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(54) **Title**: ONE TRIP LINER DRILLING AND CEMENTING

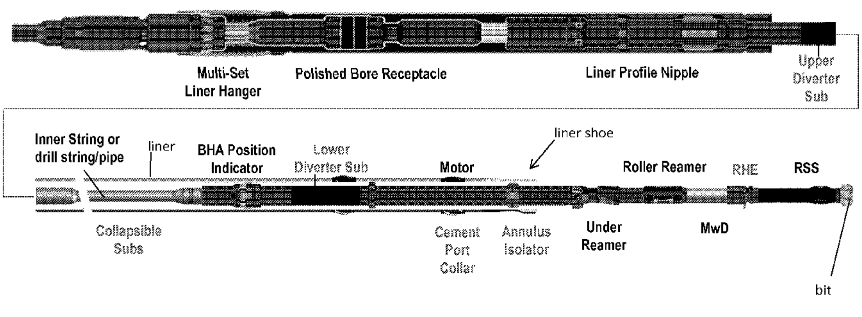

FIGURE 1

(57) **Abstract**: A liner drilling system and method to at least partially drill a wellbore with a liner and cement the liner in place in the wellbore, all in a single downhole trip.

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ONE TRIP LINER DRILLING AND CEMENTING

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to United States Provisional Application 61/929,494, filed on January 20, 2014, the entirety of which is incorporated by reference.

FIELD OF THE INVENTION

[0002] Aspects of the disclosure relate to subsurface drilling. More specifically, aspects relate to casing and liner drilling.

BACKGROUND

[0003] Oil and gas wells are conventionally drilled with drill pipe to a certain depth, then casing is run and cemented in the well. The operator may then drill the well to a greater depth with drill pipe and cement another string of casing. In this type of system, each string of casing extends to the surface wellhead assembly.

[0004] In some well completions, an operator may install a liner rather than a full string of casing. The liner is made up of joints of pipe in the same manner as casing. Also, the liner is normally cemented into the well. The liner, however, does not extend back to the wellhead assembly at the surface. Instead, the top of the liner may either be placed inside the liner or secured by a liner hanger to the last string of casing just above the lower end portion of the casing. The operator may later install a tieback string of casing that extends from the wellhead downward into engagement with the liner hanger assembly.

[0005] When installing a liner, in most cases, the operator drills the well to the desired depth, retrieves the drill string, and then assembles the liner. A liner top packer may be incorporated into the liner. A cement shoe and/or float collar with a check valve will normally be secured to the lower end portion of the liner as the liner is made up. When the desired length of liner is assembled, the operator attaches a liner top assembly which may include a plurality of tools (and may or may not include a liner hanger, setting collar top, running tool profile adaptor, liner top packer, tieback receptacle (polished bore receptacle), and/or a releasable running tool) to the upper end portion of the liner. The operator then runs the liner into the wellbore on a string of drill pipe attached to the running tool. The operator functions the liner top assembly and may or may not release the running tool. The operator then conditions the wellbore and pumps cement through the drill pipe, down the liner, and back up an annulus surrounding the liner. The cement floats prevent backflow of cement into the liner. The running tool may dispense a wiper plug behind the cement to both separate the cement and displacement fluid, and to wipe cement from the interior of the liner at the conclusion of the cement pumping. It should be noted that a lead plug may also be pumped in front of the cement to isolate the cement from the drilling and/or conditioning fluid and to wipe filter cake from the inside of the drill pipe, casing or liner. The operator then sets the liner top packer, if employed, releases the running tool from the liner (if not already released prior to cementing), and retrieves the drill pipe.

[0006] A variety of designs exist for liner hangers. Some may be set in response to mechanical movement or manipulation of the drill pipe, including rotation. Others may be set by dropping a ball or dart into the drill string, then applying fluid pressure to the interior of the drill string after the ball or dart lands on a seat in the running tool. Some are set prior to cement being pumped and some are set afterward. Some are designed to be rotated before setting, some may be rotated after setting to facilitate cement displacement around the liner pipe. The running tool may be attached to any of the liner top assembly components or body thereof by threads, shear elements, or by a hydraulically actuated arrangement or by other means.

[0007] In another method of installing a liner, the operator runs the liner while simultaneously drilling the wellbore. This method is similar to a related technology known as casing drilling. However, in casing drilling, the upper end portion of the casing is at the rig floor. Therefore, the bottom hole assembly used for drilling may be retrieved upward through the casing from the bottom end portion thereof and rerun by wire line, drill pipe, or by pumping the bottom hole assembly down and back up. Due to its expense, the bottom hole assembly is often retrieved prior to cementing of the casing. After such retrieval, cementing of the casing may thus be accomplished by pumping cement downward from surface through the casing and upward in the annulus between the casing and the wellbore.

[0008] In liner drilling, conversely, the upper end portion of the liner is deep within the wellbore and the liner is attached to and suspended by the drill string. After liner drilling with a two or more trip system, the operator may set a liner hanger, release a running tool, and then retrieve the drill string with its bottom hole assembly and bit positioned at a bottom end portion thereof. If the liner is at the total depth desired after retrieving the bottom hole assembly, the operator may then run a cementing assembly on a running tool back into engagement with the liner. The cementing assembly includes a seal assembly that stabs into sealing engagement with an upper portion of the liner string. A liner top packer may also be included with the cementing assembly for sealing an annulus surrounding the liner. In addition, a liner wiper plug (or dual wiper plug assembly) may be carried by the cementing assembly to be pumped down to a lower end portion of the liner and latched after cementing. The plug assembly separates the cement from the drilling, conditioning, and displacement fluids, wipes the casing or liner clean of filter cake and/or cement, and prevents backflow of cement.

[0009] Unfortunately, the multiple downhole runs to drill with liner, retrieve the bottom hole assembly, set the liner hanger and cement the liner are time consuming and thus expensive processes. If the liner is left downhole in a sloughing or hole susceptible to excessive fill, circulation of the liner may not be possible once the cementing assembly or the cement retainer is run into the hole. Therefore, there is a need for a single trip liner drilling and cementing system and method that overcomes the cost, time, and reliability problems of the prior art and/or time sensitivity or open-hole issues.

SUMMARY

[0010] Described herein are implementations of various technologies for one trip liner drilling and cementing.

[0011] In a method of liner drilling and cementing in a single trip, a wellbore is at least partially drilled with a liner. The liner is coupled to a drill string extending through an axial bore of the liner. The drill string has a bottom hole assembly proximate a downhole end portion thereof and the bottom hole assembly has a drill bit at a distal end portion thereof. The drill string and the liner define a liner annulus radially therebetween. The bore of the liner is isolated from a wellbore annulus defined between the liner and the wellbore. A cement path is established downhole through a bore of the drill string and radially outward into the liner annulus through a diverter sub. The diverter sub is disposed in the drill string uphole of the bottom hole assembly. The liner is decoupled from the drill string. Cement is pumped along the cement path with the cement flowing downhole through the liner annulus and at least partially uphole into the wellbore annulus. A displacement fluid is pumped along the cement path to displace the cement at least partially into the wellbore annulus. The bottom hole assembly is withdrawn from the wellbore. The method is accomplished in a single downhole trip.

[0012] In a system of liner drilling and cementing in a single trip, a liner is coupled to a drill string extending through an axial bore of the liner. The drill string has a bottom hole assembly proximate a downhole end portion thereof with the bottom hole assembly having a drill bit at a distal end portion thereof arranged and designed to rotate to at least partially drill a wellbore. The drill string and the liner define a liner annulus radially therebetween. The system also has an annulus isolator arranged and designed to isolate the bore of the liner from a wellbore annulus defined between the liner and the wellbore. The annulus isolator is actuated in the same trip as the drill bit rotates to at least partially drill the wellbore. A diverter sub is also disposed in the drill string uphole of the bottom hole assembly. The diverter sub establishes a cement path radially outward from a bore thereof into the liner annulus.

[0013] The above referenced summary section is provided to introduce a selection of concepts in a simplified form that are further described below in the detailed description section. The summary is not intended to be used to limit the scope of the claimed subject matter. Furthermore, the claimed subject matter is not limited to implementations that solve disadvantages noted in any part of this disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] Implementations of various techniques will hereafter be described with reference to the accompanying drawings. It should be understood, however, that the accompanying drawings illustrate various implementations described herein and are not meant to limit the scope of various techniques disclosed herein.

[0015] Figure 1 illustrates a system for liner drilling and cementing in a single trip, according to one or more implementations.

[0016] Figures 2 to 13 illustrate a method for liner drilling and cementing in a single trip while employing the system of Figure 1, according to one or more implementations.

[0017] Figure 14 illustrates another method of cementing using the system of Figure 1, according to one or more embodiments.

[0018] Figure 15 illustrates another implementation of the system for liner drilling and cementing in a single trip, according to one or more implementations.

[0019] Figure 16a illustrates one implementation of an annulus isolator that may be employed in the system of Figure 15.

[0020] Figures 16b to 16d illustrate the annulus isolator of Figure 16a as it may be employed, according to one or more implementations.

[0021] Figure 17 illustrates another implementation of an annulus isolator that may be employed in the system of Figure 15.

[0022] Figure 18a illustrates another implementation of an annulus isolator that may be employed in the system of Figure 15.

[0023] Figures 18b to 18d illustrate the annulus isolator of Figure 18a as it may be employed, according to one or more implementations.

[0024] Figure 19 illustrates another implementation of an annulus isolator that may be employed in the system of Figure 15.

[0025] Figures 20 to 23 illustrate a method for liner drilling and cementing in a single trip while employing the system of Figure 15, according to one or more implementations.

DETAILED DESCRIPTION

[0026] The discussion below is directed to certain specific implementations. It is to be understood that the discussion below is for the purpose of enabling a person with ordinary skill in the art to make and use any subject matter defined now or later by the patent “claims” found in any issued patent herein.

[0027] It is specifically intended that the claims not be limited to the implementations and illustrations contained herein, but include modified forms of those implementations including portions of the implementations and combinations of elements of different implementations as come within the scope of the following claims.

[0028] Reference will now be made in detail to various implementations, examples of which are illustrated in the accompanying drawings and figures. In the following detailed description, numerous specific details are set forth in order to provide a thorough understanding of the present disclosure. However, it will be apparent to one of ordinary skill in the art that the present disclosure may be practiced without these specific details. In other instances, well-known methods, procedures, components, apparatuses and systems have not been described in detail so as not to obscure aspects of the embodiments.

[0029] It will also be understood that, although the terms first, second, etc. may be used herein to describe various elements, these elements should not be limited by these terms. These terms are used to distinguish one element from another. For example, a first object could be termed a second object, and, similarly, a second object could be termed a first object, without departing from the scope of the claims.

The first object and the second object are both objects, respectively, but they are not to be considered the same object.

[0030] The terminology used in the description of the present disclosure herein is for the purpose of describing particular implementations and is not intended to be limiting of the present disclosure. As used in the description of the present disclosure and the appended claims, the singular forms “a,” “an” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will also be understood that the term "and/or" as used herein refers to and encompasses one or more possible combinations of one or more of the associated listed items. It will be further understood that the terms "includes" and/or "including," when used in this specification, specify the presence of stated features, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, operations, elements, components and/or groups thereof.

[0031] As used herein, the terms "up" and "down"; "upper" and "lower"; "upwardly" and downwardly"; "below" and "above"; and other similar terms indicating relative positions above or below a given point or element may be used in connection with some implementations of various technologies described herein. However, when applied to equipment and methods for use in wells or boreholes that are deviated or horizontal, or when applied to equipment and methods that when arranged in a well or borehole are in a deviated or horizontal orientation, such terms may refer to a left to right, right to left, or other relationships as appropriate.

[0032] Various implementations will now be described in more detail with reference to Figures.

[0033] Figure 1 depicts one implementation of a system used in the various techniques for one trip liner drilling and cementing. As illustrated, the drill pipe has an upper diverter sub. The upper diverter sub permits fluid flowing downward through the drill pipe to the bottom hole assembly to be diverted and circulated through the annulus between the liner and the drill pipe. One or more collapsible subs may be coupled within the drill pipe. As shown, one or more collapsible subs are positioned between the upper diverter sub and a lower diverter sub but may be positioned anywhere between the running tool and the bottom hole assembly. The lower diverter permits cement (or any fluid) flowing downward through the drill pipe to bypass the bottom hole assembly by flowing into the annulus between the liner and drill pipe and/or an outside portion of the bottom hole assembly. The drill pipe may also have coupled thereto a downhole motor or turbine. A bottom hole assembly, which may include an underreamer, a roller reamer, a rotary steerable system and/or a measurement-while-drilling system, may be coupled to the drill pipe further downhole. As shown, the bottom hole assembly may also include a rat hole eliminator reamer coupled within the drill pipe proximate to the drill bit. A drill bit completes the bottom hole assembly at the bottom end portion of the drill pipe.

[0034] The system may also include a multi-set or single-set liner hanger (or no liner hanger at all), a polished bore receptacle and a liner profile nipple coupled to the liner. A bottom hole assembly indicator system may also be employed as shown in Figure 1. The liner may include a BHA (bottom hole assembly) position indicator sub with one or more grooves on an inner surface thereof. The drill pipe has a BHA position indicator housing with, *e.g.*, spring-loaded dogs, which mate with the one or more grooves on the inner surface of the BHA position indicator sub when the drill pipe is lowered and extended through the liner. The BHA position indicator sub is positioned a distance above the liner shoe and the BHA position indicator housing is positioned a distance above the bottom hole assembly such that when the housing mates with the sub, the BHA is properly positioned relative to the liner.

[0035] Positioned downhole of the BHA position indicator sub, a cement port collar may be coupled to the liner to divert cement flow from inside the liner to the outside of the liner. In one or more implementations, an annulus isolator is coupled to a bottom end portion of the liner to mitigate cement flow upward into the liner. In one or more other implementations, the annulus isolator may be coupled to the drill pipe. In yet one or more other implementations, the annulus isolator may have components coupled to the liner and to the drill pipe, which cooperate to mitigate cement flow upward into the liner.

[0036] One or more implementations of methods of using the system of Figure 1 to liner drill and cement the liner in a single trip will now be described.

[0037] Figure 2 illustrates a method of employing the system of Figure 1 to ream the pilot hole after liner drilling to total depth. The bit at the bottom end portion of the drill pipe drills (*e.g.*, rotated by motor/turbine coupled thereto) a pilot hole, which is a drilled hole having a diameter substantially that of the drill bit. The underreamer and/or roller reamer (see Figure 1) may be employed to support the bottom hole assembly while drilling the wellbore. However, the position of the underreamer and/or roller reamer above the bit will leave some distance of un-reamed pilot hole. This un-reamed pilot hole is referred to as the rat hole. The rat hole eliminator is another reamer often placed closer in proximity to the bit. Upon reaching total depth of liner drilling, the drill pipe is moved uphole such that the rat hole eliminator reamer may be actuated in the previously reamed (*i.e.*, enlarged diameter) hole provided by the underreamer and/or roller reamer. The drill pipe is then lowered downhole with the rat hole eliminator actuated until the drill bit hits total depth. Thus, at least a portion of the previous rat hole is eliminated (*i.e.*, equivalent to the distance between the lower positioned underreamer/roller reamer and the rotary steerable system) with only a small distance of rat hole remaining. The remaining portion of rat hole being equivalent to the distance between the rat hole eliminator reamer and the drill bit. After reaming the pilot hole until the drill bit hits total depth, the rat hole eliminator is then de-actuated. In one or more other implementations, the rat hole is not reamed after the initial pilot hole is drilled.

[0038] Figure 3 illustrates a method of employing the system of Figure 1 to flush the liner. Such method may be employed after reaming the pilot hole with the rat hole eliminator as shown in Figure 2. To flush the inside bore of the liner, a ball, dart, RFID tag or other device may be dropped, *e.g.*, from surface, through the drill pipe to the upper diverter sub. The dropping of an actuation device may be used in tandem with another physical function (*e.g.*, rotation, picking up, or slacking off) to function the rat hole eliminator (or other tool) into an active or inactive state. As is well known in the art, the ball may seat on a ball seat coupled to the upper diverter sub and restrict fluid flow therethrough. The increased fluid pressure causes the upper diverter sub to actuate thereby opening a fluid bypass from the bore of the drill pipe to the annulus between the liner and the drill pipe. The bypass fluid flow is then diverted downward through the annulus, around the BHA and out (or downhole) of the liner shoe. The fluid flow thus bypasses the motor or turbine such that the motor/turbine is static, the bit does not rotate to drill and the various reamers remain unactuated with their reamer arms in a retracted or collapsed state. The fluid flow through the annulus serves to flush or clean out any gas or debris, such as cuttings, that may be present in the bore of the liner below the upper diverter sub. In one or more other implementations, an upper diverter sub is not employed to flush the bore of the liner.

[0039] Figure 4 illustrates a method of employing the system of Figure 1 to cover the rat hole. In this method, a ball, dart or RFID (radio frequency id) tag is dropped downhole to deactuate the upper diverter sub into a closed position, if such upper diverter sub is actuated into an open or diverting position. As well known in the art, the same ball, dart or RFID tag may drop further downhole within the bore of the liner to actuate the lower diverter sub into its diverting position. Actuation and de-actuation of the upper diverter sub may also be accomplished by manipulating the drill pipe (*e.g.*, set down, pick up, rotate, etc.) with the first actuation device in place or having passed down through the drill pipe to be disposed at or near the lower diverter sub. The collapsible subs are actuated to reduce the length of the drill pipe thereby lowering the liner over the bottom hole assembly. Such lowering of the liner also causes the liner to “cover” the rat hole. In other words, the liner is lowered into proximity with rat hole such that the liner and/or liner shoe encloses or nearly encloses the rat hole. Fluid flow diverted by the lower diverter sub washes the bore of the liner downward around the bottom hole assembly to the liner shoe. The liner shoe is washed to ledge to cover the underreamed section (This method can also be done prior to deactivating the upper diverter sub and activating the lower diverter sub). In one or more other implementations, the rat hole is left uncovered.

[0040] Figure 5 illustrates a method of employing the system of Figure 1 to ream the remainder of the rat hole to pilot hole total depth using the cutting structures on the liner shoe, *e.g.*, a reamer shoe. In this way, the liner and liner shoe coupled to an end portion thereof cover or envelop the remainder of the rotary steerable system and bit that were left in the pilot hole. In one or more other implementations, the drill pipe may be raised uphole relative to the liner such that the rotary steerable system and bit are covered by (*i.e.*, retracted into the bore of) the liner and liner shoe.

[0041] Figure 6 illustrates a method of employing the system of Figure 1 to isolate the bore of the liner from the annulus between the outer surface of the liner and the wall of the wellbore. In this method, an annulus isolator is activated to seal off the bore of the liner from the annulus. Such isolation facilitates pulling the BHA out of the hole after cementing without causing cement to be suctioned into the bore of the liner from the annulus. The annulus isolator may be activated in any manner known to those skilled in the art including, but not limited to, using set down weight of the drill pipe or using hydraulic fluid pressure. One example of an annulus isolator may be an inflatable annular casing packer disposed on the outer surface of the liner near the bottom end portion thereof. As is well known in the art, cement or other fluid is used to activate/inflate the annular casing packer to effectively seal the annulus above such packer from the bore of the liner. The annulus isolator described above is one example. Another annulus isolator may be a solid expandable tubular. The solid expandable tubular is a radially expandable metal pipe or sleeve that increases in outer diameter to seal the liner to the wellbore. This operation may be performed inside of a casing as a patch or liner hanger. Such solid expandable tubular may be deployed hydraulically, mechanically (via a piston), or by setting down on the liner shoe to drive a cone under the solid expandable tubular to force it to expand. Other implementations of annulus isolation will be described hereinafter.

[0042] Figure 7 illustrates a method of employing the system of Figure 1 to establish a flow path for cementing. In this method, the cement port collar is hydraulically or mechanically activated. As described above, the cement port collar may be coupled to the liner to divert cement flow from inside the liner to the outside of the liner. The cement port collar may also be incorporated into the annular isolator body. If the cement port collar is hydraulically activated, fluid pressure in the drill pipe, out the lower diverter sub and in the annulus between the drill pipe and liner is increased (*i.e.*, increased against the liner shoe). This increased pressure creates a differential pressure that causes the cement port collar to open thereby permitting fluid flow therethrough. Because significant differential pressure does not occur proximate the cement port collar during drilling (*i.e.*, the annulus between the liner and drill pipe is open to the annulus between the liner and the wellbore), the liner shoe needs to be planted into the bottom surface of the hole or the annulus isolator activated in order to create such differential pressure. If the cement port collar is mechanically activated, the drill pipe may be manipulated to mechanically actuate the cement port collar into its open position. The annular isolator may also be set concurrently with the setting down of the drill pipe against the liner shoe. The annular isolator and/or cement port collar may be actuated by placing the liner shoe against the formation. A fluid (*i.e.*, cement) flow path is thus established down the inner sting of drill pipe, outward through the lower diverter, downward through the annulus between the drill pipe and liner, outward through the cement port collar, into the annulus between the liner and the wellbore, and up to the parent casing.

[0043] Figure 8 illustrates a method of employing the system of Figure 1 to release the liner and cement. In this method, the drill pipe is picked up or raised slightly off bottom to set the liner hanger. The drill pipe is then released from the liner. Drilling fluid or cement circulation may be then be commenced along the pathway disclosed with respect to Figure 7. It should be noted that rotation of the liner is possible with a cement swivel and v-packing or similar assembly proximate the liner shoe.

[0044] Figure 9 illustrates a method of employing the system of Figure 1 to begin termination of cementing operations. In this method, a dart is dropped downhole through the drill pipe. The dart is thus dropped behind or uphole of the cement. A displacement fluid is then pumped downhole behind or uphole of the dart. The movement of the dart downhole through the drill pipe serves to wipe or clean the cement from the cementing flow path downhole to the lower diverter sub. Dual cementing plugs may be deployed in the system if desired to fully isolate the cement during the pumping and displacement methods.

[0045] Figure 10 illustrates a method of employing the system of Figure 1 to confirm full displacement of cement from the cementing flow path to the lower diverter sub.

When the dart of Figure 9 lands into a corresponding profile in the bore of the lower diverter sub, the dart bumps and/or latches into the lower diverter sub and causes a plugging of the lower diverter sub such that fluid pressure increases uphole of the landed dart. This increase in fluid pressure signals the full displacement of cement from the cementing flow path downhole to the lower diverter sub (*i.e.*, full cement displacement from the bores of the drill string, the liner running tool and drill pipe).

[0046] Figure 11 illustrates a method of employing the system of Figure 1 to shut the cement port collar and re-establish fluid circulation through the drill pipe. In this method, the drill string/drill pipe is picked up or raised. The upper pack-off is thus removed from the polished bore receptacle. This pick up or raising of the drill string/drill pipe causes the cement port collar to close via a closing device positioned above or uphole of the bottom hole assembly. The closing device may be a lip, protrusion or other radial structure coupled with the drill pipe that mechanically interacts with, *e.g.*, physically contacts, the cement port collar of the liner to transition the cement port collar from an open position to a closed position. The fluid pressure in the bore of the drill pipe may then be increased to cause the landed dart in the lower diverter sub to move the lower diverter sub from a non-diverting position to a diverting position (*e.g.*, by the breaking of shear pins and axial movement of the dart seat). The shifting of the lower diverter sub from non-diverting to diverting may be effectuated by, *e.g.*, the landed dart being forced at least partially through the lower diverter sub in response to increased fluid pressure. Those skilled in the art will readily recognize that other devices, *e.g.*, electrical, etc., may be employed to function the lower diverter sub. Once the lower diverting sub is once again diverting fluid into the annulus between the liner and the drill pipe, fluid may then be circulated downhole through the drill pipe, diverted into the annulus between the liner and drill pipe, and back to the top of the liner. This opening also permits communication between the drill string and the annulus such that the drill string evacuates fluid while being pulled out of the hole to minimize mud spillage on the rig floor. In another implementation (not shown), the fluid pressure in the bore of the drill pipe may be increased to cause the landed dart to move such that fluid flow may be reestablished through the lower diverter sub, through the bottom hole assembly and out the bit, if desired.

[0047] Figure 12 illustrates a method of employing the system of Figure 1 to re-establish flow through drill pipe, into the annulus between the drill pipe and liner and back to the top of the liner, as described in greater detail with respect to Figure 11. Any excess cement proximate the bottom end portion of the liner may then be circulated uphole through the annulus between the liner and the drill pipe. Further, any excess cement proximate the top end portion of the liner may then be circulated uphole through the annulus between the drill string and the parent casing.

[0048] Figure 13 illustrates a method of pulling the drill string/drill pipe out of the hole with the bottom hole assembly coupled thereto after completing the cementing operation. A second or subsequent run or trip may be make into the hole to polish the polished bore receptacle and/or to install and seal a liner top packer, if desired.

[0049] In an additional implementation, the liner may be cemented in a reverse cementing flow path than the conventional cementing flow path illustrated in Figure 8. Figure 14 illustrates a method of releasing the liner and reverse cementing. In this method, the drill pipe is picked up or raised slightly off bottom to set the liner hanger. The drill pipe is then released from the liner. Drilling fluid or cement circulation may be then commenced along the reverse pathway shown in Figure 14. Thus, cement or other fluid flow travels downhole through the annulus between the liner and the wellbore, uphole in the annulus between the liner and the drill pipe, through the lower diverter sub and uphole through the bore of the drill pipe/drill string. It should be noted that rotation of the liner is possible with a cement swivel and v-packing or similar assembly proximate the liner shoe.

[0050] In an additional implementation, the annulus isolator may be an internal annulus isolator such at that provided by a flapper valve or the like.

[0051] Figure 15 illustrates another implementation of the system for liner drilling and cementing in a single trip. In this particular implementation, the annulus isolator described with respect to Figure 6 is not employed. Likewise, the method described with respect to Figure 6 is not employed. Because there is no annulus isolator disposed between the liner and the wellbore, a cement port collar disposed in the liner is also not employed. Rather, the annulus isolator of Figure 15 may be disposed in a bore of the liner between the liner and the drill pipe, and may be a flapper valve or the like, as further described herein.

[0052] Figure 16a illustrates one implementation of an annulus isolator that may be employed in the system of Figure 15. As shown, a box and pin sub is disposed in the liner. Within this sub is disposed a valve disc or flapper valve, which may be movably coupled on one side portion to the liner to move between an open position and a closed position. In the closed position, the valve disc seats with a valve seat to seal close the liner bore. The valve disc may be movably coupled to the liner by a spring loaded flapper pivot point, as shown in Figure 16a. The spring loaded flapper pivot point may be arranged to bias the valve disc in its closed position sealing off the liner bore. A bow spring or other such biasing device may be movable coupled to an uphole portion of the valve disc. The bow spring may be arranged and designed to also bias the valve disc in the closed position. As shown, the bow spring movably couples to the valve disc via a track disposed in the uphole portion of the valve disc. This track permits the coupling point of the bow spring to move radially when the valve disc moves from an open to closed position and vice versa. An upper end portion of the bow spring couples to an inner surface of the liner.

[0053] Figures 16b through 16d illustrate the annulus isolator of Figure 16a as it may be employed, according to one or more implementations. Figure 16b illustrates that as the bottom hole assembly is moved through the liner, the bottom hole assembly / drill pipe contacts the bow spring and elongates the bow spring in a downhole direction thereby moving and maintaining the valve disc into an open position. Figure 16c illustrates that the contact between the bow spring and the bottom hole assembly / drill pipe uphole of the valve seat continues to maintain the valve disc in the open position while the bottom hole assembly / drill pipe are withdrawn or raised uphole within the liner. This elongated bow spring prevents the valve disc or flapper from moving inward and interfering/contacting the tool joints or bit. As illustrated in Figure 16d, once the bit moves upwardly past the upper portion of the bow spring (above the valve seat), the bow spring no longer contacts and is elongated by the bottom hole assembly / drill pipe. Therefore, the bow spring returns to its original biasing position, which in turn closes the valve disc against its seat. This effectively seals off the liner bore from cement flow from therebelow.

[0054] Figure 17 illustrates another implementation of an annulus isolator that may be employed is the system of Figure 15. The annulus isolator of Figure 17 is similar to the annulus isolator of Figure 16a in that a valve disc or flapper is employed within a box and pin sub to close or isolate the bore of the liner from the annulus between the liner and the wellbore. Rather than a bow spring, the annulus isolator of Figure 17 employs a pivoting actuator positioned uphole of and coupled to the valve disc. The valve disc is similar to the valve disc of Figure 16a and will not be further described. The pivoting actuator has an uphole facing surface that is tapered or rounded to prevent the bottom hole assembly from catching upon its surface as the bottom hole assembly moves uphole and downhole across the pivoting actuator. The pivoting actuator is movably coupled on one side portion to the liner via a spring loaded flapper pivot point, similar to the coupling of the valve disc. The spring loaded flapper pivot point may be arranged to bias the pivoting actuator in its unactuated position, which seals off the liner bore. A link or coupling device couples between the pivoting actuator and the valve disc. As the bottom hole assembly / drill pipe moves downhole across the pivoting actuator, a portion of the bottom hole assembly contacts a portion of the pivoting actuator pushing it in a downhole direction and pivoting it into its actuated position. This pivoting movement of the pivoting actuator in turn moves the link downhole to move and maintain the valve disc in its open position. As those skilled in the art will readily recognize, as the bottom hole assembly / drill pipe is raised uphole through the liner, the pivoting actuator will no longer be contacted by the bottom hole assembly and the valve disc will return to its closed position.

[0055] Figure 18a illustrates another implementation of an annulus isolator that may be employed is the system of Figure 15. The annulus isolator of Figure 18a is similar in arrangement and function as the annulus isolator described with respect to Figure 16a. However, the annulus isolator of Figure 18a is illustrated as part of a liner shoe rather than as being disposed within a box and pin sub. Another difference between the annulus isolators of Figures 16a and 18a is that the annulus isolator of Figure 18a may have a window disposed in the inner sidewall of the liner shoe for disposition of the flapper valve when such flapper valve is in its open position.

[0056] Figures 18b through 18d illustrate the annulus isolator of Figure 18a as it may be employed, according to one or more implementations. As those skilled in the art will readily recognize, the methods and implementations shown in Figures 18b through 18d are similar to the methods shown in Figures 16b through 16d and therefore do not need any further description.

[0057] Figure 19 illustrates another implementation of an annulus isolator that may be employed in the system of Figure 15. The annulus isolator of Figure 19 is similar to the annulus isolator of Figure 18a in that a valve disc or flapper is employed within the liner shoe to close or isolate the bore of the liner from the annulus between the liner and the wellbore. Rather than a bow spring, the annulus isolator of Figure 19 employs a pivoting actuator positioned uphole of and coupled to the valve disc. The valve disc is similar to the valve disc of Figure 18a and will not be further described. The pivoting actuator has an uphole facing surface that is tapered or rounded to prevent the bottom hole assembly from catching upon its surface as the bottom hole assembly moves uphole and downhole across the pivoting actuator. The pivoting actuator is movably coupled on one side portion to the liner via a spring loaded flapper pivot point, similar to the coupling of the valve disc. The spring loaded flapper pivot point may be arranged to bias the pivoting actuator in its unactuated position, which seals off the liner bore. A link or coupling device couples between the pivoting actuator and the valve disc. As the bottom hole assembly / drill pipe moves downhole across the pivoting actuator, a portion of the bottom hole assembly contacts a portion of the pivoting actuator pushing it in a downhole direction and pivoting it into its actuated position. This pivoting movement of the pivoting actuator in turn moves the link downhole to move and maintain the valve disc in its open position. As those skilled in the art will readily recognize, as the bottom hole assembly / drill pipe is raised uphole through the liner, the pivoting actuator will no longer be contacted by the bottom hole assembly and the valve disc will return to its closed position.

[0058] Figures 20-23 illustrate a method for liner drilling and cementing in a single trip while employing the system of Figure 15, according to one or more implementations.

[0059] Figure 20 illustrates the flapper valve according to an implementation shown in Figure 17. The internal flapper valve, movably coupled to the liner and residing in the bore of the liner, has a upper pivoting actuator and a lower valve disc as previously described. The internal flapper valve is held open by the drill pipe/bottom hole assembly while the drill pipe / bottom hole assembly are positioned downhole thereof. Cement (shown by the downward arrows) is shown flowing downward through the bore of the drill pipe, radially outward through the lower diverter valve and downward through the annulus between the liner and the drill pipe / bottom hole assembly. The cement then flows out of the bottom end portion of the liner and upward through the annulus between the liner and the wellbore. While the flapper valve of Figure 17 is depicted in this Figure and Figures 21-23, those skilled in the art will readily recognize that any of the implementations of flapper valves or similar disclosed herein may be employed.

[0060] Figure 21 illustrates a dart dropped behind the cement such that displacement fluid may be pumped downhole behind the dart, as previously described. The dart or other wiper tool wipes the bore of the drill string, running tool and drill pipe.

[0061] Figure 22 illustrates the dropped dart landing into a profile in the lower diverter sub. The landed dart bump plugs the openings into the annulus through which the cement was previously flowing. This causes an increase in fluid pressure in the bore of drill sting / drill pipe, which confirms full displacement.

[0062] Figure 23 illustrates the employment of the internal flapper valve to prevent cement from flowing thereabove in the liner bore after the drill pipe / bottom hole assembly are raised uphole of the internal flapper valve. The raising of the bottom hole assembly above the internal flapper allows the flapper valve to shut, thereby isolating the liner bore from the annulus (*i.e.*, between the liner and the wellbore). In this particular implementation, the internal flapper valve is disposed in a box and pin sub a distance uphole of the bottom end portion of the liner. Therefore, cement may be permitted to “U” tube uphole within the bore of the liner to the internal flapper valve. The pressure in the drill string / drill pipe is increased to shift the landed dart in the lower diverter sub to once again divert flow to the annulus. This permits fluid circulation through the drill pipe and into the annulus at the lower diverter sub, as previously described, while withdrawing the bottom hole assembly from the wellbore.

[0063] While the foregoing is directed to implementations of various techniques disclosed herein, other and further implementations may be devised without departing from the basic scope thereof. Although the subject matter has been described in language specific to structural features and/or methodological acts, it is to be understood that the subject matter defined in the appended claims is not limited to the specific features or acts described above. Rather, the specific features and acts described above are disclosed as example forms of implementing the claims.

What Is Claimed Is:

1. A method of drilling comprising,

at least partially drilling a wellbore with a liner, the liner coupled to a drill string extending through an axial bore of the liner, the drill string having a bottom hole assembly proximate a downhole end portion thereof, the bottom hole assembly having a drill bit, the drill string and the liner defining a liner annulus radially therebetween,

isolating the axial bore of the liner from a wellbore annulus defined between the liner and the wellbore,

establishing a cement path downhole through a bore of the drill string into the liner annulus through a diverter sub,

decoupling the liner from the drill string,

pumping cement along the cement path, the cement flowing downhole through the liner annulus and at least partially uphole into the wellbore annulus,

pumping a displacement fluid along the cement path to displace the cement at least partially into the wellbore annulus, and

withdrawing the bottom hole assembly from the wellbore, the method accomplished in a single downhole trip.

2. The method of claim 1 further including, retracting the bottom hole assembly into the bore of the liner.

3. The method of claim 1 wherein, the isolating of the bore of the liner is accomplished with a flapper valve disposed in the bore of the liner.

4. The method of claim 1 wherein, the isolating of the bore of the liner is accomplished with an inflatable packer disposed in the wellbore annulus.

5. A system of liner drilling and cementing in a single trip, comprising,

a liner coupled to a drill string, the drill string extending through an axial bore of the liner, the drill string having a bottom hole assembly proximate a downhole end portion thereof, the bottom hole assembly having a drill bit arranged and designed to rotate to at least partially drill a wellbore, the drill string and the liner defining a liner annulus radially therebetween,

an annulus isolator arranged and designed to isolate the bore of the liner from a wellbore annulus defined between the liner and the wellbore, and

a diverter sub disposed in the drill string uphole of the bottom hole assembly, the diverter sub establishing a cement path into the liner annulus.

6. The system of claim 5 wherein, the annulus isolator is a flapper valve disposed in the bore of the liner.

7. The system of claim 5 wherein, the annulus isolator is an inflatable packer disposed in the wellbore annulus.

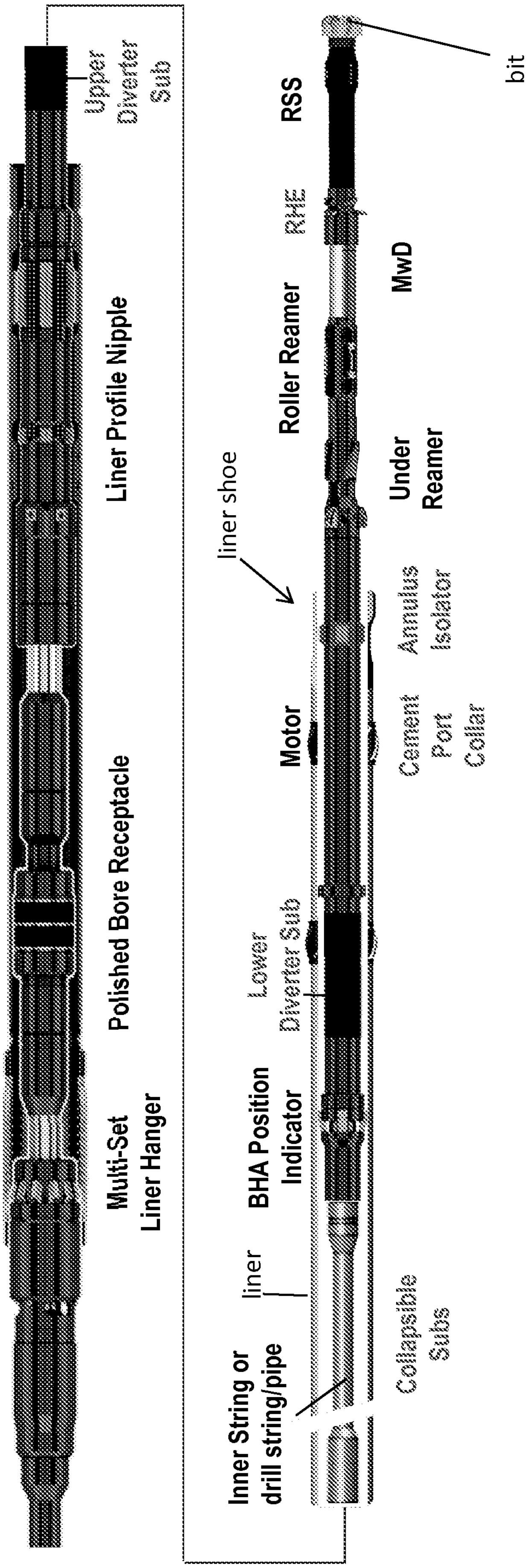

Upper Diverter Sub
Liner Profile Nipple
Polished Bore Receptacle
Multi-Set Liner Hanger
bit
RSS
RHE
MwD
Roller Reamer
Under Reamer
liner shoe
Annulus Isolator
Motor
Cement Port Collar
Lower Diverter Sub
BHA Position Indicator
liner
Inner String or drill string/pipe
Collapsible Subs

FIGURE 1

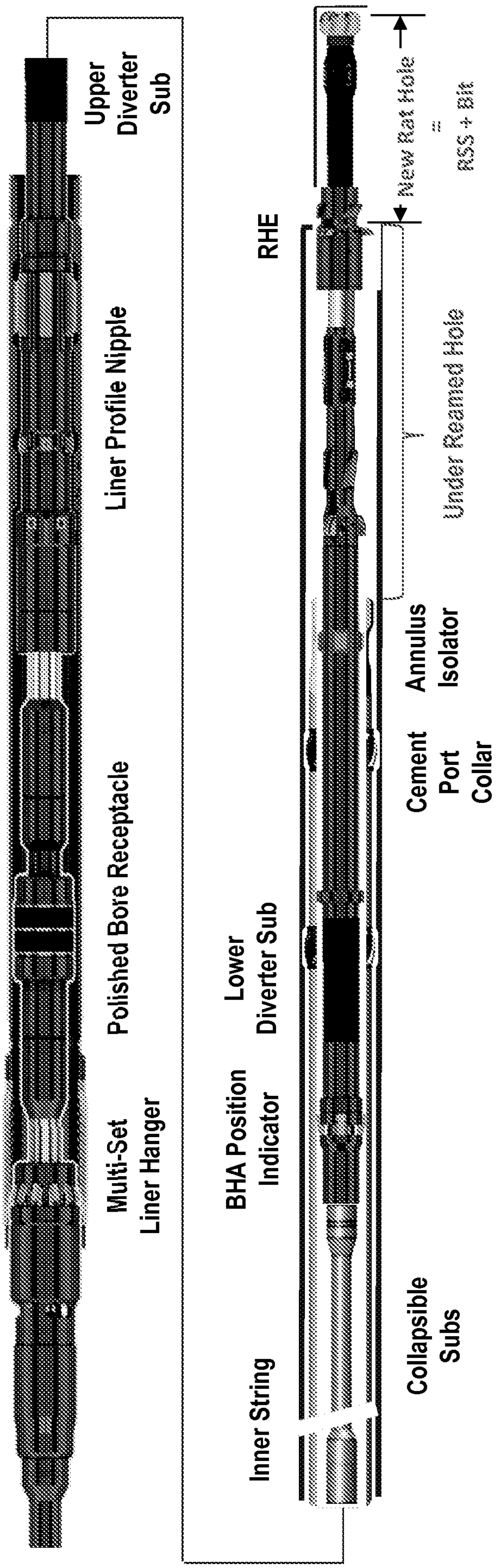

Upper Diverter Sub
Liner Profile Nipple
Polished Bore Receptacle
Multi-Set Liner Hanger
RHE
Lower Diverter Sub
BHA Position Indicator
Inner String
New Rat Hole = RSS + Bit
Under Reamed Hole
Annulus Isolator
Cement Port Collar
Collapsible Subs

FIGURE 2

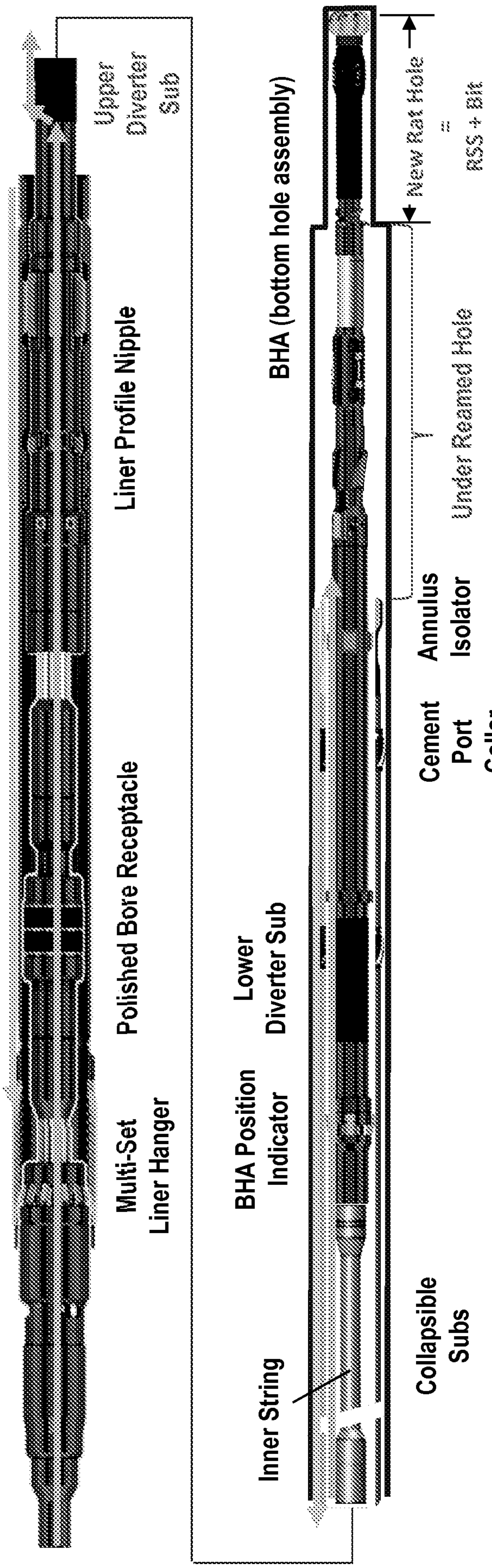

Upper Diverter Sub
Liner Profile Nipple
Polished Bore Receptacle
Multi-Set Liner Hanger
BHA (bottom hole assembly)
New Rat Hole
=
RSS + Bit
Under Reamed Hole
Annulus Isolator
Cement Port Collar
Lower Diverter Sub
BHA Position Indicator
Collapsible Subs
Inner String

FIGURE 3

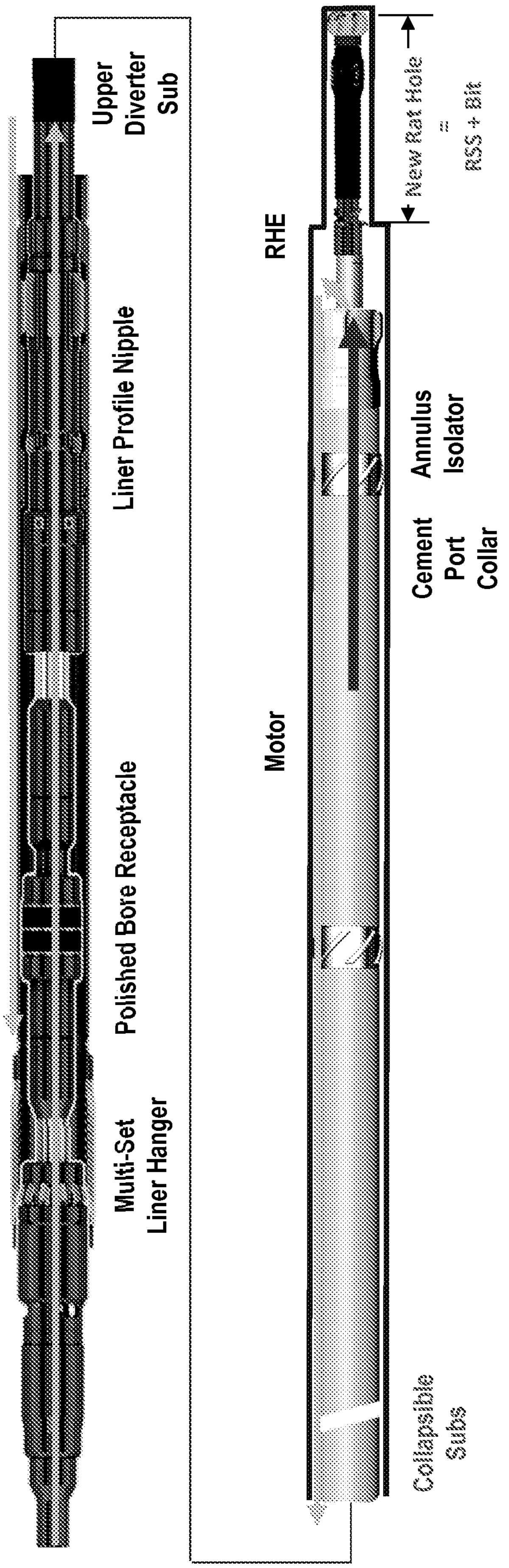

Upper Diverter Sub
Liner Profile Nipple
Polished Bore Receptacle
Multi-Set Liner Hanger
RHE
Motor
New Rat Hole = RSS + Bit
Annulus Isolator
Cement Port Collar
Collapsible Subs

FIGURE 4

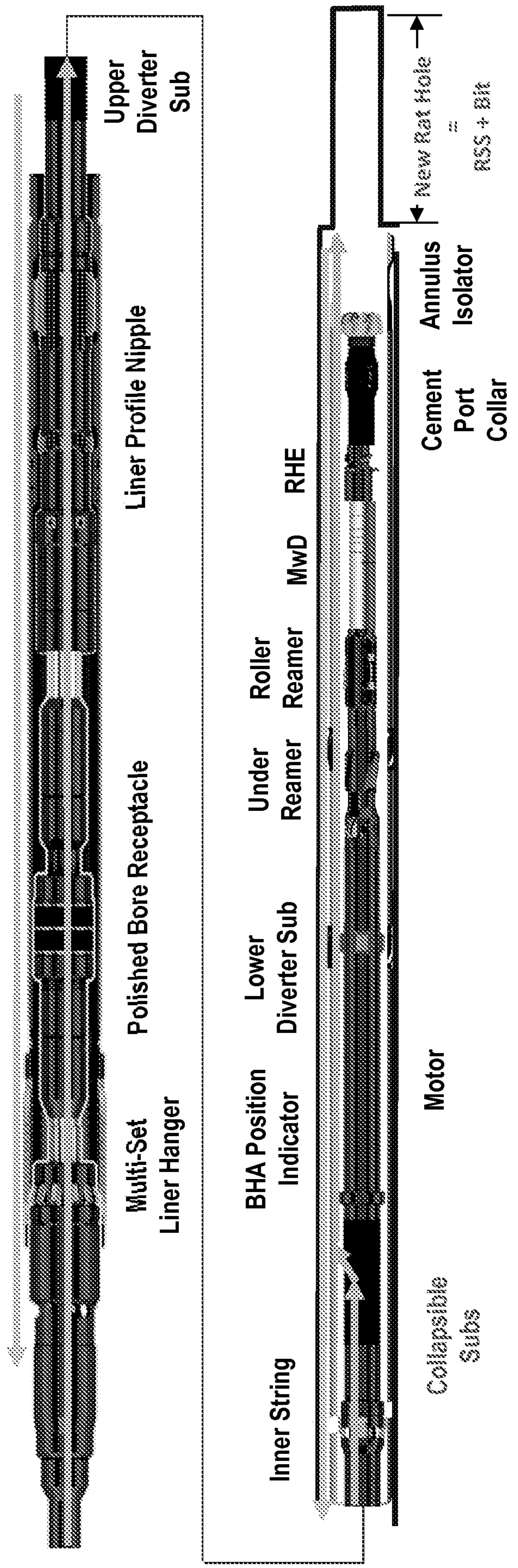

Upper Diverter Sub
Liner Profile Nipple
Polished Bore Receptacle
Multi-Set Liner Hanger
New Rat Hole = RSS + Bit
Annulus Isolator
Cement Port Collar
RHE
MwD
Roller Reamer
Under Reamer
Lower Diverter Sub
BHA Position Indicator
Motor
Collapsible Subs
Inner String

FIGURE 5

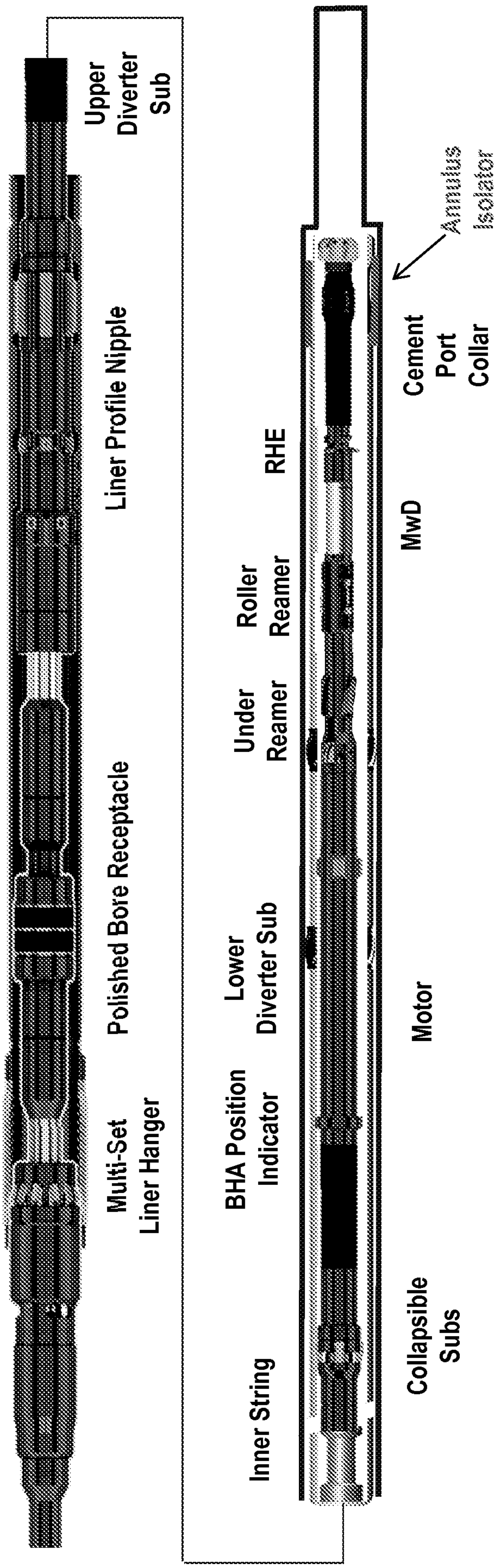

Upper Diverter Sub
Liner Profile Nipple
Polished Bore Receptacle
Multi-Set Liner Hanger
Annulus Isolator
Cement Port Collar
RHE
MwD
Roller Reamer
Under Reamer
Lower Diverter Sub
Motor
BHA Position Indicator
Collapsible Subs
Inner String

FIGURE 6

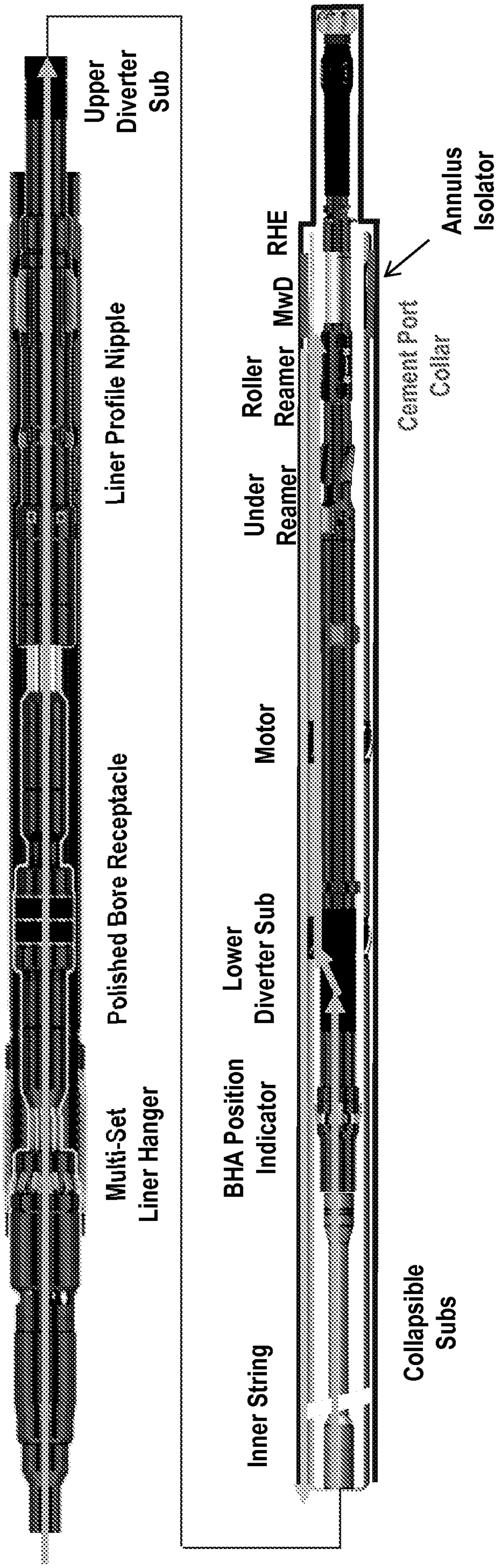

Upper Diverter Sub
Liner Profile Nipple
Polished Bore Receptacle
Multi-Set Liner Hanger
RHE
MwD
Roller Reamer
Under Reamer
Motor
Lower Diverter Sub
BHA Position Indicator
Inner String
Annulus Isolator
Cement Port Collar
Collapsible Subs

FIGURE 7

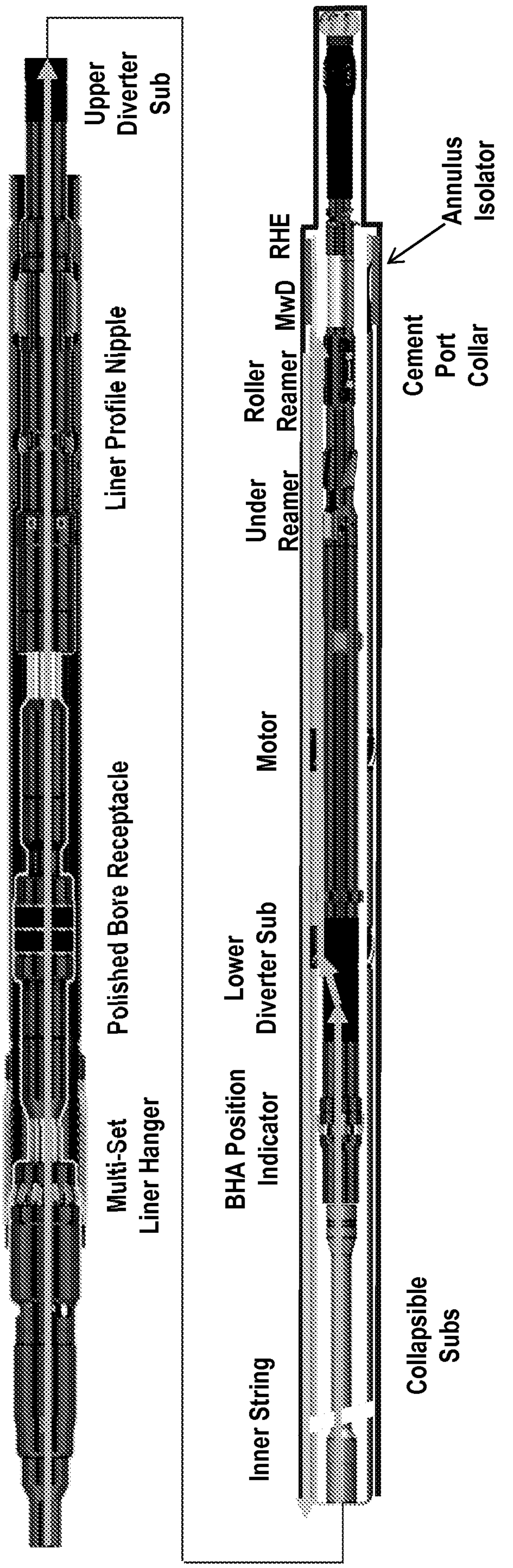

Upper Diverter Sub
Liner Profile Nipple
Polished Bore Receptacle
Multi-Set Liner Hanger
RHE
MwD
Roller Reamer
Under Reamer
Motor
Lower Diverter Sub
BHA Position Indicator
Inner String
Annulus Isolator
Cement Port Collar
Collapsible Subs

FIGURE 8

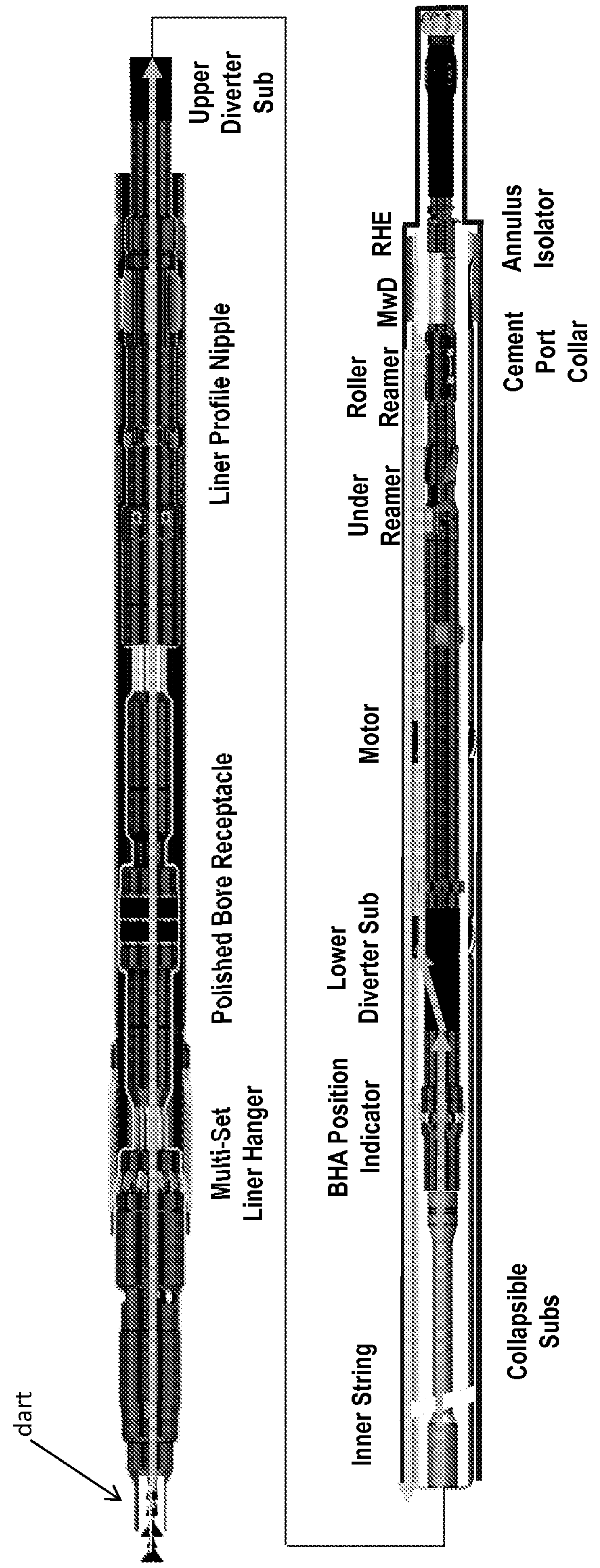

Upper Diverter Sub
Liner Profile Nipple
Polished Bore Receptacle
Multi-Set Liner Hanger
dart
RHE
MwD
Roller Reamer
Under Reamer
Motor
Lower Diverter Sub
BHA Position Indicator
Inner String
Annulus Isolator
Cement Port Collar
Collapsible Subs

FIGURE 9

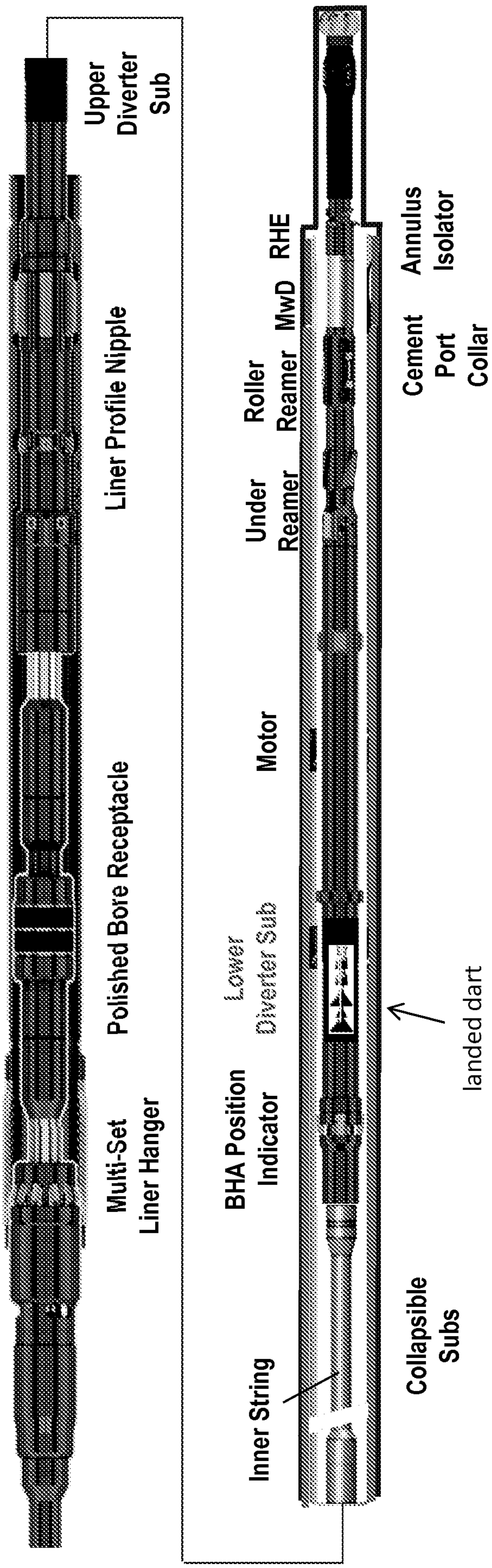

Upper Diverter Sub
Liner Profile Nipple
Polished Bore Receptacle
Multi-Set Liner Hanger
RHE
MwD
Roller Reamer
Under Reamer
Motor
Lower Diverter Sub
BHA Position Indicator
Inner String
Annulus Isolator
Cement Port Collar
landed dart
Collapsible Subs

FIGURE 10

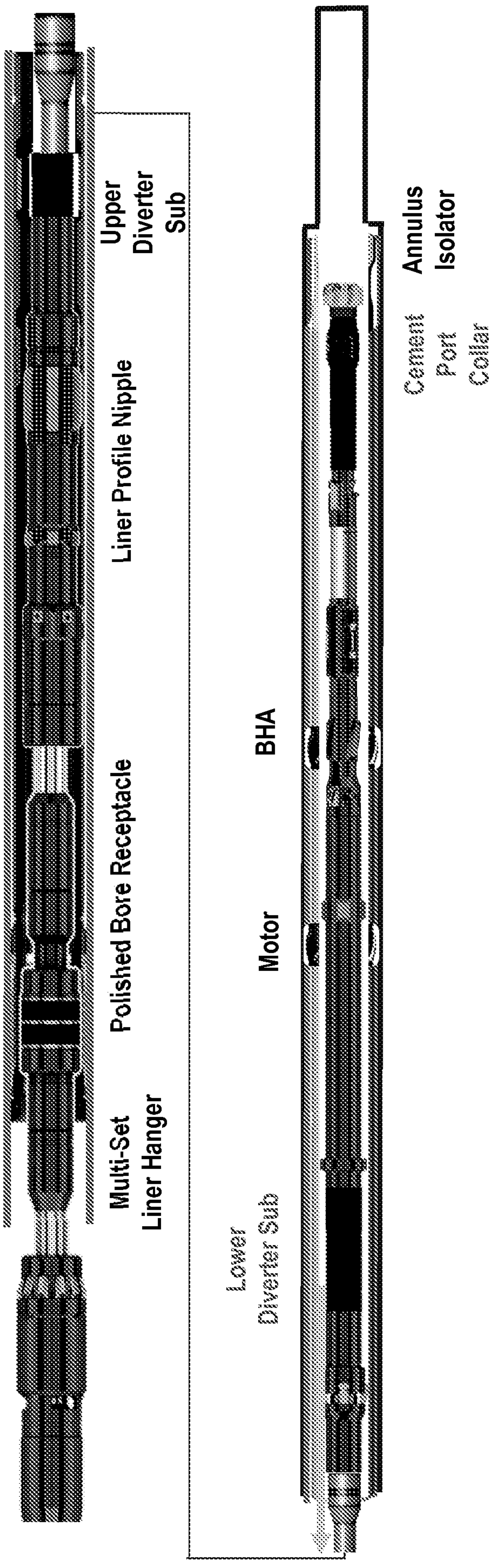

Upper Diverter Sub
Liner Profile Nipple
Polished Bore Receptacle
Multi-Set Liner Hanger
Annulus Isolator
Cement Port Collar
BHA
Motor
Lower Diverter Sub

FIGURE 11

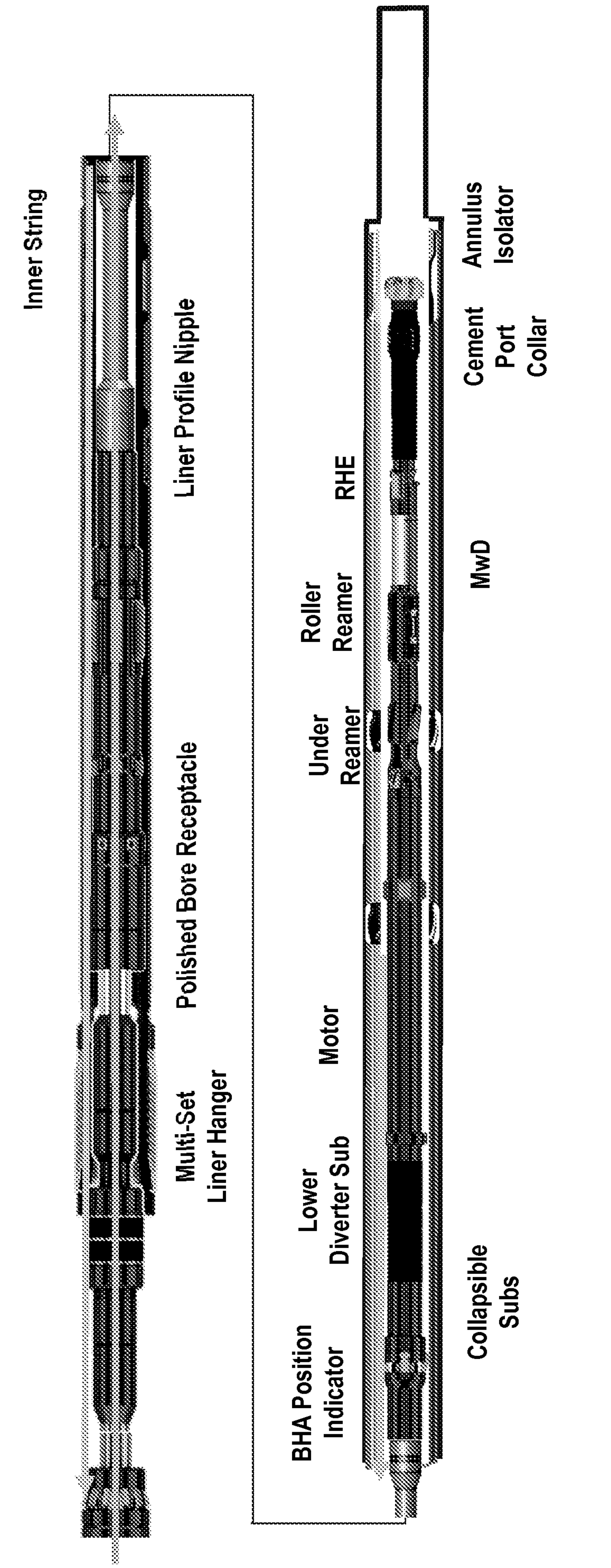

Inner String
Liner Profile Nipple
Polished Bore Receptacle
Multi-Set Liner Hanger
Annulus Isolator
Cement Port Collar
RHE
MwD
Roller Reamer
Under Reamer
Motor
Lower Diverter Sub
Collapsible Subs
BHA Position Indicator

FIGURE 12

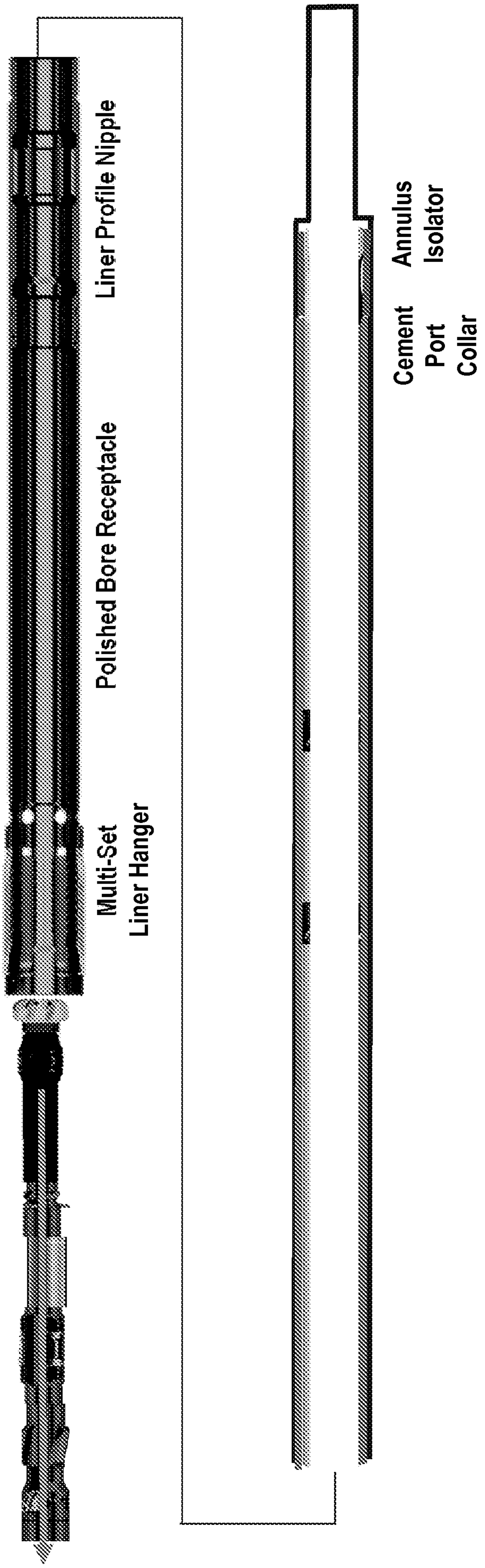

Liner Profile Nipple
Polished Bore Receptacle
Multi-Set Liner Hanger
Annulus Isolator
Cement Port Collar

FIGURE 13

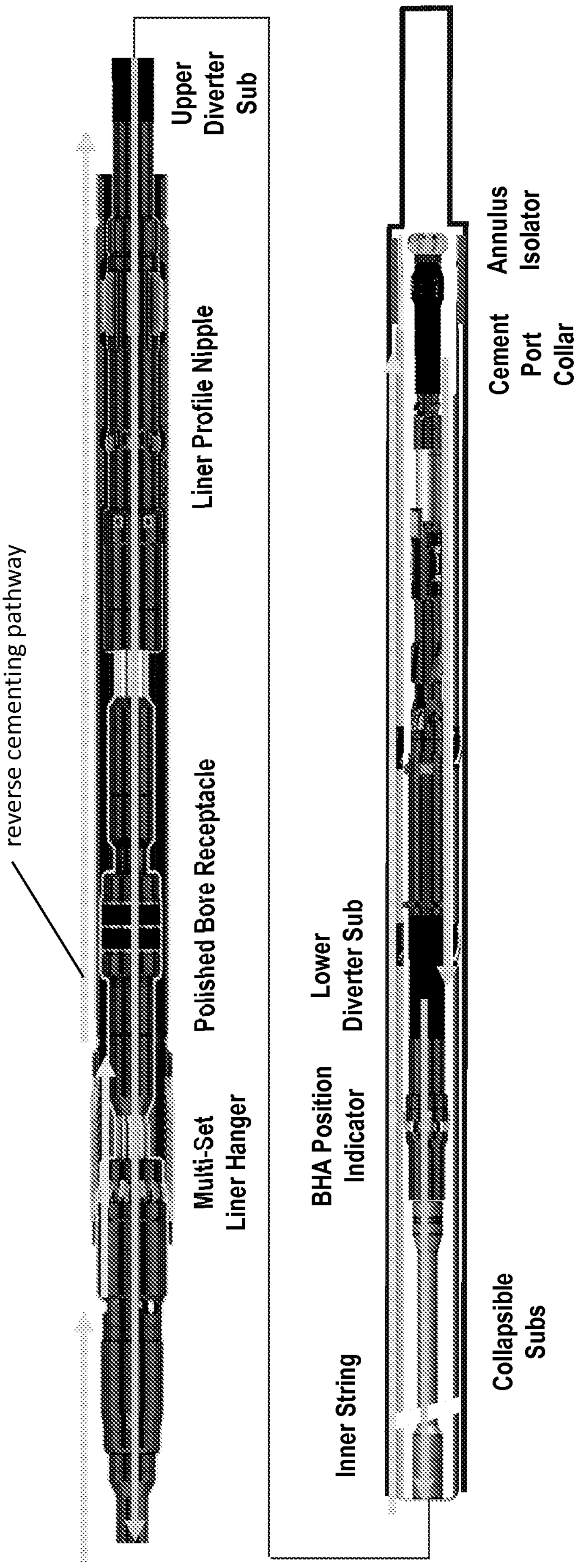

reverse cementing pathway
Upper Diverter Sub
Liner Profile Nipple
Polished Bore Receptacle
Multi-Set Liner Hanger
Lower Diverter Sub
BHA Position Indicator
Inner String
Annulus Isolator
Cement Port Collar
Collapsible Subs

FIGURE 14

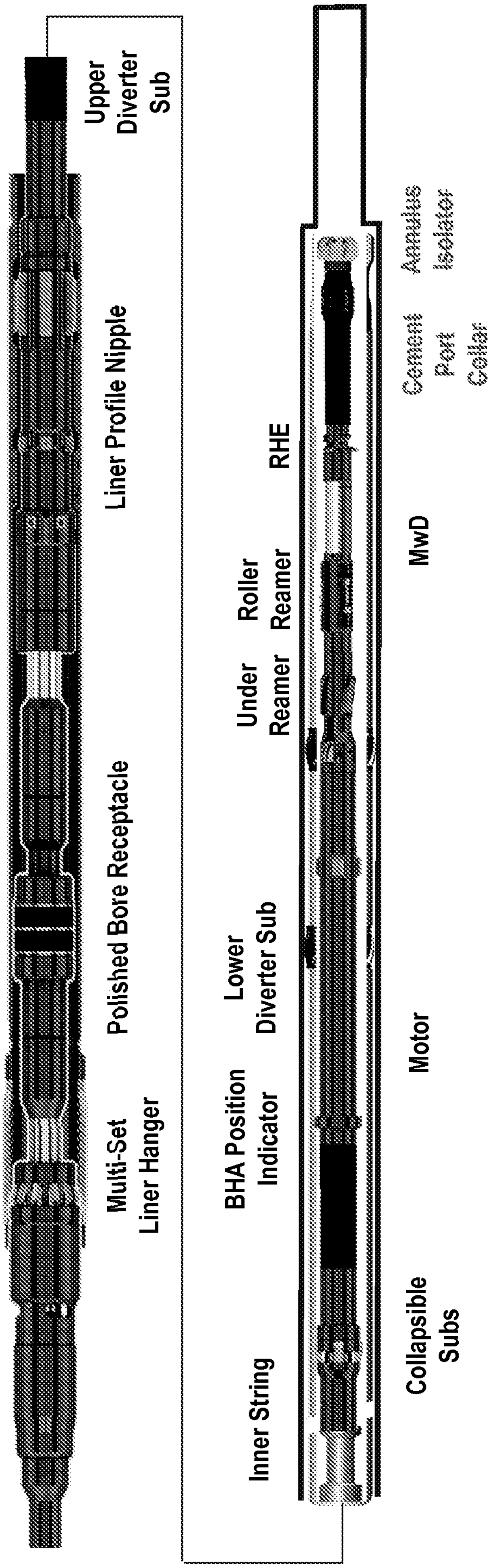

Upper Diverter Sub
Liner Profile Nipple
Polished Bore Receptacle
Multi-Set Liner Hanger
Annulus Isolator
Cement Port Collar
RHE
MwD
Roller Reamer
Under Reamer
Lower Diverter Sub
Motor
BHA Position Indicator
Collapsible Subs
Inner String

FIGURE 15

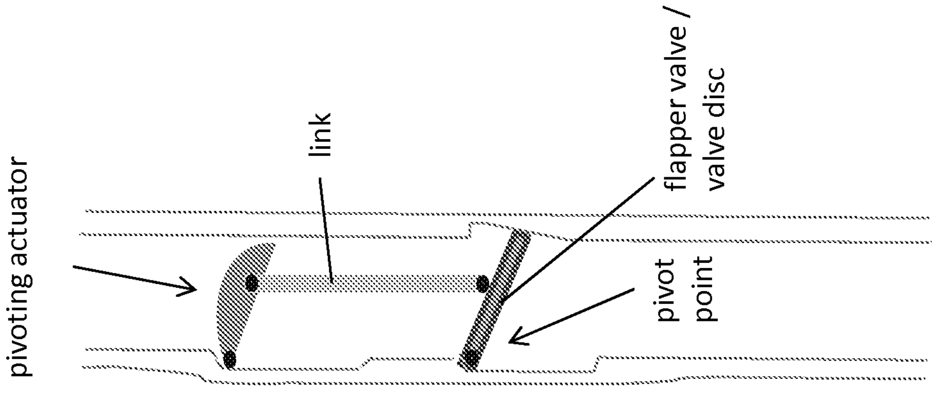
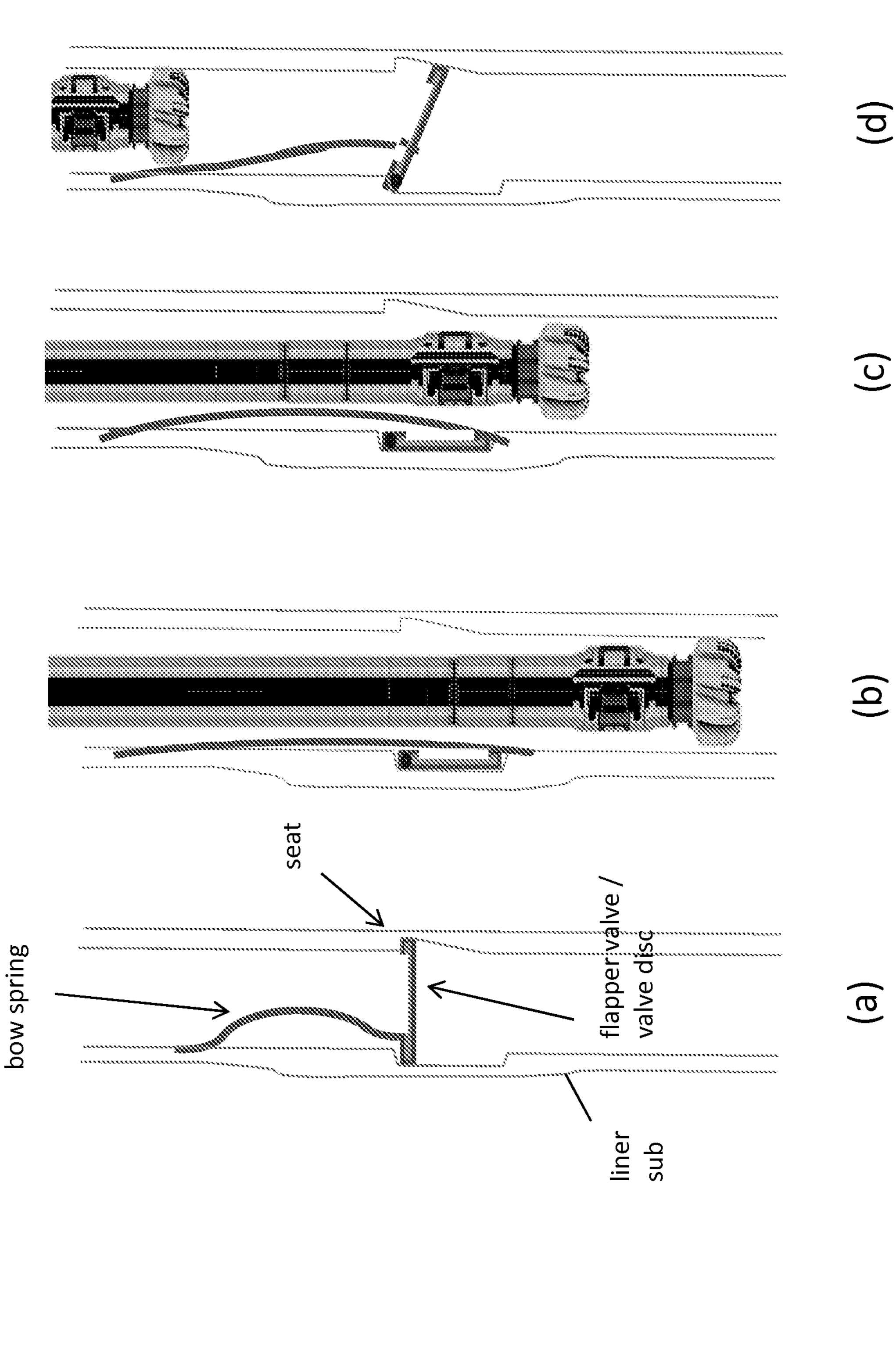


FIGURE 17



FIGURES 16a-16d

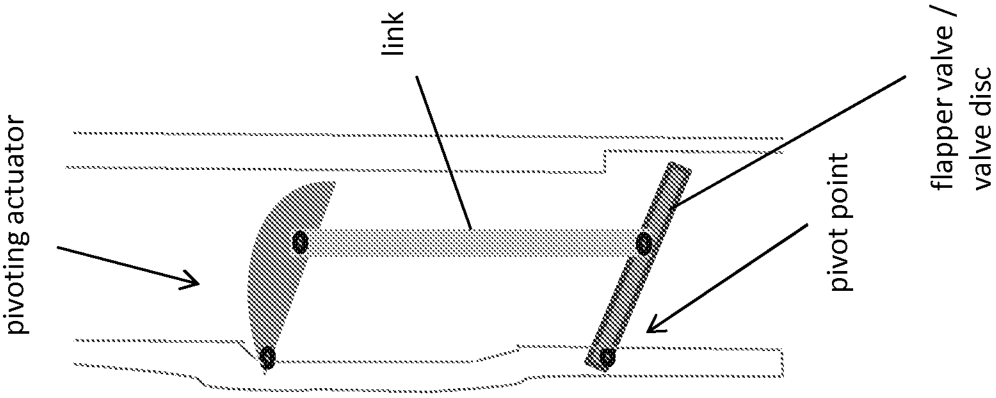
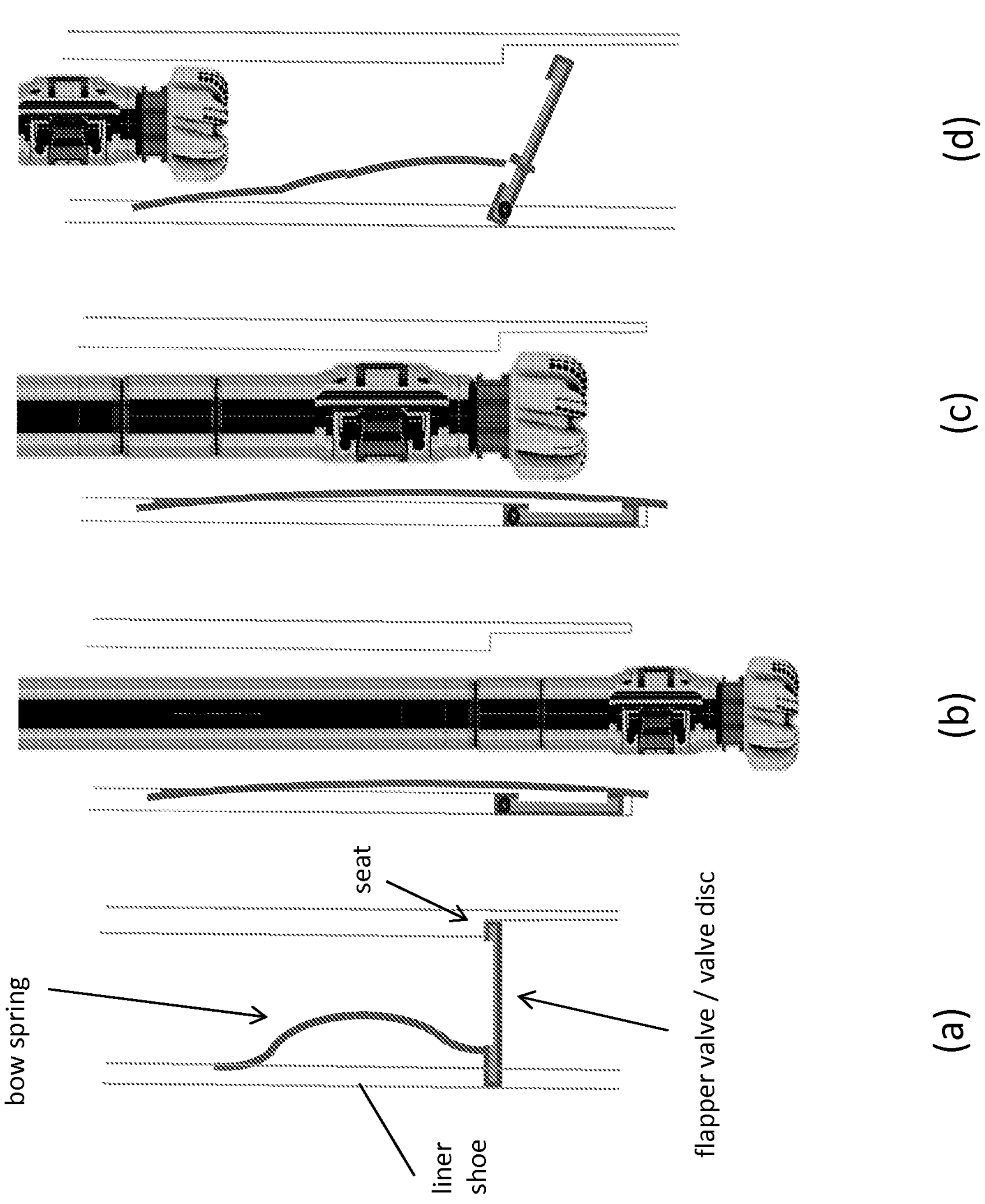


FIGURE 19



FIGURES 18a-18d

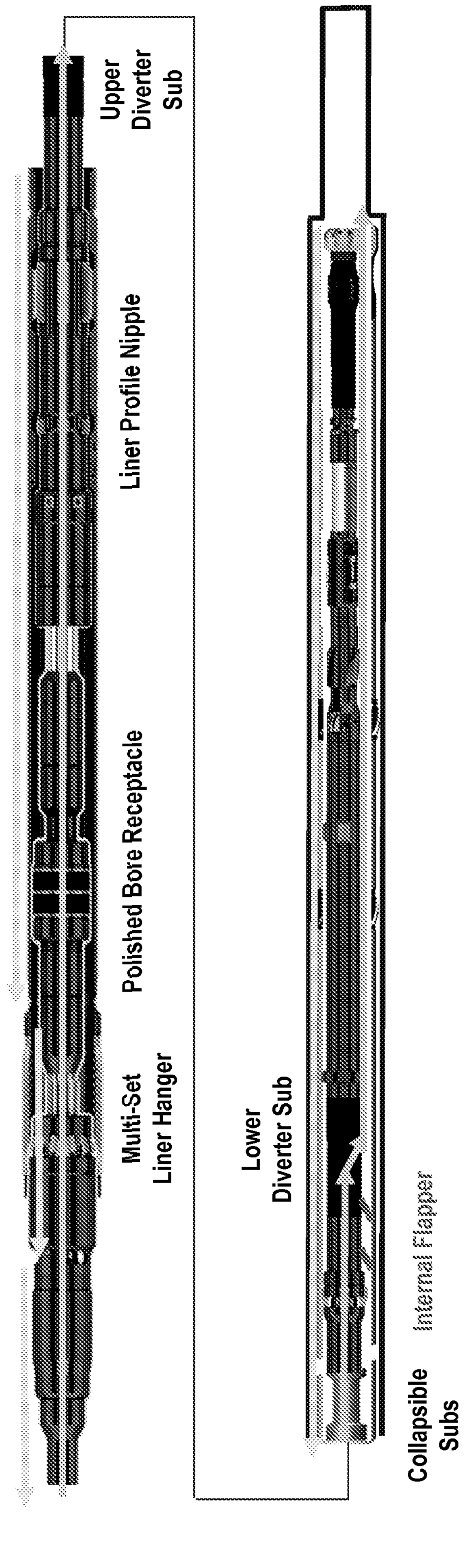

Upper Diverter Sub
Liner Profile Nipple
Polished Bore Receptacle
Multi-Set Liner Hanger
Lower Diverter Sub
Internal Flapper
Collapsible Subs

FIGURE 20

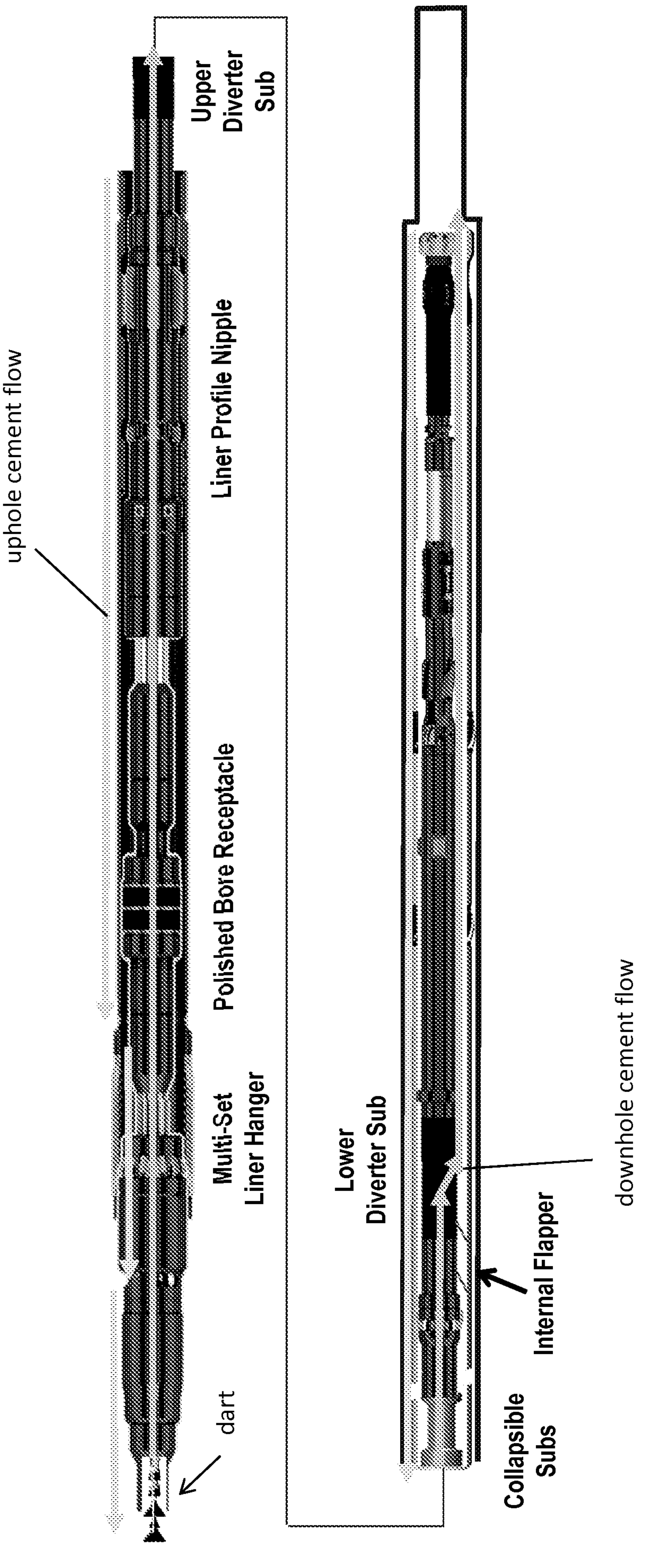

Upper Diverter Sub
Liner Profile Nipple
uphole cement flow
Polished Bore Receptacle
Multi-Set Liner Hanger
dart
Lower Diverter Sub
downhole cement flow
Internal Flapper
Collapsible Subs

FIGURE 21

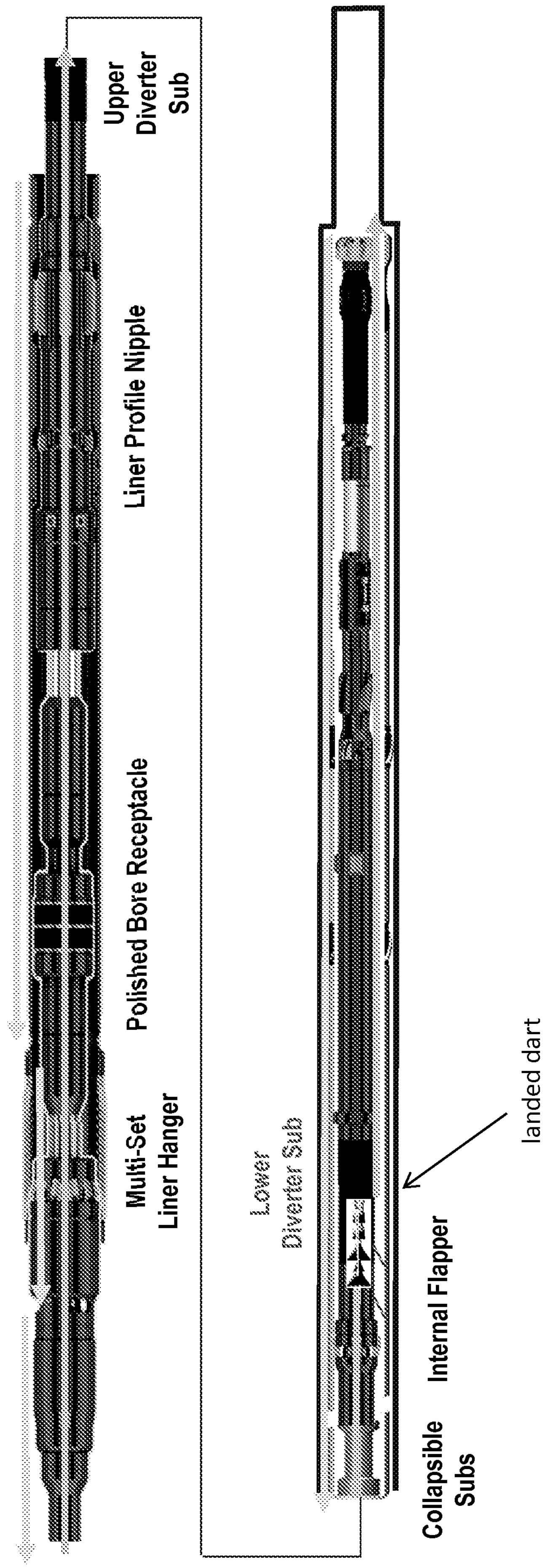

Upper Diverter Sub
Liner Profile Nipple
Polished Bore Receptacle
Multi-Set Liner Hanger
Lower Diverter Sub
landed dart
Internal Flapper
Collapsible Subs

FIGURE 22

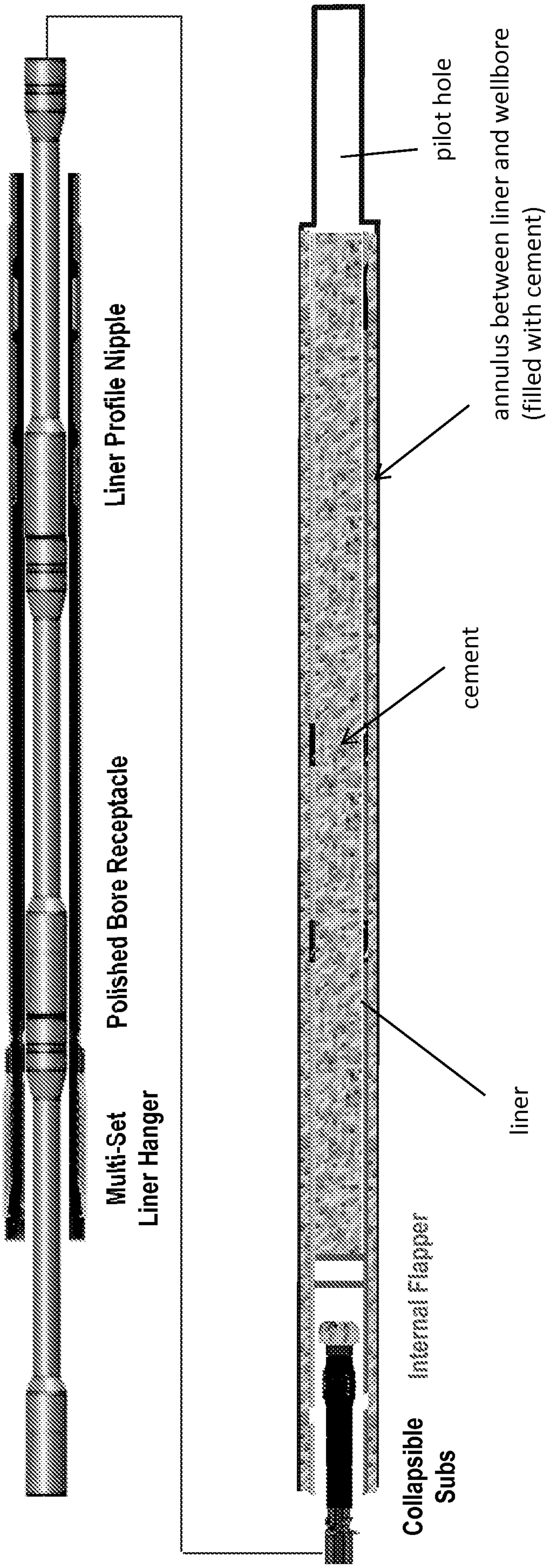

Liner Profile Nipple
Polished Bore Receptacle
Multi-Set
Liner Hanger
pilot hole
annulus between liner and wellbore
(filled with cement)
cement
liner
Internal Flapper
Collapsible
Subs

FIGURE 23

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/011699

A. CLASSIFICATION OF SUBJECT MATTER

E21B 33/13(2006.01)i, E21B 17/00(2006.01)i, E21B 34/06(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
E21B 33/13; E21B 7/00; E21B 7/128; E21B 34/06; E21B 43/00; E21B 21/10; E21B 10/66; E21B 33/14; E21B 7/20; E21B 43/11; E21B 17/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: wellbore, single trip, cementing, liner, bottom hole assembly, drill bit, diverter sub, annulus isolator, and cement path

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2013-0299169 A1 (REX et al.) 14 November 2013 See paragraphs [0001], [0005], [0027]-[0033] and figures 1-9.	1-7
Y	US 2013-0043020 A1 (ERIKSEN, ERIK P.) 21 February 2013 See paragraphs [0040]-[0045] and figures 1-3.	1-7
A	US 2012-0168228 A1 (GIROUX et al.) 05 July 2012 See paragraphs [0028]-[0041] and claims 1,13.	1-7
A	US 2004-0003944 A1 (VINCENT et al.) 08 January 2004 See paragraphs [0021]-[0028] and figures 1-10.	1-7
A	US 2012-0186816 A1 (DIRKSEN et al.) 26 July 2012 See paragraphs [0018]-[0020] and figure 2.	1-7

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 April 2015 (29.04.2015)	**29 April 2015 (29.04.2015)**

Name and mailing address of the ISA/KR
International Application Division
Korean Intellectual Property Office
189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea
Facsimile No. ++82 42 472 7140

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

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