or similar mechanical device, usually installed redundantly in stacks, used to seal, control and monitor oil and gas wells. Blowout preventers were developed to cope with extreme erratic pressures and uncontrolled flow (formation kick) emanating from a well reservoir during drilling. Kicks may lead to a potentially catastrophic event known as a blowout. In addition to controlling the down hole (occurring in the drilled hole) pressure and the flow of oil and gas, blowout preventers are intended to prevent tubing (e.g. drill pipe and well casing), tools and drilling fluid from being blown out of the wellbore (also known as bore hole, the hole leading to the reservoir) when a blowout threatens. Blowout preventers improve the safety of crew, rig (the equipment system used to drill a wellbore) and environment, and to the monitoring and maintenance of well integrity; thus blowout preventers are intended to provide fail-safety to the systems that include them.

The reaming system 11 includes a mandrel assembly 38 coupled to a bottom end of the casing 13 and configured to ream a drill hole when a shoe is coupled to a bottom

end thereof. The mandrel assembly 38 may be coupled to the bottom end of the casing in a variety of manners, including but not limited to mating threads, snap-fits, friction fitting, adhesives, bolts, and the like and combinations thereof. The mandrel assembly 38 grips a shoe, which is the operating component that interfaces with the interior of the hole to be reamed and abrades away material, thereby reaming the hole. The shoe generally includes protrusions that, when the shoe spins, impact with non-smooth regions of the interior of the hole and thereby abrade the same making such regions more smooth and increasing the effective interior diameter of the same so that the casing can follow behind without getting stuck.

Generally, after the drilling is completed for a particular section of a hole, one puts a casing down the hole to create a smooth interior bore through which additional work may be completed. However, the hole is generally not perfect and often includes defects that can stop the casing from going all the way down. Accordingly, it is desirable to put a reaming tool, the operating tip of which is usually called a shoe, towards the bottom to ream out the hole as the casing slides down.

In one non-limiting embodiment, there is a reaming system, device, and/or mandrel assembly that is, advantageously, a low costs system that attaches to any of a great variety of shoes (e.g. float shoe, reamer shoe, guide shoe) from a variety of manufacturers. It includes an internal/central axle that rotates inside a housing and/or includes a pin-down connection (e.g. pin to pin, box-pin) to couple to a shoe so it can connect to any tool/shoe. The internal axle spins when you pump fluid through the mandrel assembly and spins a sub that is connected to the shoe which therefore also spins. The internal axle and/or other centrally positioned parts are generally of an

aluminum and/or zinc alloy (or other material that may be drilled through rather easily, since the mandrel assembly is generally left at a bottom of the hole when the casing is finished being installed). There is an internal corkscrew/auger shaped set of blades/lobes that cause the internal axle to rotate and thus cause the tool to rotate when fluid is pumped through the housing that contains the corkscrew/auger.

It is understood that the above-described embodiments are only illustrative of the application of the principles of the present invention. The present invention may be embodied in other specific forms without departing from its spirit or essential characteristics. The described embodiment is to be considered in all respects only as illustrative and not restrictive. The scope of the invention is, therefore, indicated by the appended claims rather than by the foregoing description. All changes which come within the meaning and range of equivalency of the claims are to be embraced within their scope.

For example, although the illustrated system/assembly includes a single centralizer, the invention may be practiced without multiple centralizers or even with no centralizer.

Additionally, although the figures illustrate an outer mandrel having ten spiral lobes on an interior thereof, a different number of lobes and/or lobes of different slopes, curvatures, sizes, shapes and the like may be present.

Finally, it is envisioned that the components of the device may be constructed of a variety of materials, including but not limited to metals (both drillable and not), plastics, ceramics, composites and the like and combinations thereof.

Thus, while the present invention has been fully described above with particularity and detail in connection with what is presently deemed to be the most practical and preferred embodiment of the invention, it will be apparent to those of ordinary skill in the art that numerous modifications, including, but not limited to, variations in size, materials, shape, form, function and manner of operation, assembly and use may be made, without departing from the principles and concepts of the invention as set forth in the claims. Further, it is contemplated that an embodiment may be limited to consist of or to consist essentially of one or more of the features, functions, structures, methods described herein.

What is Claimed is:

1. A reaming power assembly, comprising:

a) an inner mandrel having spiral lobes disposed on an outer surface thereof;

b) an outer mandrel disposed around the inner mandrel and having spiral lobes disposed on an inner surface of the outer mandrel; and

c) a spacing between the outer surface of the inner mandrel and the inner surface of the outer mandrel through which fluid may be pumped to generate torque therebetween; wherein at least one of the inner and outer mandrel is free to rotate.

2. The assembly of Claim 1, wherein the outer mandrel has a number of spiral lobes equal to the number of spiral lobes of the inner mandrel plus one.

3. The assembly of Claim 1, wherein one of the inner and outer mandrel is non-rotatably coupled to an end of a casing and the other is non-rotatably coupled to a bit or shoe.

4. The assembly of Claim 1, further comprising an upper flow diverter that diverts fluid flow from a center region of the reaming assembly to the spacing between the inner and outer mandrels.

5. The assembly of Claim 1, further comprising a lower flow diverter that diverts fluid flow from the spacing between the inner and outer mandrels to a center region of the reaming assembly.

6. The assembly of Claim 1, wherein the inner mandrel is hollow.

7. The assembly of Claim 6, wherein the hollow of the inner mandrel is sized large enough to freely pass a standard drill bit therethrough.

8. The assembly of Claim 1, further comprising upper and lower bearing assemblies rotatably coupled between the inner and outer mandrels.

9. The assembly of Claim 1, further comprising:

a) an elongated tubular housing, including:

a1) a first end having a fluid inlet aperture;

a2) a second end, opposite the first end, having a fluid outlet aperture; and

a3) a coupling structure at the first end of the housing that selectably mates with a bottom end of a casing tube.

10. The assembly of Claim 9, further comprising a reaming tool functionally coupled to an end of the assembly such that torque therefrom may be used to rotate the reaming tool.

11. The assembly of Claim 9, further comprising a casing tube coupled to the housing.

12. A reaming device, comprising:

a) a hollow inner mandrel having spiral lobes disposed on an outer surface thereof;

b) an outer mandrel disposed around the inner mandrel and having spiral lobes disposed on an inner surface of the outer mandrel; and

c) a spacing between the outer surface of the inner mandrel and the inner surface of the outer mandrel through which fluid may be pumped to generate torque therebetween; wherein at least one of the inner and outer mandrel is free to rotate; wherein the outer mandrel has a number of spiral lobes equal to the number of spiral lobes of the inner mandrel plus one.

13. The device of Claim 12, wherein one of the inner and outer mandrel is non-rotatably coupled to an end of a casing and the other is non-rotatably coupled to a bit or shoe.

14. The device of Claim 13, further comprising an upper flow diverter that diverts fluid flow from a center region of the reaming assembly to the spacing between the inner and outer mandrels.

15. The device of Claim 14, further comprising a lower flow diverter that diverts fluid flow from the spacing between the inner and outer mandrels to a center region of the reaming assembly.

16. The device of Claim 15, wherein the hollow of the inner mandrel is sized large enough to freely pass a standard drill bit therethrough.

17. The device of Claim 16, further comprising upper and lower bearing assemblies rotatably coupled between the inner and outer mandrels.

18. The device of Claim 17, further comprising:

a) an elongated tubular housing, including:

a1) a first end having a fluid inlet aperture;

a2) a second end, opposite the first end, having a fluid outlet aperture; and

a3) a coupling structure at the first end of the housing that selectably mates with a bottom end of a casing tube;

b) a first bearing pack disposed circumferentially about the first end of the housing; and

c) a reaming tool functionally coupled to the auger.

19. The device of Claim 18, further comprising a casing tube coupled to the housing

20. A reaming system, comprising:

a) an inner mandrel having spiral lobes disposed on an outer surface thereof; wherein the inner mandrel is hollow; wherein the hollow of the inner mandrel is sized large enough to freely pass a standard drill bit therethrough;

b) an outer mandrel disposed around the inner mandrel and having spiral lobes disposed on an inner surface of the outer mandrel;

c) a spacing between the outer surface of the inner mandrel and the inner surface of the outer mandrel through which fluid may be pumped to generate torque therebetween; wherein at least one of the inner and outer mandrel is free to rotate; wherein the outer mandrel has a number of spiral lobes equal to the number of spiral lobes of the inner mandrel plus one; wherein one of the inner and outer mandrel is non-rotatably coupled to an end of a casing and the other is non-rotatably coupled to a bit or shoe;

d) an upper flow diverter that diverts fluid flow from a center region of the reaming assembly to the spacing between the inner and outer mandrels;

e) a lower flow diverter that diverts fluid flow from the spacing between the inner and outer mandrels to a center region of the reaming assembly;

f) an upper and lower bearing assemblies rotatably coupled between the inner and outer mandrels;

g) an elongated tubular housing, including:

g1) a first end having a fluid inlet aperture;

g2) a second end, opposite the first end, having a fluid outlet aperture; and

g3) a coupling structure at the first end of the housing that selectably mates with a bottom end of a casing tube;

h) a first bearing pack disposed circumferentially about the first end of the housing;

i) a reaming tool functionally coupled to the inner mandrel or outer mandrel such that torque therefrom rotates the reaming tool; and

j) a casing tube coupled to the housing.

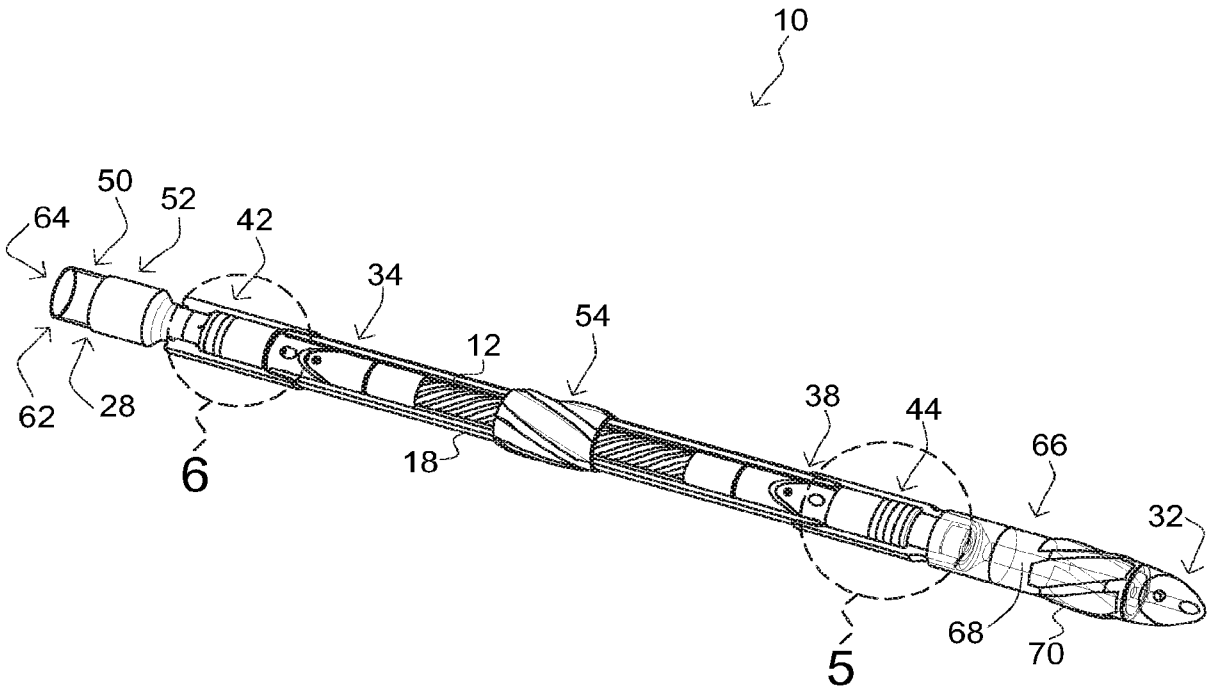

FIG. 1

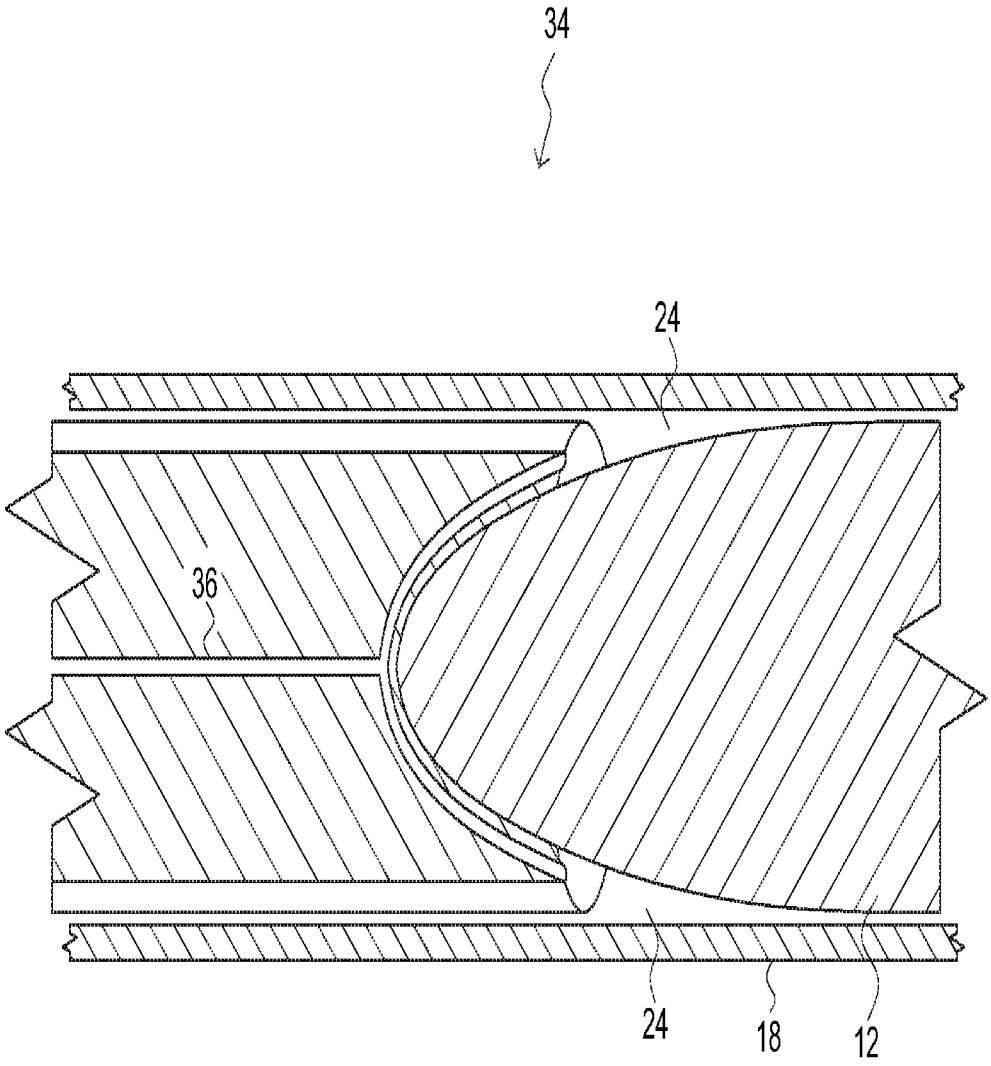

FIG. 2

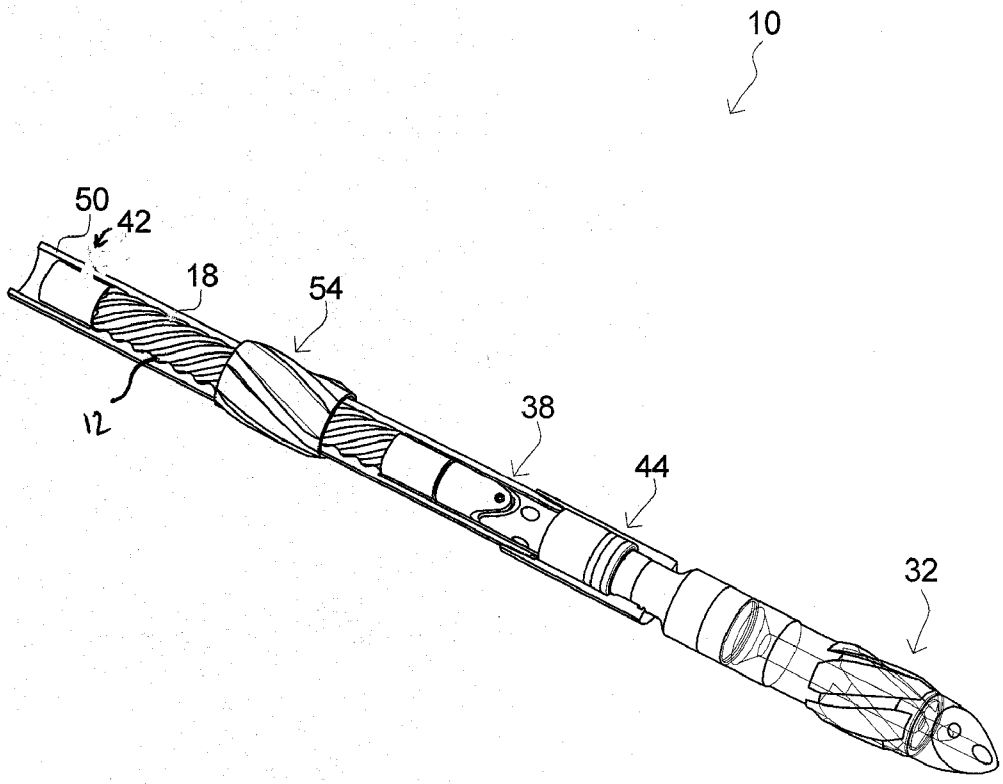

FIG. 3

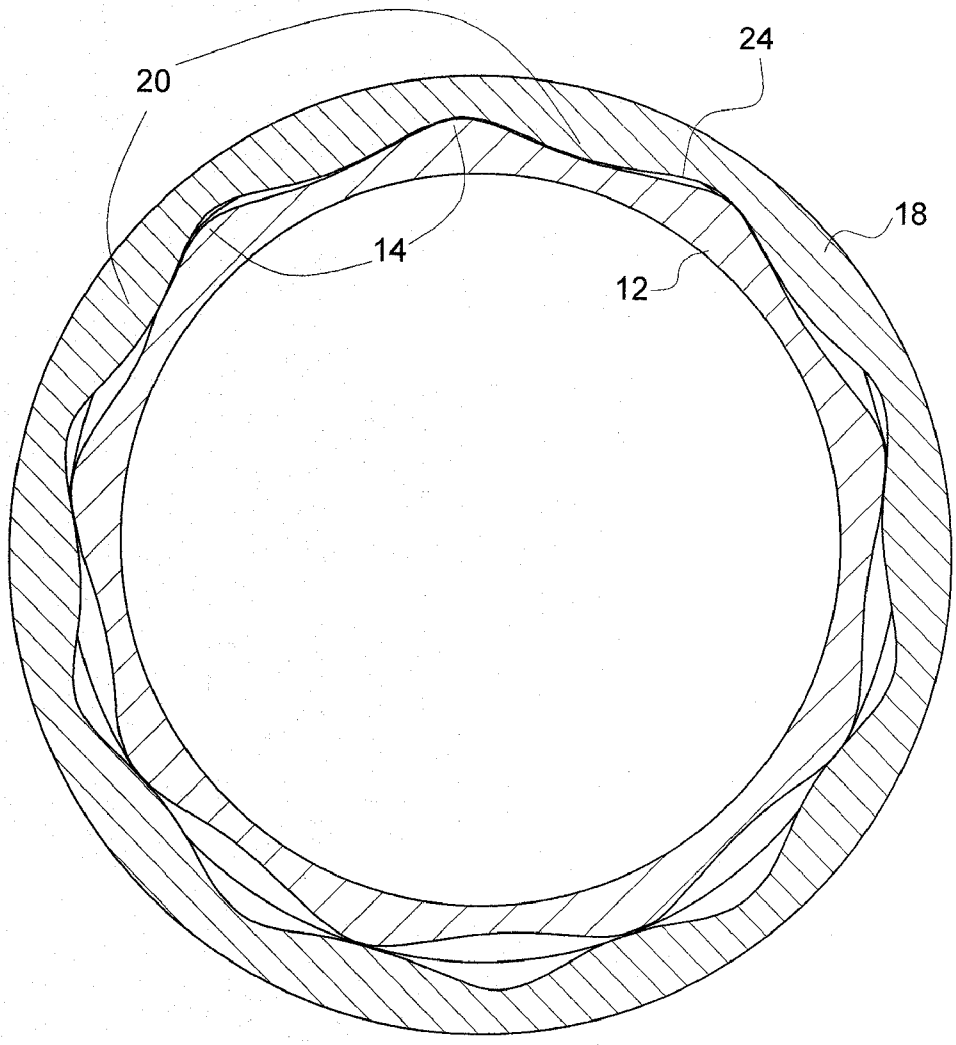

FIG. 4

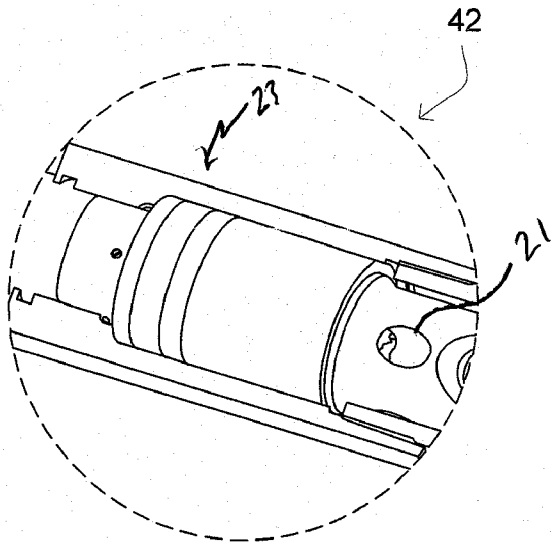

FIG. 6

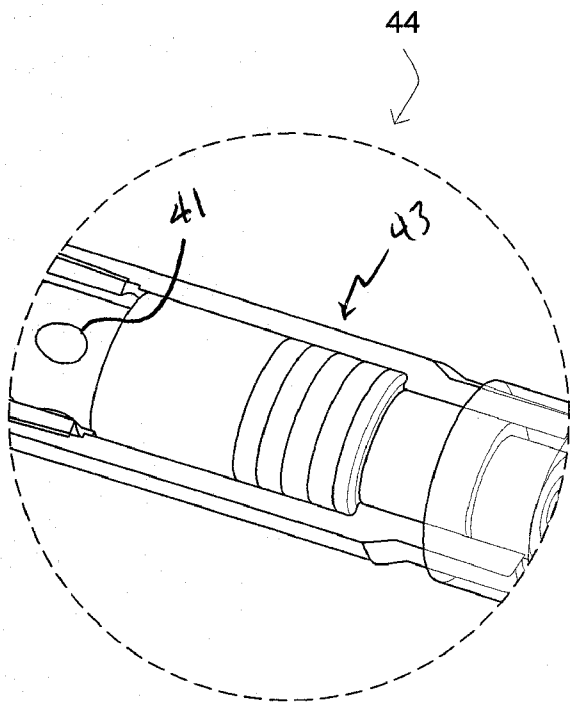

FIG. 5

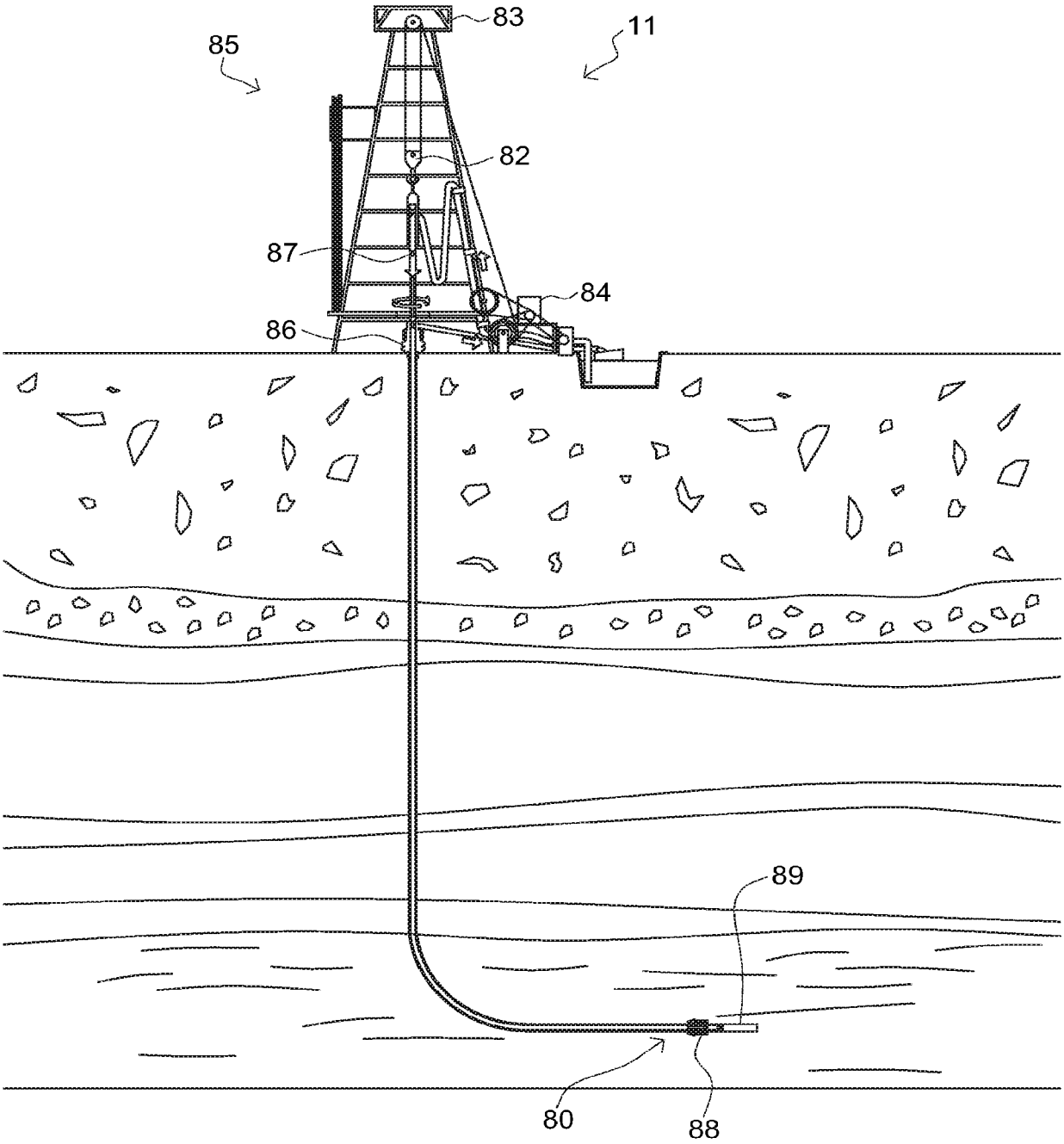

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2017/050281

A. CLASSIFICATION OF SUBJECT MATTER
INV. E21B29/00 E21B4/02 E21B7/20 E21B10/26 E21B17/14
ADD.

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

B. FIELDS SEARCHED

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

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2015/368978 A1 (PRILL JONATHAN RYAN [CA] ET AL) 24 December 2015 (2015-12-24) paragraph [0018]; figures 1-4	1-20
X	GB 2 520 752 A (DEEP CASING TOOLS LTD [GB]) 3 June 2015 (2015-06-03) paragraphs [0032] - [0038]; figures 1-5	1-20
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X	GB 2 461 309 A (FUTURETEC LTD [GB]) 30 December 2009 (2009-12-30) page 6, line 20 - page 9, line 17	1,2,4-6, 13-15,20

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

☒ See patent family annex.

* Special categories of cited documents :

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

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

"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
28 March 2017	05/04/2017

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Manolache, Iustin

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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