COMPONENT OF BOTTOM HOLE ASSEMBLY HAVING UPWARDLY-DIRECTED FLUID CLEANING FLOW AND METHODS OF USING SAME

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ABSTRACT

A stabilizer, drill bit, or other component of a bottom hole assembly for use in drilling a borehole includes an elongate and generally cylindrical body, a flow bore in the body; a plurality of outwardly-extending blades, with a valley disposed between adjacent blades. A ring segment that is spaced from the body and extends across at least one valley to define a flow passage through which cuttings-laden drilling mud is conveyed with an upwardly-direct trajectory. The body includes a hole or passageway for conveying drilling mud from the flow bore to between the blades. The passageway terminates in an exit directed toward the flow passage so as to provide fresh drilling mud with a trajectory such that the fluid passes through the flow passage.
COMPONENT OF BOTTOM HOLE ASSEMBLY HAVING UPWARDLY-DIRECTED FLUID CLEANING FLOW AND METHODS OF USING SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] None

BACKGROUND

[0002] The field of endeavour relates to a stabilizer and a drill bit for use in a drill string. The stabilizer and drill bit preferably, but not exclusively, forms part of a bottom hole assembly of the drill string.

[0003] In the drilling of a borehole in the construction of an oil or gas well, a drill bit is arranged at a lower end of a drill string, which is rotated to bore the borehole through a formation. A drilling fluid, referred to herein as “drilling mud,” is pumped through the drill string to the drill bit to lubricate the drill bit and returns carrying drill cuttings in an annulus between an outer wall of the drill string and the borehole. As the drill bit progresses through the formation, stands of drill pipe are added to the drill string. Stands of drill pipe typically comprise two, three or four joints of drill pipe threaded together in a mousehole in a drilling rig floor using an iron roughneck. The stand is then sent back in a fingerboard pipe rack. A joint of drill pipe is typically 31 ft 6 inches long (9.65 m). Each joint of drill pipe has a hollow cylindrical body with a lower threaded pin end and an upper threaded box end. As the drill bit progresses in the borehole, the drill string moves downward. When an upper end of the drill string nears the rig floor, a stand is pulled out of the fingerboard pipe rack. The top of the stand is placed in an elevator, and the lower end aligned with a top of the drill string at well center. A lower threaded pin end of the stand of drill pipe is stabbed into an upper box of the drill string and threaded connected using the iron roughneck. Drilling then continues using rotation of a top drive, a rotary table or downhole motor. The drill string can be many hundreds or thousands of metres long.

[0004] The borehole may be substantially vertical and may comprise deviated portions. A deviated portion of a borehole may be horizontal. A horizontal portion of a bore may be several kilometres long.

[0005] The drill bit is usually arranged in a Bottom Hole Assembly at the bottom end of a drill string. The drill bit has a pin end with a male thread and has a flow bore leading to a body of the drill bit. The body of the drill bit has a number of cutting elements with a plurality of nozzles therebetween. Drilling mud flows down through the flow bore and out through the nozzles to inter alia carry drill cuttings from the drill bit through the annulus.

[0006] The drill bit is usually threaded into a box end of a stabilizer. The stabilizer attempts to reduce vibration induced by the drill bit progressing through the formation and to improve directional stability. The stabilizer is generally a thick walled tubular with a plurality of spaced blades thereabout which may be arranged in parallel curved paths which may be helical, or spiral. The spaced blades define interleaved valleys. The valleys may also follow a helical or spiral path to inter alia facilitate the flow of drill cuttings laden drilling mud in the annulus around and along the bottom hole assembly. The stabilizer usually has an upper box end into which further components of a Bottom Hole Assembly are attached. Such components may include: a Measurement While Drilling (MWD) tool, for obtaining data; a Logging While Drilling tool, for logging the data; further stabilizers; drill collars for providing weight to facilitate Weight On Bit (WOB); a jar for providing a shock to BHA if a tool or drill bit becomes stuck in the borehole; and cross-over subs having pin-to-pin connectors.

[0007] The drill string may be pulled out of the borehole for many reasons, such as: to change the drill bit; to allow for a string of casing to be lowered into the borehole for casing the borehole; to hang a liner; to set a whipstock for deviated drilling; to lower milling tools; to fish for stuck tools; to clean the borehole; and prepare the borehole for production. The step of pulling the drill string out of the borehole is known as “tripping-out” and the step of lowering the drill string back into the borehole is known as “tripping-in”. During tripping, the string of drill pipe is not rotated or only rotated slowly in order to facilitate a smooth movement along a borehole, which may be vertical, deviated or partly horizontal.

[0008] As the drill string is pulled out of the borehole, a stand of drill pipe is disconnected using an iron rough neck and the stand placed back into the fingerboard pipe rack, usually using a pipe handling tool, such as a racker.

[0009] During tripping-out, circulation of drilling mud through the drill string may be maintained to inter alia maintain a constant head of drilling mud in the well, inhibit solids suspended in the drilling mud from settling out; and to maintain a constant pressure in the borehole to inhibit the borehole collapsing. During tripping out more drilling mud will be added to the well to replace the drill pipe removed from the borehole. During tripping-in drilling mud will be displaced from the borehole as the drill string is lowered into the well.

[0010] It is common to stop circulation of drilling mud during tripping. Although it is common during tripping to circulate drilling mud between making or breaking a threaded connection between a stand of drill pipe and the drill string. It is also possible to have a continuous circulation of drill mud during tripping using a Continuous Circulation System to maintain continuous circulation of drilling mud through the entire drill string during making or breaking a connection.

SUMMARY OF THE DISCLOSURE

[0011] A stabilizer incorporates a plurality of blades with interleaved valleys and may have a ring or ring segments between the blades over the valleys forming flow passages. Upon upward movement of the stabilizer, such as being lifted, reciprocated or upon tripping-out, an upper face of the ring may scrape along a wall of the borehole, collecting small solids, such as clay particles, which can agglomerate to form clumps, known as balling. Once a small clump forms, solids suspended in the drilling mud may additionally land on the clump, increasing the clump’s size. The clumps stick to the stabilizer, possibly blocking flow passages and can also fall into the well. The clumps can build up in parts of the borehole in a worse case, block the borehole. Upon tripping-in and during drilling, a bottom face of the ring may scrape along a wall of the borehole, collecting small solids, such as clay particles, which can agglomerate to form clumps, known as balling. Once a small clump forms, solids suspended in the drilling mud may additionally land on the clump, increasing the clump’s size. These clumps may block or partially block the flow passages defined by the ring and the valleys.

[0012] Furthermore, the balling may occur around the ring or ring segment during drilling.
[0013] There is disclosed a stabilizer for use in drilling a borehole, the stabilizer comprising a cylindrical body having an inner wall defining a flow bore and a plurality of blades extending outwardly from said cylindrical body with a valley disposed between adjacent blades, the stabilizer further comprising at least one ring segment spaced from said cylindrical body over at least one valley to define a flow passage characterised in that said cylindrical body further comprises at least one fluid passageway or "hole" therein for conveying drilling mud from said flow bore to between the blades.

[0014] The hole may provide a flow path for fresh drilling mud to flow out of the flow bore and direct the flow to inhibit clumps of drill cuttings and other solids from forming, particularly but not exclusively around the ring segment. The flow through the hole exits the hole as a jet of fresh drilling mud. The jet may be sufficient to break up clumps of drilled cuttings and other solids which have already formed.

[0015] The hole may have any suitable cross-sectional shape, such as circular, oval, square, rectangular, slot-like or polygonal. There may be more than one hole under each ring segment. The holes may be pointed in different directions.

[0016] Optionally, the hole comprises an entrance in said inner wall and an exit in the at least one valley. Having the exit positioned in the valley facilitates direction of the flow of fresh drilling mud therefrom in a radial direction. Optionally, the hole has an exit directed through at least a portion of the flow passage. The flow of fresh drilling mud through the flow passage may facilitate fluidizing solids knocked, scraped or reamed from the formation surrounding the borehole by the ring segment. The flow of fresh drilling mud through the flow passage may encourage a smooth flow of solids-laden drilling mud therethrough. Optionally, the exit of the hole is located underneat the ring segment, which may encourage solids-laden drilling mud to be pulled through as well as pushing solids through the ring, and may prevent solids from settling on the ring. Preferably, the exit of the hole is located underneat the ring segment, towards a bottom face thereof, which may allow the jet to develop and have a spread which facilitates removal of settled solids and solids about to settle on and about the ring segment.

[0017] Optionally, the hole is lined with a liner. The liner may provide erosion resistance in the body around the entrance, exit and along the length of the hole. Optionally, the liner projects into the flow bore of the stabilizer, which may help reduce the risk of erosion of the body around the entrance to hole. Optionally, the liner is made from a wear resistant material, such as tungsten carbide. Optionally, the hole comprises a nozzle having a nozzle bore through which drilling fluid flows. The nozzle provides a jet having known qualities, such as spread pattern and speed. The nozzle may also be used to facilitate direction of the jet of fresh drilling mud. The nozzle bore has a length and a cross-sectional flow area which changes along the length. A change in cross-sectional bore area may induce different jet speeds and spread patterns. Optionally, the nozzle bore has a fluid entry end which has a first flow area and a fluid exit end which has a smaller flow area. The nozzle preferably reduces in diameter between the fluid entry end and fluid exit end. The nozzle bore may have a smooth internal surface which follows a curved path. The nozzle may be replaceable, so that the nozzle can be replaced with a nozzle having different flow characteristics, such as a different ratio of entry and exit flow areas. Optionally, the nozzle has a thread and the hole has a corresponding thread, such that the nozzle can be threaded into the hole in the body of the stabilizer.

[0018] Optionally, the body has a wall that varies in thickness, and includes a thick wall in the valley along a portion of the length of the blades and a thin wall under the ring or ring segment. Thus, a greater flow area may be obtained under the ring, whilst structural strength may not be excessively reduced thanks to additional support provided by the ring or ring segment, including a structural component that may be employed therein. Optionally, the hole is arranged in a transition zone between the thick wall portion and a thin wall portion. The hole is thus placed in a position which minimises reduction of structural integrity, whilst being placed in a position which provides a flow of fresh drilling mud to inhibit solids from forming clumps on the ring segment. Optionally, the stabilizer has a lower end provided with a box for receiving a pin of a drill bit. Optionally, an entrance to the hole is arranged in the body between the box and the ring.

[0019] Optionally, the hole is arranged at an obtuse angle to the direction of flow of drilling mud through the flow bore. The obtuse angle provides an acute angle at the exit when the hole is formed along a linear path. The acute angle at the exit, in use, provides a trajectory for the jet of fresh drilling mud. Optionally, the hole is arranged at between 140 degrees and 170 degrees to the direction of flow of drilling mud through the flow bore, and optionally, between 150 degrees and 160 degrees.

[0020] Optionally, the ring segment is arranged between every adjacent blade to form a complete ring about the stabilizer. Thus each blade has two ring segments, one to the left and one to the right. A complete ring may increase stability. Optionally, only one ring segment spans between adjacent blades, such that on a stabilizer with four blades there are only two ring segments, each on an opposing side. Optionally, the blades are curved about a central axis of the stabilizer. The curved blades may curve about the axis by an angle such that the angle of all blades adds up to at least 360 degrees. Thus a complete 360 degree contact with the borehole is possible along the length of the blades. With such blade contact, only one ring segment per blade may be provided, whilst maintaining vibration control of the drill bit.

[0021] Optionally, the ring or ring segment is arranged on a part of each of the blades, which may be a part axially aligned with a main axis of the stabilizer. This may allow the flow passage to have sides which are substantially axially aligned. Optionally, the stabilizer further comprises an upper portion of thick walled pipe. Optionally, the thick walled pipe has a box in an upper end to facilitate connection in a bottom hole assembly. Optionally, the upper portion has a recess therein for holding a measuring while drilling ("MWD") device.

[0022] There is disclosed a stabilizer for use in drilling a borehole, the stabilizer comprising a cylindrical body having an inner wall defining a flow bore and a plurality of blades extending outwardly from the cylindrical body with a valley formed between adjacent blades, the stabilizer further comprising at least one ring or ring segment spaced from the cylindrical body characterised in that the cylindrical body further comprises at least one hole therein for conveying drilling mud from the flow bore.

[0023] A drill bit incorporates a plurality of blades with interleaved valleys and may have a ring or ring segments between the blades over the valleys forming flow passages. Upon upward movement of the drill, such as being lifted,
reciprocated or upon tripping-out, an upper face of the ring may scrape along a wall of the borehole, collecting small solids, such as clay particles, which can agglomerate to form clumps, known as balling. Once a small clamp forms, solids suspended in the drilling mud may additionally land on the clamp, increasing the clamp’s size. The clumps stick to the drill bit, possibly blocking flow passages and can also fall into the well. The clumps can build up in parts of the borehole and in a worse case, block the borehole. Upon tripping-in and during drilling, a bottom face of the ring may scrape along a wall of the borehole, collecting small solids, such as clay particles, which can agglomerate to form clumps, known as balling. Once a small clamp forms, solids suspended in the drilling mud may additionally land on the clamp, increasing the clamp’s size. These clumps may block or partially block the flow passages defined by the ring and the valleys.

Furthermore, balling may occur around the ring or ring segment during drilling.

There is disclosed a drill bit for use in drilling a borehole, the drill bit comprising a cylindrical body having an inner wall defining a flow bore for conveying fresh drilling mud and a plurality of blades extending outwardly from the cylindrical body with a valley disposed between adjacent blades, the drill bit further comprising at least one ring segment spaced from the cylindrical body over at least one valley to define a flow passage through which cuttings-laden drilling mud flows, the cylindrical body further comprises at least one fluid passageway or “hole” therein for conveying drilling mud from the flow bore, characterised in that the hole has an exit directed to provide fresh drilling mud with a trajectory passing through at least a portion of the flow passage.

There is disclosed a drill bit for use in drilling a borehole, the drill bit comprising a cylindrical body having an inner wall defining a flow bore for conveying fresh drilling mud and a plurality of blades extending outwardly from the cylindrical body with a valley disposed between adjacent blades, the drill bit further comprising at least one ring segment spaced from the cylindrical body over at least one valley to define a flow passage through which cuttings-laden drilling mud flows, the cylindrical body further comprises at least one fluid passageway or “hole” therein for conveying drilling mud from the flow bore, characterised in that the hole has an exit in the flow passage.

There is disclosed a drill bit for use in drilling a borehole, the drill bit comprising a cylindrical body having an inner wall defining a flow bore for conveying fresh drilling mud and a plurality of blades extending outwardly from the cylindrical body with a valley disposed between adjacent blades, the drill bit further comprising at least one ring segment spaced from the cylindrical body over at least one valley to define a flow passage through which cuttings-laden drilling mud flows, the cylindrical body further comprises at least one fluid passageway or “hole” therein for conveying drilling mud from the flow bore, characterised in that the hole has an exit directed to provide fresh drilling mud with a trajectory passing through at least a portion of the flow passage.

Optionally, the body comprises a nozzle having a nozzle bore through which drilling fluid flows. Optionally, the nozzle bore has a length and a cross-sectional flow area which changes along the length. Optionally, the nozzle bore has a fluid entry end which has a first flow area and a fluid exit end which has a smaller flow area. The nozzle optionally reduces in diameter between the fluid entry end and fluid exit end. The nozzle bore optionally has a smooth internal surface which follows a curved path. Advantageously, the nozzle is replaceable, so that the nozzle can be replaced with a nozzle having different flow characteristics, such as a different ratio of entry and exit flow areas. Optionally, the nozzle has a thread and the hole has a corresponding thread, such that the nozzle can be threaded into the hole in the body of the drill bit.

Optionally, the body has a thick wall in the valley along a portion of the length of the blades and a thin wall under the ring or ring segment. Optionally, the hole is arranged in a transition zone between the thick wall portion and thin wall portion. Optionally, an exit of the hole is arranged under the ring. Preferably, the hole is arranged at an obtuse angle to the direction of flow of drilling mud through the flow bore. Optionally, the hole is arranged at between 140 degrees and 170 degrees to the direction of flow of drilling mud through the flow bore and optionally, between 150 degrees and 160 degrees.

Optionally, the ring segment is arranged between every adjacent blade to form a complete ring about the drill bit. Thus each blade has two ring segments, one to the left and one to the right. Optionally, only one ring segment spans between adjacent blades, such that on a drill bit with four blades there are only two ring segments, each on an opposing side.

Optionally, the ring or ring segment is arranged on a part of each of the blades.

Optionally the part of each blade is axially aligned with a main axis of the drill bit.

Also disclosed is a bottom hole assembly comprising a stabiliser and/or a drill bit in accordance with an embodiment of the present disclosure.

Also disclosed is a method of tripping using a stabiliser and/or drill bit in accordance with an embodiment of the present disclosure, the method comprising the steps of circulating drilling mud through the flow bore, a portion of the drilling mud passing through the hole and through the flow passage.

Thus solids which are scraped off the wall of the borehole or have otherwise collected on the ring segment, are fluidised or inhibited from forming clumps. The solid particles are thus suspended in the drilling mud and circulated as any other solids in the drilling mud, such as drill cuttings. Clumps which may have already formed may be broken up by the jet of fresh drilling mud. The drill cuttings-laden drilling fluid in the flow passage is diluted with fresh drilling mud by a small amount.

Optionally, the drilling mud is circulated between threading operations. Optionally, the drilling mud is also circulated during threading operations with a circulating head. Optionally, the circulating head comprises a seal which seals inside the drill string or about the drill string, so that a threaded connection does not have to be made in order to circulate drilling mud through the drill string. Optionally, the drill string is threaded connected to a rotor of a top drive and the drilling mud circulated therethrough. Optionally, a con-
tinuous circulation system is used to maintain circulation of drilling mud throughout tripping.

[0037] Also disclosed is a method of drilling a borehole using a drill bit or stabilizer in accordance with an embodiment of the present disclosure, the method comprising the steps of circulating drilling mud through the flow bore, a portion of the drilling mud passing through the hole and through the flow passage. Optionally, the drilling mud is circulated continuously during drilling.

[0038] Also disclosed is a method of drilling a borehole using a drill bit in accordance with an embodiment of the present disclosure, the method comprising the steps of circulating drilling mud through the flow bore, a portion of the drilling mud passing through the hole and through the flow passage. Optionally, the drilling mud is circulated continuously during drilling.

[0039] Also disclosed is an apparatus for use in a bottom hole assembly in drilling a borehole, the apparatus comprising a cylindrical body having an inner wall defining a flow bore and a plurality of blades extending outwardly from the cylindrical body with a valley disposed between adjacent blades, the apparatus further comprising at least one ring segment spaced from the cylindrical body over at least one valley to define a flow passage, characterised in that the cylindrical body further comprises at least one hole therein for conveying drilling mud from the flow bore. The apparatus may be one of a drill bit, stabilizer, on-gauge sub or other BHA component.

**BRIEF DESCRIPTION OF THE DRAWINGS**

[0040] For a better understanding of the disclosed exemplary embodiments of the invention, reference will now be made to the accompanying drawings, in which:

[0041] FIGS. 1A and 1B show a schematic view of a drilling rig 1 illustrating a wellbore with a drill string comprising a stabilizer in accordance with certain of the embodiments disclosed herein;

[0042] FIG. 2 is a perspective view of a stabilizer in accordance with a disclosed embodiment, the stabilizer shown before a layer of hardfacing material has been applied;

[0043] FIG. 3 is a side view of the stabilizer shown in FIG. 2;

[0044] FIG. 4 is an end view of the stabilizer shown in FIG. 2;

[0045] FIG. 5 is an enlarged view in section of a part of the stabilizer shown in FIG. 2 taken along line V-V, shown with a layer of hardfacing material applied to parts thereof, showing details of a nozzle;

[0046] FIG. 6a is a side view of the nozzle shown in FIG. 5;

[0047] FIG. 6b is an end view of the nozzle shown in FIG. 6a;

[0048] FIG. 6c is a view in section taken along line V1c-V1c shown in FIG. 6b;

[0049] FIG. 7 shows an alternative to the part of the stabilizer shown in FIG. 5;

[0050] FIG. 8 is a further alternative to the part of the stabilizer shown in FIG. 7;

[0051] FIG. 9 is a perspective view of the stabilizer shown in FIG. 2 with hardfacing material applied to parts thereof;

[0052] FIG. 10 is a drill bit in accordance with an exemplary embodiment disclosed herein; and

[0053] FIG. 11 is a view in cross-section of part of the drill bit shown in FIG. 10.

**DETAILED DESCRIPTION OF THE DISCLOSED EXEMPLARY EMBODIMENTS**

[0054] Referring to FIGS. 1a and 1b there is shown a drilling rig generally identified by reference numeral 1. The drilling rig 1 has a derrick 2 arranged on a drill floor 3 supported on legs 4. The legs 4 are seated on a substructure 5 on ground 6.

[0055] A top drive apparatus 7 is arranged on a carriage 10 raised and lowered with a travelling block 8 on line 9 along a vertical track 10. The line 9 passes over a crown block 11 located at the top of the derrick 2 and down to a drawworks 12 on the rig floor 3 for reeling the line 9 in and out. A stand of drill pipe 13 depends from an elevator 14. The elevator 14 depends from links 15 which are looped over ears 16 of a swivel 16a of the top drive apparatus 7.

[0056] A drill string 17 passes through a spider 18 in the drill floor 3, through a wellhead 19 into a borehole 20 in formation 21. A bottom hole assembly 22 is arranged on a lower end of the drill string 17. The bottom hole assembly 22 comprises a drill bit 23 connected to a stabilizer 100 on a lower end thereof. The bottom hole assembly also comprises a Measurement While Drilling tool 24, a further stabilizer 25 and a drill collar 26. A mud motor may also be incorporated into the bottom hole assembly. An annulus 29 is defined between the borehole 20 and the bottom hole assembly 22.

[0057] A flow line 30 is fluidly connected at one end to an annulus 29 at the wellhead 19 and the other end to an active mud system 31. The annulus 29 is an annular flow passage defined by the formation 21 (or casing (not shown) if the borehole is cased) and an outer surface of the drill string 17 or bottom hole assembly 22. Returned solids-laden drilling mud DM flows from the annulus 29, through wellhead 19, into flow line 30 and to the active mud system 31, which cleans and processes the solids-laden drilling mud DM to produce fresh drilling mud M. The active mud system 31 comprises a trip tank, an active mud tank and a series of pieces of mud processing equipment, such as: a shale shaker, a degasser, a mud conditioner, and a centrifuge. Fresh drilling mud M is pumped with a mud pump MP at a pressure up to between 200 bar and 1000 bar at between 300 and 4800 litres per minute from the active mud system 31 through a hose 32 to a goose neck connection 33 on top drive 34 of the top drive apparatus 7. Processed and now fresh drilling mud flows through the goose neck connection 33 into a main rotating shaft 35. The drilling mud continues to flow through an Internal Blow Out Preventer (IBOP) 36 and sub 37 and through the drill string 17, when connected.

[0058] An iron rough neck 38 is arranged on the rig floor 3 for rotating the stand of drill pipe 13 relative to the static drill string 17 to thread the stand of drill pipe 13 to the drill string 17 or unthread the stand of drill pipe 13 from the drill string 17.

[0059] The stand of drill pipe 13 is threaded and torqued to the drill string 17 using the iron roughneck 38. The sub 37 of the top drive apparatus 7 is threaded to the top of the connected stand of drill pipe 13. The top drive 34 is activated to rotate the drill string 17, if desired. The drill bit 23 drills through the formation 21 extending the borehole 20. The drilling mud M is circulated through the drill string 17 and out of nozzles in the drill bit 23, washing drilled solids through the annulus to the active mud system 31. Rate Of Penetration of the drill bit 23 in a formation may vary dramatically, but may often be in the order of 30 metres per hour.
When required, the drill string 17 is tripped-out of the borehole 20. During tripping-out, the sub 37 of the top drive apparatus 7 is not usually threadedly mated with the drill string 17, thus the top drive 34 is not rotationally connected to the drill string 17 or stands of drill pipe 13. The elevator 14 is used to raise the drill string 17 until typically two, three or four joints of drill pipe are above the rig floor 3. The iron roughneck 38 is used to disconnect a stand of drill pipe 13. A single joint elevator system 46 may be used to set the stand of drill pipe 13 back into a fingerboard pipe rack 44, which stores a multiplicity of stands of drill pipe 45. The elevator 14 is then lowered with the top drive apparatus 7 until it is just below the box end of the stem 49 of the drill string 17. The elevator 14 is opened and clamped or slideably looped around the stem 49 of the drill string 17 above the rig floor 3. The operation is repeated until the entire drill string 17 and bottom hole assembly 22 are out of the borehole 20. Accordingly, tripping-out is usually very quick and can be carried out at 600 metres per hour with modern rigs and experimental rigs expect tripping-out at up to 3,600 metres per hour.

When required, the drill string 17 is tripped-in to the borehole 20. During tripping-in, the sub 37 of the top drive apparatus 7 is not usually threadedly mated with the drill string 17, thus the top drive 34 is not rotationally connected to the drill string 17 or stands of drill pipe 13. A single joint elevator system 46 may be used to pull a stand of drill pipe 13 from the fingerboard pipe rack 44, which stores a multiplicity of stands of drill pipe 45 and is placed in an elevator 14 hanging above stem 49 at well-centre. The iron roughneck 38 on the rig floor 3 is used to connect the stand of drill pipe 13 to the stem 49. The elevator 14 is raised with the top drive apparatus 7 to lift the drill string 17 a little to allow the spider 18 to be released. The elevator 14 is then lowered with the top drive apparatus 7 until only a stem 49 of the drill string 17 is above the rig floor 3. The operation is repeated until the entire drill string 17 and bottom hole assembly 22 are at the bottom of the borehole 20. Accordingly, tripping-in is usually very quick and can be carried out at 600 metres per hour with modern rigs and experimental rigs expect tripping-out at up to 3,600 metres per hour.

Optionally, the sub 37 of the top drive apparatus 7 is threadedly mated with the drill string 17 to allow circulation of drilling mud.

Optionally, a circulating head 50 is connected to the sub 37. Reference is made to WO 2009/098473, WO 2009/098474, WO 2009/098475, WO 2009/098482, WO 2010/08577, WO 2010/08575 which are hereby incorporated by reference for all purposes. The circulating head 50 has a spear 51 which moves axially into a sealing engagement with the top end of the stand of drill pipe 13 held in the elevator 14, which has been threadedly connected to the drill string 17. Thus a continuous flow path between the goose neck 33 and the drill string 17 is now provided to allow drilling mud to circulate through the drill string 17 from the goose neck 33. As the drill string 17 is raised when tripping-out or lowered when tripping-in, drilling mud can circulate. The sealing engagement is rated to approximately 5,000 psi (320 bar) to allow circulation.

Optionally, a continuous circulation system may be used, such as the continuous circulation system (CCS) 55 manufactured by the National Oilwell Varco, which provides a continuous circulation of drilling mud during tripping-in and tripping-out. Reference is made to WO 98/16716, which is hereby incorporated by reference for all purposes. The CCS 55 is moved to well-centre and fits about the pipe stub 49. A lower seal seals about the stem 49 and allows drilling mud to flow from the MS into the stem 49 of the drill string 17 via a flow line even when the stand of drill pipe 13 is disconnected from the stem 49. The bottom end of the stand of drill pipe 13 is lowered into the CCS 55 and an upper seal seals thereabout. A middle seal is opened which provides a flow path for drilling mud to flow from the goose neck 33 through the top drive 34 into the drill string 17. The flow of drilling mud through the flow line is stopped, and the stand of drill pipe 13 in threaded to the stem 49. The drill string can then be tripped-in. The reverse procedure is used when tripping-out.

Referring to FIGS. 2 to 5 and 9, there is shown a stabilizer 100 in accordance with an exemplary embodiment of the disclosure. The stabilizer 100 has an upper portion 101 of heavy weight pipe and a lower portion 102. The lower portion 102 has a body 103 made from a single piece of steel, such as a steel comprising chromium and/or molybdenum and to the standard AISI 4145. The body 103 has a flow bore 104 extending from a top end 106 to a bottom end 108 of the body 103, which provides a drilling mud flow path from the drill string 17 to the drill bit 23. The flow bore 104 is preferably of circular cross-section and has a constant diameter along at least a portion of the length of the lower portion 102. The drilling mud M flows in a downward direction MA along axis AX. A sub connector 105 is located at the top end 106 of the lower portion 102 to provide a connection with the upper portion 101. The sub connector 106 has an external surface which is welded to the upper portion 102. An internally threaded box 107 is provided at the bottom end 108 of the body 103. The internally threaded box 107 has a thread 109 for providing a connection with a pin end (not shown) of drill bit 23.

The body 103 has four equally spaced blades 110, 111, 112 and 113 defining four valleys 114, 115, 116 and 117. Each blade 110, 111, 112 and 113 has a curved portion which extends in a curved path about the axis AX, which may be a helical or spiral path from the bottom end 108 towards the top end 106 in a clockwise direction when viewed from the bottom end as shown in FIG. 4. Each curved portion of each blade 110, 111, 112 and 113 has a width which circumscribes approximately 40 degrees and extends along the curved path to circumscribe approximately 90 degrees, when viewed from the bottom end as shown in FIG. 4. All four blades 110, 111, 112 and 113 follow the curved path to circumscribe approximately ninety degrees each to complete 360 degrees of the circumference of the body 102. Each blade 110, 111, 112 and 113 has a lead end 118, 119, 120 and 121 and a trailing end 122, 123, 124 and 125. Each lead end 118, 119, 120, 121 has a sloped lead face rising from the bottom end 108 at a first perimeter 126, up to a table portion 127, 128, 129 and 130 located and following an outer perimeter. The table portion 127, 128, 129 and 130 follows an outer diameter. A step 131, 132, 133 and 134 is provided between a top of the sloped lead face and the table portion 127, 128, 129 and 130. The table portion 127, 128, 129 and 130 is hardfaced. Beads of hardfacing material 135 are shown on blade 110 in FIG. 5 and FIG. 9. Beads of hardfacing material 135 may be applied by a plasma transfer arc or a tungsten powder spray or any other suitable means. The hardfacing material may have diamonds inserted therein. The outer ridges of the beads of the hardfacing material 135 preferably has the same diameter as the diameter of a gauge 136 of the drill bit 23, as shown in FIG. 10.
A ring segment 140 is arranged between trailing ends 122 and 123 of blades 110 and 111. The ring segment 140 lies transverse to the main axis AX of the body 103. The ring segment 140 forms a bridge over the valley 114 defining a cuttings-laden drilling mud flow path 142 between the body 103 and the ring segment 140, as best shown in FIG. 5. The valley 114 circums approximately 50 degrees when viewed from the end, as shown in FIG. 4. The cross-sectional area available in which the cuttings-laden drilling mud flows at any given point along the length of the stabilizer 100 is known as a Junk Slot Area, the units of which is square inches (or square mm). The Junk Slot Area at any point under the ring segment 140 is typically between 9 and 14 sq inches (5,800 to 9,000 sq mm).

A ring segment 144 is arranged between trailing ends 124 and 125 of blades 112 and 113. The ring segment 144 lies transverse to the main axis AX of the body 103. The ring segment 144 forms a bridge over the valley 116 defining a cuttings-laden drilling mud flow path, like ring segment 140. The valley 116 circums approximately 50 degrees when viewed from the end, as shown in FIG. 4. The Junk Slot Area at any point under the ring segment 144 is typically between 9 and 14 sq inches (5,800 to 9,000 sq mm) and is, in this example, the same as cuttings-laden drilling mud flow path 142.

An outer surface 141 of the ring segment 140 has a ring perimeter which is the same as the outer perimeter of the table surface 127, 128, 129 and 130. The ring segments 140 and 144 are hard-faced. Beads of hard-facing material 135 may be applied by a plasma transfer arc or a tungsten powder spray or any other suitable means. The hard-facing material may have diamonds inserted therein. The outer ridges of the beads of the hard-facing material 135 in this example has the same diameter as the diameter of gauge 136 of the drill bit 23 and may be 1/8" (3.2 mm) smaller than the diameter of the borehole 20. Optional cutters 145 and 146 may be arranged on a rotationally leading end 147 and 148 of the ring segments 140 and 144.

The trailing ends 122 and 123 of the blades 110 and 111 have an axial portion 149 and 150 between the curved portion and respective ends of the ring segment 140. An inclined leading radial land 151 is defined by part of an end face 152 of the curved portion of blade 111, a part of a bottom face 153 of the ring segment 140, the outer diameter and a line above the base of the valley 114. An end face 155 of the curved portion of blade 110 forms an inclined trailing radial land, bound at a top corner by a part of a bottom face 153 of the ring segment 140, the outer diameter and a curved inclined line above the base of the valley 114.

The trailing ends 124 and 125 of the blades 112 and 113 have an axial portion 156 and 157 between the curved portion and respective ends of the ring segment 144. An inclined leading radial land 158 is defined by part of an end face 159 of the curved portion of blade 113, a part of a bottom face 160 of the ring segment 144, the outer diameter and a line above the base of the valley 116. An end face 161 of the curved portion of blade 112 forms an inclined trailing radial land, bound at a top corner by a part of a bottom face 160 of the ring segment 144, the outer diameter and a curved inclined line above the base of the valley 116.

The ring segment 140 has a top face 166, which is of a smaller radial thickness than bottom face 153, but has the same outer diameter. The body 103 has a reduced thickness B under a portion of the ring segment 140 and a corresponding increased cross-sectional flow area 142 therebetween. The floor of the valleys 114 and 116 curves downwardly undulating down underneath the ring segment 140 and 144 respectively and upwardly after the respective ring segment 140 and 144. Thus the thickness of the body 103 undulates from thickness A below the ring segment 140, 144 to the smaller thickness B under the ring segment 140, 144 to thickness C above the ring segment 140, 144.

At least one system is arranged in the body 103 that comprises a hole 170 in a sloped region in which the body 103 decreases in thickness from thickness A to thickness B. The hole 170 follows a linear path from the flow bore 104 through the body 103 to an exit in the valley 114. In this manner, hole 170 is a fluid passageway between flow bore 104 and the borehole annulus 29. The hole 170 is disposed at an obtuse angle to the general direction of flow of drilling fluid through the flow bore 104, of optionally between one hundred and fifty to one hundred and sixty degrees. As is used herein, an angle that is obtuse relative to the general direction of flow of drilling fluid through the flow bore 104 after it has passed by hole 170 and is moving towards the bottom of the borehole 20, not as the fluid is approaching the hole 170. The hole 170 comprises an inner portion 171 having a smooth inner wall having a first diameter, and an outer portion 172 of a larger diameter, with a shoulder 173 therebetween. A liner, for example a sleeve 175 has a smooth inner surface defining a bore 176 and smooth outer surface with an outwardly projecting flange 177 at a proximal end. The sleeve 175 is insertable through the upper portion 172 of the hole 170 and slid therein until the flange 177 abuts the shoulder 173. The upper portion 172 of the hole 170 is at least partly internally threaded. A nozzle 180 is threaded into internal threads of the upper portion 172 of the hole 170 which locks the sleeve 175 in place. A first end of the sleeve 175 projects into the flow bore 104, and this end may have an upper point in line with the bore of the borehole 204 and a lower part projecting in to the flow bore 204. The sleeve 175 is preferably made from a tungsten-carbon material, resistant to erosion. The sleeve 175 inhibits erosion in the body 103 around the hole 170 induced by the flow of drilling mud through the flow bore 104 and through the hole 170. The hole 170 may be between 10 mm to 25 mm in diameter and in this example 17 mm to 20 mm in diameter.

The nozzle 180 is shown in more detail in FIGS. 6a to 6c, which has a cylindrical body 181 of circular cross-section having an entrance portion provided with a male thread 182 for threaded engagement in the female threads of hole 170. An exit portion 183 is castellated having four upstands 184 with interleaved notches 185. A nozzle bore 186 has a large diameter at the entrance, converging non-linearly to a small diameter bore at the exit.

A corresponding system may be provided on the other side of the stabilizer 100 for ring segment 144.

When the bottom hole assembly 22 is at the bottom of the borehole 20, the drill bit 23 and stabilizer 100 are rotated, either by the top drive 34, a rotary table (not shown) or a mud motor (not shown) to extend the borehole 20. Mud pump MP is used to pump fresh drilling mud M through the drill string 17, which flows through the flow bore 104 of the stabilizer 100. The majority of the fresh drilling mud M continues on to the drill bit 23, through nozzles therein and washes drill cuttings up through the annulus 29 back to the mud system 31 located at surface 6. However, a small portion
of the fresh drilling mud M passes through the hole 170 in the body 103 of the stabilizer 100. The pressure in the flow bore 104 may be different from the pressure in the cuttings-laden drilling mud in the annulus 29 at the flow path 142, at the exit of the hole 170. The pressure is typically higher in the fresh drilling mud M in the flow bore 104 than in cuttings-laden drilling mud in the annulus 29 at the exit of the hole 170. Fresh drilling mud M flows from the flow bore 104 through hole 170 into the flow path 142 defined by the ring segment 140 and the valley 114.

A fast jet of fresh drilling mud M is induced by a reduction in the diameter of the hole 170 by nozzle 180. The hole 170 and nozzle 180 are directed upwardly through the cuttings-laden drilling mud flow path 142 and optionally, at a region above the top face 166 of the ring segment 140. The jet of fresh drilling mud may facilitate maintaining suspension of drill cuttings and other solids in the cuttings-laden drilling mud. This may reduce the risk of solids forming clumps on the top face 166 of the ring segment 140.

Upon the bottom hole assembly 22 being tripped-out of the borehole 20, fresh drilling mud M may flow through the hole 170. If the drilling fluid is circulated through the drill string 17 as herein described, the flow of drilling mud through the flow bore 104 at the flow rate and pressure produced by the mud pump MP is intended to induce a better flow through the hole 170. A good flow rate through the hole 170, induces a jet of fresh drilling mud directed through the cuttings-laden drilling mud flow path 142. As the stabilizer 100 is pulled through the borehole 20, the top surface 166 of the ring segment 140 may scrape along the wall of the borehole 20 scraping solid particles therefrom. The solid particles may collect to form a clump on the ring segment 140. However, the jet of fresh drilling mud through the cuttings-laden drilling mud flow path 142 will stimulate the solids, inducing the solids to fluidize and other drill cuttings and solids to remain suspended in the drill mud.

Upon the bottom hole assembly 22 being tripped-in to the borehole 20, fresh drilling mud M may flow through the hole 170. If the drilling fluid is circulated through the drill string 17 as hereinbefore described, the flow of drilling mud through the flow bore 104 is intended to induce a better flow through the hole 170. A good flow rate through the hole 170, induces a jet of fresh drilling mud directed through the cuttings-laden drilling mud flow path 142. As the stabilizer 100 passes down through the borehole 20, the bottom face 153 of the ring segment 140 may scrape along the wall of the borehole 20 scraping solid particles therefrom. The solid particles may collect to form a clump on the ring segment 140. However, the jet of fresh drilling mud through the cuttings-laden drilling mud flow path 142 will stimulate the solids, inducing the solids to fluidize and other cuttings and solids to remain suspended in the drill mud and pull them through the cuttings-laden drilling mud flow path 142.

Such methods for circulating drilling mud through the drill string whilst tripping include threadedly connecting the drill string to a sub 37 of the top drive apparatus 7 during tripping. This may be carried out between each connection or disconnection of a stand of drill pipe 13, or once every two, three or more connections or disconnections.

Alternatively, circulating drilling mud through the drill string whilst tripping may be employed using a circulating whilst tripping tool, which allows circulation between making and breaking threaded connections, without the need for making a threaded connection with the sub 37.

Alternatively, circulating drilling mud continuously through the drill string 17 whilst tripping may be employed using a Continuous Circulation System 55, such as the CCSTM manufactured by the National Oilwell Varco.

FIG. 7 shows a further exemplary embodiment in which reference numerals in the two hundred series are used for similar parts referred to previously in the one hundred series. The system 269 comprises a fluid passageway or hole 270 through the body 203 which is partly lined with a sleeve 275. The sleeve 275 is arranged at an obtuse angle to the direction of flow in flow bore 204. The sleeve 270 has an inner portion 271 which is of a smaller diameter than a threaded outer portion 272, with a shoulder therebetween. A proximal end of the sleeve 275 has a threaded flange 277 threaded into the threaded outer portion 272 and is seated on the shoulder 273. A first end of the sleeve 275 extends into the flow bore 204. The first end may have an upper point in line with the bore of the borehole 204 and a lower part projecting in to the flow bore 204. Alternatively, the sleeve 275 may line the entire length of the hole 270. The system 269 may be used in the stabilizer 100 or drill bit 23. A flow axis of the sleeve 275 is directed through a cuttings-laden drilling mud flow path 242 defined by the ring segment 240 and the body 203.

In use, fresh drilling mud M flows from flow bore 204, through the sleeve 275 and exits the sleeve 275 as a jet of fresh drilling mud directed upwardly through the cuttings-laden drilling mud flow path 242. Optionally the jet has a trajectory aimed at a region above the top face 266 of the ring segment 240 which may reduce the risk of solids forming clumps on the top face 266 and bottom face 253 of the ring segment 240.

FIG. 8 shows a yet further exemplary embodiment of the invention, in which reference numerals in the three hundred series are used for similar parts referred to previously in the one hundred series. The system 369 comprises a fluid passageway or hole 370 through the body 303 which is arranged at an obtuse angle to the direction of flow in flow bore 304. The system may be used in the stabilizer 100 or drill bit 23. A flow axis of the hole 370 is directed through a cuttings-laden drilling mud flow path 342 defined by the ring segment 340 and the body 303.

In use, fresh drilling mud M flows from flow bore 304, through the hole 370 and exits the hole 370 as a jet of fresh drilling mud directed upwardly through the cuttings-laden drilling mud flow path 342. Optionally, the jet has a trajectory aimed at a region above the top face 366 of the ring segment 340 which may reduce the risk of solids forming clumps on the top face 366 and bottom face 353 of the ring segment 340.

FIG. 10 shows an example of a drill bit made in accordance with certain of the principles disclosed herein. The drill bit 23 comprises a bit body 403 having a series of curved blades (two shown) 410 and 411 with a valley (one shown) 412 therebetween. The blades 410 and 411 curve around a forward end of the drill bit 23. Each blade 410 and 411 has a rotationally leading face 413 and 414 each provided with a plurality of cutting elements 415 for boring the borehole 20. A ring segment 416 is arranged between trailing ends 417 and 418 of respective blades 410 and 411 spanning over valley 412 to define a cuttings-laden drilling mud flow path 542 between bit body 403 and ring segment 416. The ring segment 416 has cutting elements thereon at a rotationally leading edge and trailing edge, which may be set at a gauge diameter 136.
A system 569 is arranged in the body 403. The system 569 is shown more in detail in FIG. 11, in which reference numerals in the five hundred series are used for similar parts referred to previously in the one hundred series. The system 569 comprises a hole 570 that is a fluid passage-way arranged in the body 403 on a slope in a region in which the body 403 decreases in thickness A to thickness B. The fluid passage-way or hole 570 follows a linear path from the flow bore 504 through the body to an exit in the valley 414. The hole 570 is disposed at an obtuse angle to the direction of flow of drilling fluid through the flow bore 504, which in this example is between one hundred and thirty and one hundred and fifty degrees. The hole 570 comprises an inner portion 571 having a smooth inner wall having a first diameter and an outer portion 572 of a larger diameter with a shoulder 573 therebetween. A liner, such as sleeve 575 has a smooth inner surface defining a bore 576 and smooth outer surface with an outwardly projecting flange 577. The sleeve 575 is insertable through the upper portion 572 of the hole 570 and slid therein until the flange 577 abuts the shoulder 573. The upper portion 572 of the hole 570 is at least partly internally threaded. A nozzle 580 is threaded into internal threads of the upper portion 572 of the hole 570 which locks the sleeve 575 in place. A bottom of the sleeve 575 projects into the flow bore 504. The sleeve 575 may be made from a tungsten-carbon material, resistant to erosion. The sleeve 575 inhibits erosion in the body 403 around the hole 570 induced by the flow of drilling mud through the flow bore 504 and through the hole 570. The hole 570 may be between 10 mm to 25 mm in diameter and in this example approximately 17 mm to 20 mm in diameter.

When the bottom hole assembly 22 is at the bottom of the borehole 20, the drill bit 23 and stabilizer 100 are rotated, either by the top drive 34, a rotary table (not shown) or a mud motor (not shown) to extend the borehole 20. Mud pump MP is used to pump fresh drilling mud M down through the drill string 17, through flow bore 504 of the drill bit 23. The majority of the fresh drilling mud M continues on to flush out of nozzles forwardly in front of the blades 410 and 411. However, a small portion of the fresh drilling mud M flows out through the hole 570 in the body 403 of the drill bit 23. There may be a pressure difference between the pressure of the fresh drilling mud M in the flow bore 504 and in cuttings laden drilling mud in the annulus 29 at the flow path 542, at the exit of the hole 570. The pressure may be higher in the fresh drilling mud M in the flow bore 504 than in cuttings laden drilling mud in the annulus 29 at the exit of the hole 570. Fresh drilling mud M flows from the flow bore 504 through hole 570 into the flow path 542 defined by the ring segment 416 and the valley 412.

A fast jet of fresh drilling mud M is induced by a reduction in the diameter of the hole 570 by nozzle 580. The hole 570 and nozzle 580 are directed upwards through the cuttings laden drilling mud flow path 542 and preferably, at a region above the top face 566 of the ring segment 416. The jet of fresh drilling mud may facilitate maintaining drill cuttings and other solids suspended in the cuttings laden drilling mud flow path 542. This preferably reduces the risk of solids forming clumps on the top face 566 of the ring segment 416.

Upon the bottom hole assembly 22 being tripped-out of the borehole 20, fresh drilling mud M may flow through the hole 570. If the drilling fluid is circulated through the drill string 17 as hereinbefore described, the flow of drilling mud through the flow bore 504 at the flow rate and pressure produced by the mud pump MP is intended to induce a better flow through the hole 570 and nozzle 580. A good flow rate through the hole 570 and nozzle 580, induces a jet of fresh drilling mud directed through the cuttings laden drilling mud flow path 542. As the drill bit 23 is pulled through the borehole 20, the top surface 566 of the ring segment 416 may scrape along the wall of the borehole 20 scraping solid particles therefrom. The solid particles may collect to form a clump on the ring segment 416. However, the jet of fresh drilling mud through the cuttings laden drilling mud flow path 542 will stimulate the solids, inducing the solids to fluidize and stay suspended in the drill mud.

Upon the bottom hole assembly 22 being tripped-in to the borehole 20, fresh drilling mud M may flow through the hole 570. If the drilling fluid is circulated through the drill string 17 as hereinbefore described, the flow of drilling mud through the flow bore 504 is intended to induce a better flow through the hole 570. A good flow rate through the hole 570, induces a jet of fresh drilling mud directed through the cuttings laden drilling mud flow path 542. As the drill bit 23 passes down through the borehole 20, the bottom face 553 of the ring segment 416 may scrape along the wall of the borehole 20 scraping solid particles therefrom. The solid particles may collect to form a clump on the ring segment 416. However, the jet of fresh drilling mud through the cuttings laden drilling mud flow path 542 will stimulate the solids, inducing the solids to fluidize and stay suspended in the drill mud and pull them through the cuttings laden drilling mud flow path 542.

The drill string usually comprises a multiplicity of threaded joints of drill pipe. However, the drill string may comprise a multiplicity of threaded sections of other kinds of pipe, such as casing, which is known as drilling with casing.

1. A stabilizer for use in drilling a borehole, comprising: a generally cylindrical body having an inner wall defining a flow bore in said body; a plurality of blades extending outwardly from said body; a valley disposed between a pair of adjacent blades; a ring segment spaced from said body and extending over said valley; a flow passage between said ring segment and said body; a hole in said body configured to convey drilling fluid from said flow bore to said casing pair of drill pipes.

2. The stabilizer of claim 1 wherein said hole comprises an entrance in said inner wall and an exit in said valley, said hole extending between said flow bore and said flow passage.

3. The stabilizer of claim 1 wherein said hole is configured to convey drilling fluid with a trajectory through at least a portion of said flow passage.

4. The stabilizer of claim 2 wherein the hole extends at an obtuse angle to the direction of flow of drilling fluid through the flow bore.

5. The stabilizer of claim 1 wherein said exit of said hole is located beneath said ring segment.

6. The stabilizer of claim 1 further comprising a sleeve disposed in said hole, said sleeve easing at least part of said hole.

7. The stabilizer of claim 3 wherein said hole comprises a nozzle having a nozzle bore through which drilling fluid is conveyed.

8. The stabilizer of claim 7 wherein said nozzle bore includes a fluid entry end having a first flow area and a fluid exit end having a second flow area smaller than said first flow area.
9. The stabilizer of claim 1, wherein said body has a wall thickness that varies along the longitudinal length of said body and comprises a transition zone between a thick wall portion in said valley and a thin wall portion under said ring segment, wherein said hole is positioned in said transition zone.

10. The stabilizer of claim 1 wherein only one ring segment spans between adjacent blades.

11. The stabilizer of claim 1 wherein a ring segment is arranged between every adjacent blade forming a complete ring about said stabilizer.

12. A drill bit for use in drilling a borehole, the drill bit comprising:
   a generally cylindrical bit body having an inner wall defining a flow bore for conveying drilling mud;
   a pair of blades extending outwardly from said bit body;
   a valley disposed between said pair of blades;
   a ring segment spaced from said bit body and extending over said valley;
   a flow passage between said bit body and said ring segment;
   a hole in said body configured to convey drilling fluid from said flow bore to said flow passage.

13. The drill bit of claim 12 wherein said hole comprises an exit in said flow passage.

14. The drill bit of claim 12 wherein said exit is located beneath said ring segment.

15. The drill bit of claim 12 wherein said hole extends at an obtuse angle to the direction of flow of drilling fluid through said flow bore.

16. The drill bit of claim 15 wherein said obtuse angle is between 140 degrees and 170 degrees.

17. The drill bit of claim 12 wherein said exit is configured to convey drilling fluid with a trajectory passing through said flow passage.

18. The drill bit of claim 17 wherein said hole comprises a nozzle having a nozzle bore through which drilling fluid is conveyed.

19. The drill bit of claim 12 wherein said bit body has a wall thickness that varies along the longitudinal length of said body and comprises a transition zone between a thick wall portion in said valley and a thin wall portion under said ring segment, wherein said hole is disposed in said transition zone.

20. Apparatus for use in drilling a borehole in earthen formations, comprising:
   an elongate body having an outer surface and an internal flow bore configured to convey drilling fluid longitudinally through said body;
   at least a first pair of blades connected to said body and extending radially beyond said outer surface;
   a valley between said pair of blades;
   a ring segment spaced apart from said outer surface and connected to each of said first pair of blades, said ring segment bridging said valley;
   a flow passage between said ring segment and said outer surface of said body;
   a hole extending from said flow bore to said outer surface and configured to direct a portion that is less than all of the drilling fluid from said flow bore through an exit in the outer surface, and to impart a trajectory to said portion of drilling fluid such that it passes through said flow passage.

21. The apparatus of claim 20 wherein said body has a wall thickness that varies along the longitudinal length of said body and comprises a transition zone between a thick wall portion in said valley and a thin wall portion under said ring segment, wherein said hole is disposed in said transition zone.

22. The apparatus of claim 20 wherein said hole extends at an obtuse angle to the direction of flow of drilling fluid through said flow bore.

23. The apparatus of claim 22 wherein said exit is positioned beneath said ring segment.

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