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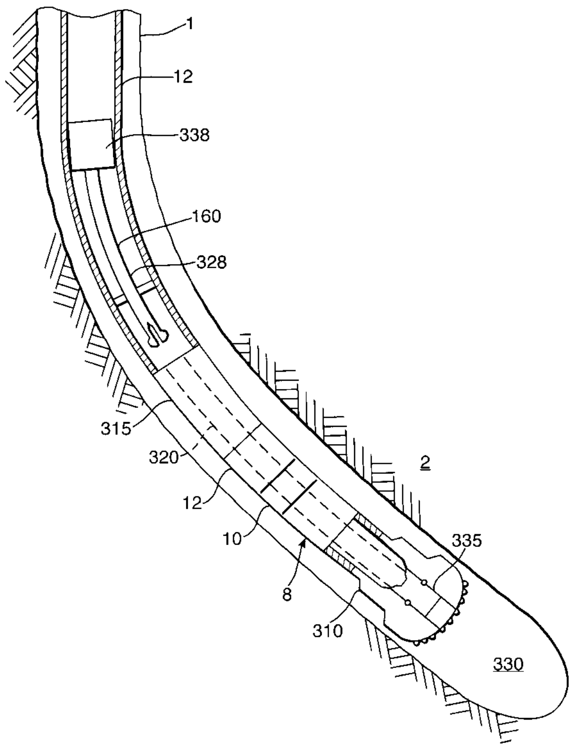
(54) Downhole check valve comprising a burst disk

(57) A valve system is provided for use in a tubing string. The valve system comprises a valve device arranged to open a passage to fluid flow upon application of a fluid pressure to the valve device, wherein the valve device is provided with an interior space for passage of a tool string therethrough, and a seal member arranged to seal the interior space. The seal member is configured to rupture upon contact with the tool string moved through said interior space.

Fig.1.



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Description

Field of the Invention

[0001] The invention relates to a valve system for use in a tubing string. Valve systems are, for example, used in the field of drilling and surveying wellbores formed in Earth formations.

Background Art

[0002] U.S. Patent Application Publication No. 2004/0118611 filed by Runia et al. describes methods and apparatus for drilling and surveying a wellbore in subsurface Earth formations in which a set of survey instruments is placed within a pipe or conduit ("tubing string") used to convey a drill bit into the wellbore. The set of survey instruments is able to exit the interior of the tubing string by a special tool causing a center segment of the drill bit to release, thus creating an opening for the survey instruments to leave the tubing string and enter the wellbore below the bottom of the pipe or conduit.

[0003] The term "tubing string" is used in the description which follows because the invention is not limited in scope to use with what is ordinarily understood as a drill string. Such understanding is that a drill string used to drill a borehole includes segments or "joints" of pipe threadedly coupled end to end such that a borehole may be drilled to a selected depth in the Earth. It is within the scope of the present invention to use coiled tubing or similar tube, pipe or conduit to extend a drilling tool assembly into the Earth's subsurface to drill a well. Accordingly, as used in the description of the present invention, the phrase "tubing string" is intended to include any pipe, tubing or conduit that may be extended into the Earth, whether such conduit is segmented (drill pipe, tubing and the like) or substantially continuous (coiled tubing).

[0004] It is known in the art to use a device called a "check valve" with a tubing string during drilling operations. A check valve is a one-way valve that enables flow of fluid from the interior of the tubing string to the wellbore, but not the reverse. Embodiments of a check valve known in the art include a sleeve type valve that is movable under fluid pressure inside the tubing string against a biasing device, such as a spring. When move by the fluid pressure, the sleeve exposes ports such that fluid may flow through the lower end of the tubing string. Generally, the interior of the sliding sleeve is closed such that solid objects disposed in the tubing string cannot move freely through the sleeve.

[0005] It is an object of the invention to provide an improved valve system that can be used with a tool string intended to move freely through the lower end of a tubing string and out the bottom thereof into a bore hole.

Summary of the Invention

[0006] In accordance with the invention there is provided a valve system for use in a tubing string extending into a borehole, comprising a valve device arranged to open a passage to fluid flow upon application of a fluid pressure to the valve device, wherein the valve device is provided with an interior space for passage of a tool string therethrough, and a seal member arranged to seal the interior space, the seal member being configured to rupture upon contact with the tool string moved through said interior space.

[0007] Suitably the valve device includes a sliding sleeve disposed in an internal bore of the valve system, the sliding sleeve and internal bore being cooperatively arranged to open said passage to fluid flow upon application of said fluid pressure to the sliding sleeve.

[0008] In a preferred embodiment the valve system further comprises a mandrel having couplings for coupling the mandrel to the tubing string, wherein said internal bore is formed in the mandrel.

[0009] The valve system suitably further comprises a biasing device arranged to move the sliding sleeve to close said passage to fluid flow in the absence of sufficient pressure on an upper end of the sliding sleeve.

[0010] In a more preferred embodiment the seal member is a burst disk configured to rupture upon contact with the tool string moved through said interior space.

Brief Description of the Drawings

[0011] The invention will be described hereinafter in more detail by way of example, with reference to the accompanying drawings in which:

FIG. 1 shows a schematic overview of an embodiment of a drill string extending into a wellbore.

FIG. 2 shows a schematic drawing of an MWD/LWD survey system of the drill string of FIG. 1.

FIG. 3 shows a schematic drawing of a drill steering system of the drill string of FIG. 1.

FIG. 4 shows a schematic drawing of a drill bit of the drill string of FIG. 1.

FIG. 5 shows a schematic drawing of a logging tool that has been passed through the bottom hole assembly of the drill string of Fig. 1 to extend into the wellbore ahead of the drill string.

FIG. 6 shows one embodiment of a check valve for use with the drill string of Fig. 1 or other tubing string.

FIG. 7 shows the check valve of FIG. 6 in the closed position.

Detailed Description

[0012] The description that follows with reference to FIGS. 1 through 5 is related to a method and device shown in U.S. Patent Application Publication No. 2004/0118611 filed by Runia et al. and incorporated herein by reference. Such method and apparatus may be adapted to be used, in some embodiments, with a tool assembly 160 disposed inside a tubing string 12 as set forth herein.

[0013] Referring to FIG. 1, the wellbore 1 extends from the Earth's surface into a subsurface Earth formation 2. The wellbore 1 is shown as deviated from vertical, wherein the curvature in the FIG. 1 has been exaggerated for the sake of clarity. It is contemplated that the present invention will have particular advantages for use in such deviated wellbores, however the deviation of the wellbore is not a limit on the scope of the invention.

[0014] At least the lower part of the wellbore 1 shown in FIG 1 may be formed by the operation of components coupled to the lower end of the tubing string 12. The components coupled to the lower end of the tubing string 12 are collectively referred to as a bottom hole assembly 8, which includes a drill bit 310, a check valve 10 (described in more detail with reference to FIGS. 6 and 7), a drill steering system 312 and a surveying system 315. The bottom hole assembly 8 is provided with a passage 320 forming part of a passageway for the tool assembly 160, which may between a first position 328 in the interior of the tubing string 12, above the bottom hole assembly 8, and a second position 330 inside the wellbore 1 below the tubing string 12, below the bottom hole assembly 8 and below the drill bit 310. It should be clearly understood that the upper part of the tool assembly 160 can remain in the tubing string 12, for example, hung in or even above the bottom hole assembly 8. For purposes of defining the present invention it is sufficient that the lower part of the tool assembly 160 reaches the second position 330 in the wellbore 1. It should be noted that sensors may be included in the tool assembly 160 that can be used to measure one or more parameters in the wellbore as the tool assembly 160 is lowered from the surface to position 328, with measurement data stored to memory or transmitted to the surface. If the tool assembly 160 is positioned or inserted in the tubing string 12 at position 328 when the bottom hole assembly 8 is at or near the surface, then the sensors can also make measurements behind the drill bit 310 in logging while drilling ("LWD") fashion as the well is drilled, in addition to measuring as described below when the tool assembly 160 is in position 330 as the tubing string 12 and bit 310 are withdrawn from the well. In this latter embodiment, with tool assembly 160 at or near position 328, the portion of the tubing string 12 adjacent to the tool assembly 160 can be composed of composite or other electrically non-conductive material to facilitate making measurements with sensors adversely affected by the presence of steel or other electrically conductive materials. It is also possible that antenna coils (not shown) can be located in grooves cut into the outside of the section of the tubing string 12 containing the tool assembly 160, and these coils used to make an induction resistivity measurements of the formations outside the wellbore. Power to the coils and signal received in the coils can be communicated across the tubing wall using electrical feed-through bulkheads of types well known in the art. Such electrically non-conductive material, whether forming an entire segment of the tubing string 12 or whether in the form of "windows" in the tubing string 12, may also provide a path for electromagnetic energy if such is used for telemetry of data from the tool assembly 160 to the Earth's surface, and/or telemetry from the Earth's surface to the tool assembly 160.

[0015] In the description which follows, the terms upper and above are used to refer to a position or orientation relatively closer to the surface end of the tubing string 12, and the terms lower and below for a position relatively closer to the end of the wellbore during operation. The term longitudinal will be used to refer to a direction or orientation substantially along the axis of the tubing string 12.

[0016] The drill bit 310 is provided with a releasably connected insert 335, which will be discussed in more detail with reference to FIG. 4. The insert 335 forms a selectively removable closure element for the passageway 320, when it is in its closing position, i.e. connected to the drill bit 310 as shown in the FIG. 1.

[0017] Referring to FIG. 2, the surveying system 315 of FIG. 1 is shown in more detail. The surveying system of this embodiment can be a measurement/logging while drilling ("MWD/LWD") system comprising a tubular sub or collar 351 and an elongated probe 355. The upper end of the tubular sub 351 is connectable to the upper part of the tubing string 12 extending to the surface, and the lower end is connectable to the steering system 312. The probe 355 contains surveying instrumentation, a gamma ray instrument 356, an orientation tool 357 including e.g. an magnetometer and accelerometer for determining dip and azimuth of the wellbore, various logging sensors (such as electromagnetic, acoustic, or nuclear sensors), a battery pack 358, and a mud pulser 359 for data communication with the Earth's surface. The collar 351 can also contain surveying instrumentation. An annular shoulder 365 is arranged on the inner circumference of the tubular sub 351, on which the probe can be hung off. The outer surface of the probe is provided with notches 367 on which keys 369 are arranged that co-operate with the annular shoulder 365. The notches 367 allow for fluid to flow through the MWD/LWD system, and also induce the mudflow to go through the pulser section 359. The upper end of the probe 355 is arranged as a connection means 372 such as a fishing neck or a latch connector, which co-operates with a tool such as a wireline tool or a pumping tool that can be lowered from surface and connected to the connection means. The probe can thus be pulled or pumped upwardly so as to remove the probe 355 from the collar 351. The MWD/LWD system has dimensions such that the interior of the collar 351 after removal of the probe 355 represents a passageway 320 of suitable size for passage of at least the lower part of the tool assembly 160.

[0018] In other embodiments, a collar-based MWD/LWD system can be used, wherein all components are arranged around a central longitudinal passageway of required cross-section, and do not include the probe 355. In particular, a mud pulser can be provided that comprises a ring-shaped rubber member around the passageway, which can be inflated such that the rubber member extends into the passageway thereby creating a mud pulse. Other types of pulsers include valves that when open divert some of the fluid flow inside the tubing string into the annular space between the wellbore and the tubing string, and thus do not obstruct the central passageway. Still other MWD/LWD systems include no pulser. Such systems may include electromagnetic or acoustic telemetry to communicate data to the Earth's surface, or may merely record data in a suitable storage device in the MWD/LWD system itself, for recovery when the MWD/LWD system is removed to the Earth's surface.

[0019] Referring to FIG. 3, an embodiment of the drill steering system 312 of FIG. 1, in the form of a mud motor 404 in combination with a bent housing 405 will now be explained. The bent housing 405 is shown with an exaggerated bend angle between the upper and lower ends for clarity of the illustration. Ordinarily, the bend angle is on the order of less than three degrees. The bent housing 405 has an interior comparable to ordinary positive displacement or turbine-type drilling motors. The upper end of the mud motor 404 can be directly or indirectly connected to the lower end of the surveying system 315.

[0020] A mud motor converts hydraulic energy from fluid (drilling mud) pumped from the Earth's surface to rotational energy to drive the drill bit (310 in FIG. 1). Such energy conversion enables bit rotation without the need for tubing string rotation, and thus is suitable for drilling using coiled tubing strings. The mud motor 404 schematically shown in FIG. 3 is a so-called positive displacement motor ("PDM"), which operates on the Moineau principle. The Moineau principle states that a helically-shaped rotor, shown at 406, with one or more lobes will rotate when it is placed inside a helically shaped stator 408 having one more lobe than the rotor when fluid is moved through annulus between stator and rotor.

[0021] Rotation of the rotor 406 is transferred to a tubular bit shaft 410, to the lower end 412 of which the drill bit (310 in FIG. 1) can be connected. To transfer the rotation to the bit shaft 410, the lower end of the rotor 406 is connected via connection means 415 to one end of a transfer shaft 418. The transfer shaft 418 extends through the bent housing 405 and is on its other end connected to the bit shaft via connection means 420. The transfer shaft 418 can be a flexible shaft made from a material such as titanium that is able to withstand the bending and torsional stresses. Alternatively, the connection means 415 and 420 can be arranged as universal joints, constant velocity joints or other flexible coupling. The bit shaft 410 is suspended in a bit shaft collar 423, which is connected to or integrated with the stator 408, through bearings 425. A seal 427 is provided between bit shaft 410 and bit shaft collar 423.

[0022] The mud motor steering system of this embodiment differs from known systems in that the connection means 420 is arranged to release the connection between the transfer shaft 418 and the bit shaft 410 when upward force is applied to the rotor 406. For example, the connection means can be formed as co-operating splines on the lower end of the transfer tool and on the upper part of the bit shaft. A suitable latch mechanism that can be operated by longitudinal pulling/pushing is another option. In order to be able to apply upward force on the rotor 406, the upper end of the rotor is arranged as a connection means 430 such as a fishing neck or a latch connector, which co-operates with a tool that can be lowered from surface, connected to the connection means, and pulled or pumped upwardly so as to release the connection at connection means 420.

[0023] The upper end 432 of the bit shaft 410 is funnel-shaped so as to guide the lower end of the transfer tool 418 to the connection means 420 when the rotor 406 is lowered into the stator 408 again. Fluid passages 435 for drilling fluid can be provided through the wall of the bit shaft 410, to allow circulation of drilling fluid during drilling operation, when the rotor 406 is connected to the bit shaft 410 through connection means 420.

[0024] Suitably, there is also arranged a means (not shown) that locks the bit shaft 410 in the bit shaft collar 423 when the rotor 406 has been disconnected from the bit shaft 410. It shall be clear that the minimum inner diameter of the stator 408 and the bit shaft 410 are dimensioned such that a sufficiently large longitudinal passageway for at least the lower part of the tool assembly 160 is provided, forming part of the passageway 320 of FIG. 1.

[0025] An alternative drilling steering system is generally known as rotary steerable system. A rotary steerable system generally consists of an outer tubular mandrel having the outer diameter of the tubing string. Through the interior of the mandrel runs a piece of drill pipe of smaller diameter. The drill string or bottom hole assembly above the rotary steering system is connected to the upper end of this inner drill pipe, and the drill bit is connected to the lower end of the drill pipe. The mandrel comprises means to exert lateral force on the inner drill pipe so as to deflect the drill direction as desired. In order to be used with the present invention, the inner drill pipe of the rotary steering system must allow passage of an auxiliary tool.

[0026] Referring to FIG. 4, a schematically a longitudinal cross-section of an embodiment of the rotary drill bit 410 of FIG. 1 is shown. The drill bit 410 is shown in the wellbore 2, and is attached in this embodiment to the lower end of the bit shaft 410 of FIG. 3. The bit body 205 of the drill bit 410 has a central longitudinal passage 420 for an auxiliary tool from the interior 207 of the tubing string 12 to the wellbore 1 exterior of the drill bit 410, as will be explained in more detail below. Bit nozzles are arranged in the bit body 205. Only one nozzle with insert 209 is shown for the sake of clarity. The nozzle 209 is connected to the passageway 20 via the nozzle channel 209a.

[0027] The drill bit 410 is further provided with a removable closure element 435, which is shown in FIG. 4 in its closing position with respect to the passageway

420. The closure element 435 of this example includes a central insert section 212 and a latching section 214. The insert section 212 is provided with cutting elements 216 at its front end, wherein the cutting elements are arranged so as to form, in the closing position, a joint bit face together with the cutters 218 at the front end of the bit body 205. The insert section can also be provided with nozzles (not shown). Further, the insert section and the cooperating surface of the bit body 205 are shaped suitably so as to allow transmission of drilling torque from the bit shaft 110 and bit body 205 to the insert section 212.

[0028] The latching section 214, which is fixedly attached to the rear end of the insert section 212, has substantially cylindrical shape and extends into a central longitudinal bore 220 in the bit body 205 with narrow clearance. The bore 220 forms part of the passage 420, it also provides fluid communication to nozzles in the insert section 212.

[0029] The closure element 435 is removably attached to the bit body 205 by the latching section 214. The latching section 214 of the closure element 435 comprises a substantially cylindrical outer sleeve 223, which extends with narrow clearance along the bore 220. A sealing ring 224 is arranged in a groove around the circumference of the outer sleeve 223, to prevent fluid communication along the outer surface of the latching section 214. Connected to the lower end of the sleeve 223 is the insert section 212. The latching section 214 further comprises an inner sleeve 225, which slidingly fits into the outer sleeve 223. The inner sleeve 225 is biased with its upper end 226 against an inward shoulder 228 formed by an inward rim 229 near the upper end of the sleeve 223. The biasing force is exerted by a partly compressed helical spring 230, which pushes the inner sleeve 225 away from the insert section 212. At its lower end the inner sleeve 225 is provided with an annular recess 232 that is arranged to embrace the upper part of spring 230.

[0030] The outer sleeve 223 is provided with recesses 234 wherein locking balls 235 are arranged. A locking ball 235 has a larger diameter than the thickness of the wall of the sleeve 223, and each recess 234 is arranged to hold the respective ball 235 loosely so that it can move a limited distance radially in and out of the sleeve 223. Two locking balls 235 are shown in the drawing, however it will be clear that more locking balls can be arranged.

[0031] In the closed position as shown in FIG. 4 the locking balls 235 are pushed radially outwardly by the inner sleeve 225, and register with the annular recess 236 arranged in the bit body 205 around the bore 220. In this way the closure element 435 is locked to the drilling bit 310. The inner sleeve 225 is further provided with an annular recess 237, which is, in the closing position, longitudinally displaced with respect to the recess 236 in the direction of the bit shaft 410.

[0032] The inward rim 229 is arranged to cooperate with a connection means 239 at the lower end of an opening tool 240. The connection means 239 is provided with a number of legs 250 extending longitudinally downwardly from the circumference of the opening tool 240. For the sake of clarity only two legs 250 are shown, but it will be clear that more legs can be arranged. Each leg 250 at its lower end is provided with a dog 251, such that the outer diameter defined by the dogs 251 at position 252 exceeds the outer diameter defined by the legs 250 at position 254, and also exceeds the inner diameter of the rim 229. Further, the inner diameter of the rim 229 is preferably larger or about equal to the outer diameter defined by the legs 250 at position 254, and the inner diameter of the outer sleeve 223 is smaller or approximately equal to the outer diameter defined by the dogs 251 at position 252. Further, the legs 250 are arranged so that they are inwardly elastically deformable as indicated by the arrows. The outer, lower edges 256 of the dogs 251 and the upper inner circumference 257 of the rim 229 are beveled.

[0033] The outer diameter of the opening tool 240 is significantly smaller than the diameter of the bore 220.

[0034] Operation of the embodiment of FIGS. 1-4 will now be described. The tubing string 12 can be used for progressing the wellbore 1 into the formation 2, when the MWD/LWD probe 355 hangs in the collar 351 as shown in FIG. 2, when the rotor 406 is arranged in the stator 408 of the mud motor 404 as shown in FIG. 3, and when the insert 435 is latched to the bit body 205 as shown in FIG. 4. The tool assembly 160 would normally be stored at surface. The tubing string 12 can thus be used to drill the wellbore 1 into a desired subsurface position. The probe 355, the rotor 406 and the insert 435 together form a closure element for the passageway 20.

[0035] In the course of the drilling operation a situation can be encountered, which requires the operation of the tool assembly 160 in the wellbore 1 ahead of the drill bit 310. This will be referred to as a tool operating condition. Examples are the occurrence of mud losses which require the injection of fluids such as lost circulation material or cement, performing a cleaning operation in the open wellbore, the desire to perform a special logging, measurement, fluid sampling or coring operation, the desire to drill a pilot hole.

[0036] Drilling is stopped then the tubing string 12 is pulled up a certain distance to create sufficient space for at least part of the tool assembly at position 430, and the passageway is opened. To open the passageway in the present embodiment the MWD/LWD probe 355 and the rotor 406 can be retrieved to surface, such as by using a fishing tool with a connector means at its lower end that can be pumped down or upwardly through the drill string and can also be pulled up again by wireline. Retrieving of the MWD/LWD probe and the rotor can be done in consecutive steps. The lower end of the probe can also be arranged so that it can be connected to the connection means 430 at the upper end of the rotor 406, so both can be retrieved at the same time.

[0037] The opening tool 240 can then be deployed, through the interior of the tubing string 12, so as to outwardly remove the closure element 435 from bit body

205. The opening tool 240 is affixed to the lower end of the tool assembly 160. The tool assembly 160 can be deployed from surface by pumping through the interior of the tubing string 12, with the transfer tool 338 connected to the upper end of the tool assembly 160 (the tool can be logging, as described above, as it is lowered to contact the BHA). The tool assembly 160 passes though the tubing string 12 and the passageway 320 of the bottom hole assembly 8, i.e. consecutively through the MWD collar 351 and the stator 408 of the mud motor, until it reaches the upper end of the drill bit 310, so that the connection means 239 engages the upper end of the latching section 214 of the closure element 435. The dogs 251 slide into the upper rim 229 of the outer sleeve 223. The legs 250 are deformed inwardly so that the dogs 251 can slide fully into the upper rim 229 until they engage the upper end 226 of the inner sleeve 225. By further pushing down, the inner sleeve 225 will be forced to slide down inside the outer sleeve 223, further compressing the spring 230. When the space between the upper end 226 of the inner sleeve 225 and the shoulder 228 has become large enough to accommodate the length of the dogs 251, the legs 250 snap outwardly, thereby latching the opening tool 240 to the closure element 435.

[0038] At approximately the same relative position between inner and outer sleeves, where the legs snap outwardly, the recesses 237 register with the balls 235, thereby unlatching the closure element 435 from the bit body 205. At further pushing down of the opening tool 240 the closure element 435 is integrally pushed out of the bore 220. When the closure element 435 has been fully pushed out of the bore 220, the passageway 320 is opened.

[0039] By moving the opening tool 240 further, the lower part of the tool assembly 160 at the upper end of the opening tool 240 enters the open wellbore 1 outside of the drill bit 410, and it can be operated there. In this embodiment the tool assembly 160 is long enough so that it extends through the entire bottom hole assembly 8 and remains connected to the transfer tool 338 above the bottom hole assembly 8. This allows straightforward retrieval of the tool assembly 160 to the surface, by slickline, wireline or reverse pumping. The wellbore 1 below the drill bit 310 may be surveyed by moving the entire tubing string 12 along the wellbore by reeling the reel (14 in FIG. 1).

[0040] FIG. 5 shows the lower end of the drill bit 310 in the situation that a logging tool 260, of which the lower part 261 has been passed through the passageway. The closure element 435 has been outwardly removed from the closing position by the opening tool 240 disposed at the lower end of the logging tool 260.

[0041] A number of sensors and/or electrodes of the logging tool are shown at 266. They can be battery-powered, or can be powered by a turbine or through electrical power transmitted along a wireline extending to surface. Data can be stored in the tool or transmitted to surface. The logging tool 260 further comprises a landing member (not shown) having a landing surface, which cooperates with a landing seat of the bottom hole assembly 8.

[0042] The drill bit 310 can for example have an outer diameter of 21.6 cm (8.5 inch), with a passageway of 6.4 cm (2.5 inch). The lower part 261 of the logging tool, which is the part that has passed out of the drill string onto the open wellbore, is in this case substantially cylindrical and has a relatively uniform outer diameter of 5 cm (2 inch). In one embodiment, the portion of the drill bit lowered beneath the tool assembly 160 can be used to continue to drill a smaller diameter bore hole for some distance below the bottom of the existing wellbore, with the sensors 266 in tool 260 continuing to measure and store and/or transmit measurement data as the smaller diameter borehole is being drilled. Drilling power may be provided by an electrical connection (not described) to the surface and a downhole electric motor, or by an additional mud motor (not shown). When the smaller borehole is drilled to the depth desired, the same sensors in the tool assembly 160 can measure, store and/or transmit data as the tubing string 12 is inserted into and/or withdrawn from the wellbore.

[0043] After the tool assembly 160 has been operated in the wellbore at 430, it can be retrieved into the tubing string 12 by pulling up the transfer tool 438. The closure insert 435 will then reconnect to the bit body 205. The opening tool 240 will disconnect from the insert 435, and the tool assembly 160 can be fully retrieved to the surface. Rotor 406 and MWD/LWD probe 355 can be lowered into the mud motor and MWD/LWD stator 408, respectively, so that the closure element is complete again, and drilling can be resumed. If a following tool operation condition occurs, the whole cycle can be repeated, wherein in particular a different tool assembly can be used. The flexibility gained in this way during a directional drilling operation is a particular advantage of the present embodiment.

[0044] An alternative design to the removable center portion of the drill bit as explained above with reference to FIGS. 1 through 5 is described in U.S. Patent Application Publication No. 2005/0029017, by Berkheimer et al., wherein the entire bit and/or entire bottom hole assembly is released and lowered below the auxiliary tool assembly. Yet another alternative embodiment is disclosed in U.S. Patent Application Publication No. 2006/0118298 filed by Millar et al., which discloses a tubing string assembly comprising a tubular first tubing string part with a passageway, and a second tubing string part co-operating with the first tubing string part. The tubing string assembly includes a releasable tubing string interconnecting means for selectively interconnecting the first and second tubing string parts. An auxiliary tool is provided for manipulating the second tubing string part. The auxiliary tool can pass along the passageway in the first tubing string part to the second tubing string part. The assembly further includes a tool-connecting means for selectively connecting the auxiliary tool to the second tubing string part, and an operating means for operating the tubing string-interconnecting means.

[0045] Wardley, U.S. Pat. No. 6,443,247 discloses a casing drilling shoe adapted for attachment to a casing string. The shoe comprises an outer drilling section constructed of a relatively hard material and an inner section made from a readily drillable material. The shoe includes means for controllably displacing the outer drilling section to enable the shoe to be drilled through using a standard drill bit and subsequently penetrated by a reduced diameter casing string or liner. Optionally, the outer section may be made of steel and the inner section may be made of aluminium. In some embodiments of a system according to the invention, such as may be used with the process of casing drilling, the drill bit (310 in FIG. 1) may be substituted by a drilling shoe as disclosed in the Wardley patent. Such a drilling shoe may be rotated by an annular drilling motor. Such combination may be in substitution for all the components shown in FIGS. 1-5 between the lower end of the tubing string 12 and the drill bit 310. Preferably, the outer section of the Wardley-type drilling shoe is provided with one or more blades, wherein the blades are moveable from a first or drilling position to a second or displaced position. Preferably, when the blades are in the first or drilling position they extend in a lateral direction to such extent as to allow for drilling to be performed over the full face of the shoe. This enables the casing shoe to progress beyond the furthest point previously attained in a particular well.

[0046] The means for displacing the outer drilling section may comprise of a means for imparting a downward thrust on the inner section sufficient to cause the inner section to move in a down-hole direction relative to the outer drilling section. The means may include an obstructing member for obstructing the flow of drilling mud so as to enable increased pressure to be obtained above the inner section, the pressure being adapted to impart the downward thrust. Typically, the direction of displacement of the outer section has a lateral component.

[0047] In the present invention, the check valve (10 in FIG. 1) includes a device for being selectively opened by passage therethrough of the tool string 160, such that the tool string 160 may be moved into the position below the bottom of the drill bit (310 in FIG. 1) as explained above. An embodiment of a check valve having such device will now be explained with reference to FIGS. 6 and 7. FIG. 6 shows the check valve open to passage of fluid therethrough. FIG. 7 shows the valve when it is closed to fluid flow. The check valve 10 may be formed from a lower mandrel 112 having an internal flow passage 16 and an upper mandrel 14 threadedly coupled to the lower mandrel 112. The threaded coupling is attained by corresponding mating threaded connections, shown respectively at 112A and 14A. The upper mandrel 14 may include an internal fluid flow passage 32 and an upper threaded connection 34 for coupling to the lower end of the tubing string (12 in FIG. 1), or other component disposed at the lower end of the tubing string 12 (e.g., drill collars, MWD/LWD collars, steerable motor, etc.). The lower mandrel 112 may include a lower threaded connection 18 for coupling to the drill bit (310 in FIG. 1). The upper mandrel 14 includes a substantially cylindrical chamber therein 20 for receiving a sliding valve sleeve 22. The valve sleeve 22 may be biased such as by a spring or the like (not shown) in the direction of the upper mandrel 14. The upper mandrel 14 may include on its lower longitudinal end a shoulder 112B that stops the sleeve 22 from further longitudinal movement. The sleeve 22 may include through the wall thereof one or more ports 24, 26 to enable fluid flow through the wall of the valve sleeve 22 when the ports 24, 26 are aligned with corresponding flow channels 28 formed into the wall of the upper mandrel 14. When the sum of the fluid pressure in the lower mandrel passage 16 and any biasing force on the sleeve 22 exceeds the force exerted on the sleeve 22 by fluid pressure in the upper mandrel 14, the valve sleeve 22 will be moved into the lower or opened-to-flow position (FIG. 6) such that fluid may move from the upper mandrel 14, through the sleeve, through the channels 28 and into the lower mandrel 112.

[0048] The sleeve 22 includes a burst disk 30 at the upper end thereof that effectively seals the longitudinal passage through the interior of the sleeve 22. The burst disk 30 is of any type known in the art and is ordinarily intended to rupture when a selected differential fluid pressure is applied thereto. In the present invention, when the tool string (160 in FIG. 1) is moved such that the opening tool (240 in FIG. 1) contacts the burst disk 30, the burst disk 30 may be ruptured by the impact force of the tool string 160, thus enabling free passage of the tool string 160 through the valve sleeve 22. Absent impact of the tool string 160 on the rupture disk 30, the rupture disk 30 serves to seal the internal bore of the sleeve 22 such that the check valve operates conventionally.

[0049] While the invention has been described with respect to a limited number of embodiments, those skilled in the art, having benefit of this disclosure, will appreciate that other embodiments can be devised which do not depart from the scope of the invention as disclosed herein. Accordingly, the scope of the invention should be limited only by the attached claims.

Claims

1. A valve system for use in a tubing string extending into a borehole, comprising:

    a valve device arranged to open a passage to fluid flow upon application of a fluid pressure to the valve device, wherein the valve device is provided with an interior space for passage of a tool string therethrough, and a seal member arranged to seal the interior space, the seal member being configured to rupture upon contact with the tool string moved through said interior space.

2. The valve system of claim 1, wherein the valve device includes a sliding sleeve disposed in an internal bore of tubing string, the sliding sleeve and internal bore being cooperatively arranged to open said passage to fluid flow upon application of said fluid pressure to the sliding sleeve.

3. The valve system of claim 2, further comprising a mandrel having couplings for coupling the mandrel to the tubing string, wherein said internal bore is formed in the mandrel.

4. The valve system of claim 2 or 3, further comprising a biasing device arranged to move the sliding sleeve to close said passage to fluid flow in the absence of sufficient pressure on an upper end of the sliding sleeve.

5. The valve system of any one of claims 1-4, wherein the seal member is a burst disk configured to rupture upon contact with the tool string moved through said interior space.

6. The valve system of any one of claims 1-5, wherein the tubing string comprises a drill bit at a lower end thereof.

7. The valve system of any one of claims 1-6, wherein the tool string comprises at least one well logging sensor.

8. A method of using the valve system of any one of claims 1-7, wherein the valve system is incorporated in the tubing string, and wherein the tubing string extends into a borehole, the method comprising:

- moving the tool string through the tubing string toward a bottom thereof;
- inducing the tool string to rupture the seal member, and
- causing at least a portion of the tool string to exit below the bottom of the tubing string.

9. The method of claim 8, whereby the tool string is moved through a passage of a drill bit disposed at the lower end of the tubing string and causing the tool string to exit through the passage.

10. The method of claim 9, further comprising holding the tool string in a substantially fixed position with respect to the tubing string, withdrawing the tubing string from the borehole, and measuring at least one parameter in the borehole below the drill bit while the tubing string, the drill bit and the tool string are withdrawn from the bore hole.

11. The valve system substantially as described hereinbefore with reference to the drawings.

12. The method system substantially as described hereinbefore with reference to the drawings.

Fig.1.

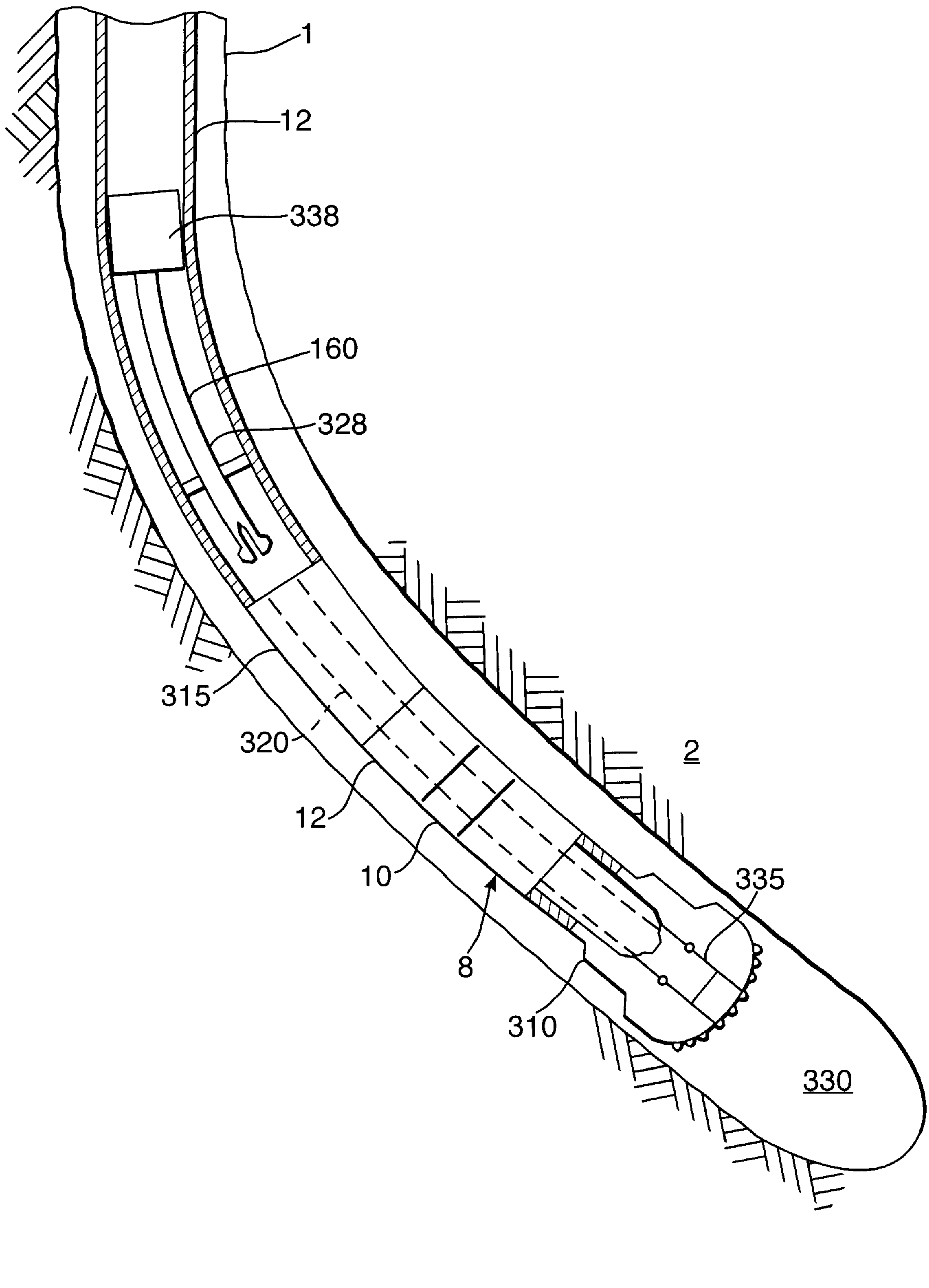

Fig.2.

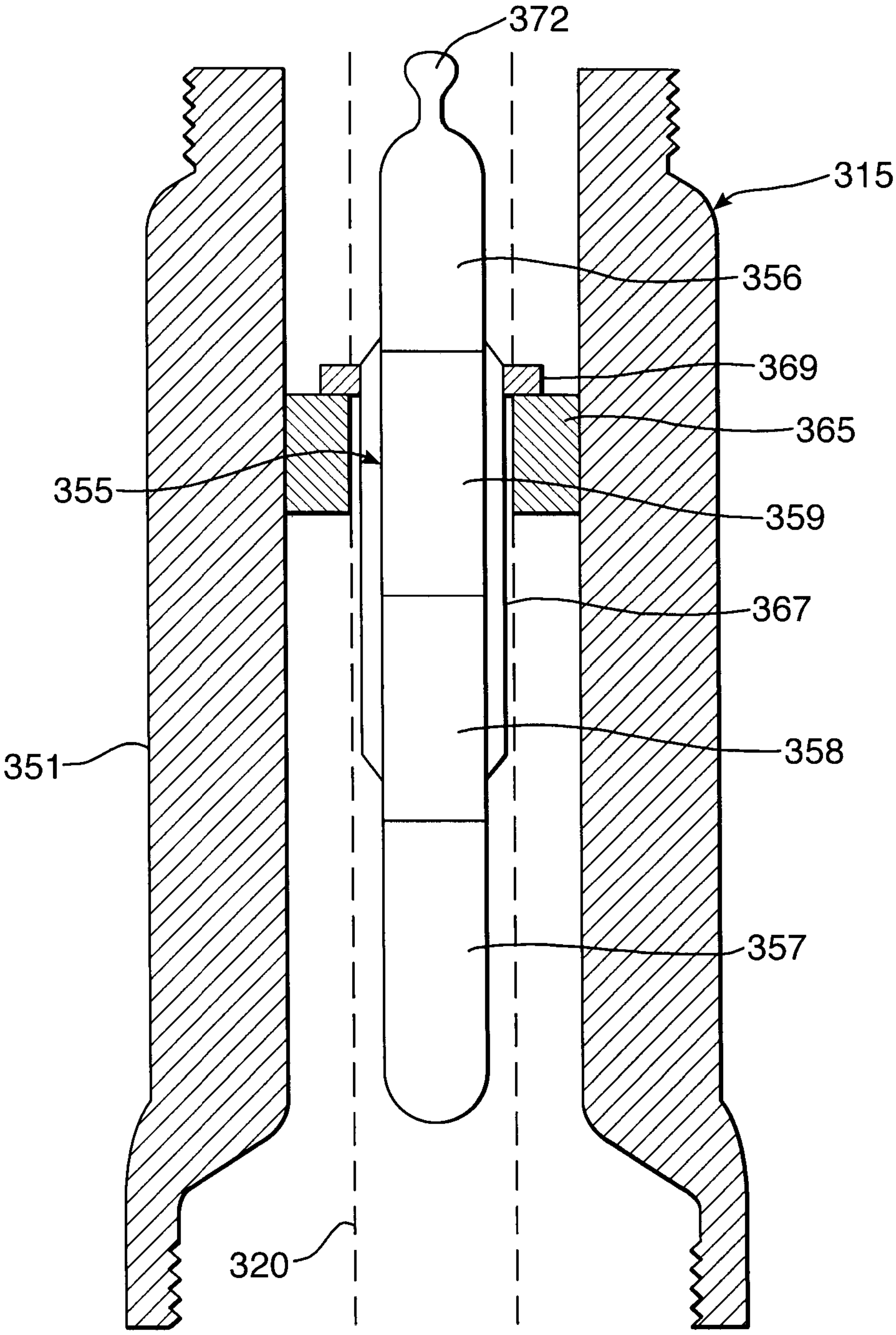

Fig.3.

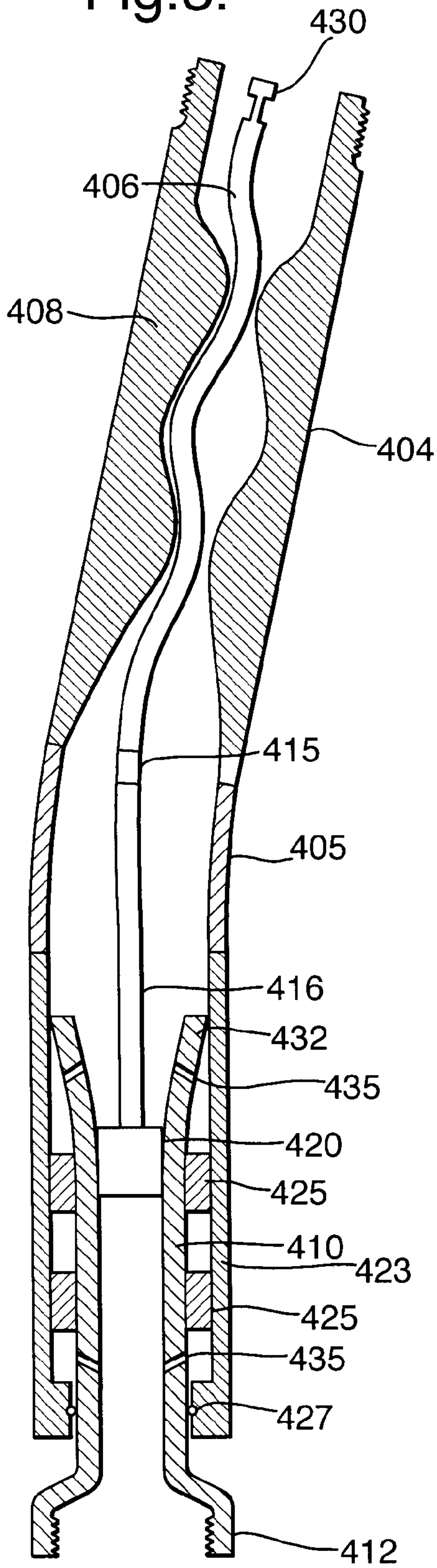
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Fig.4.

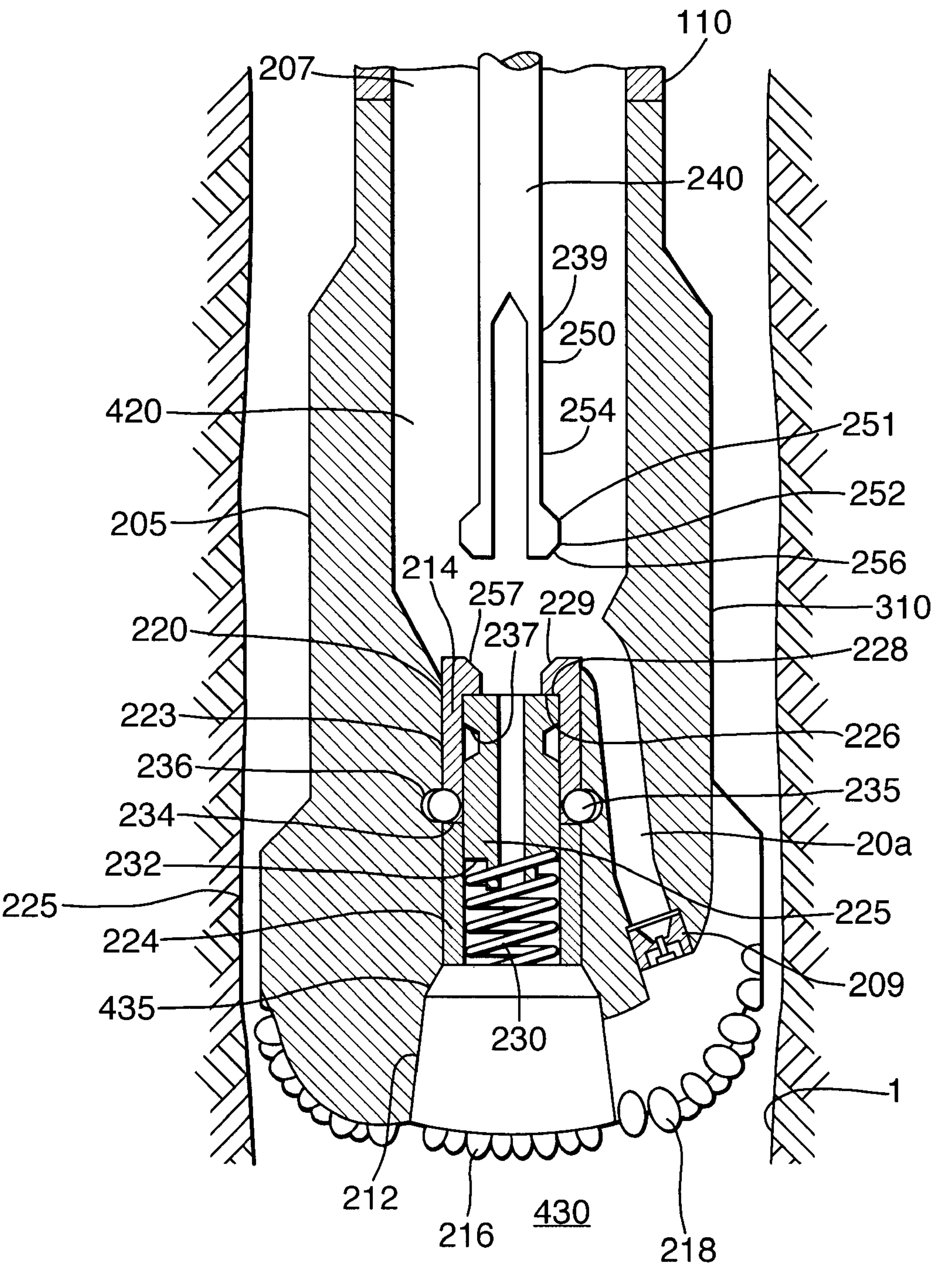
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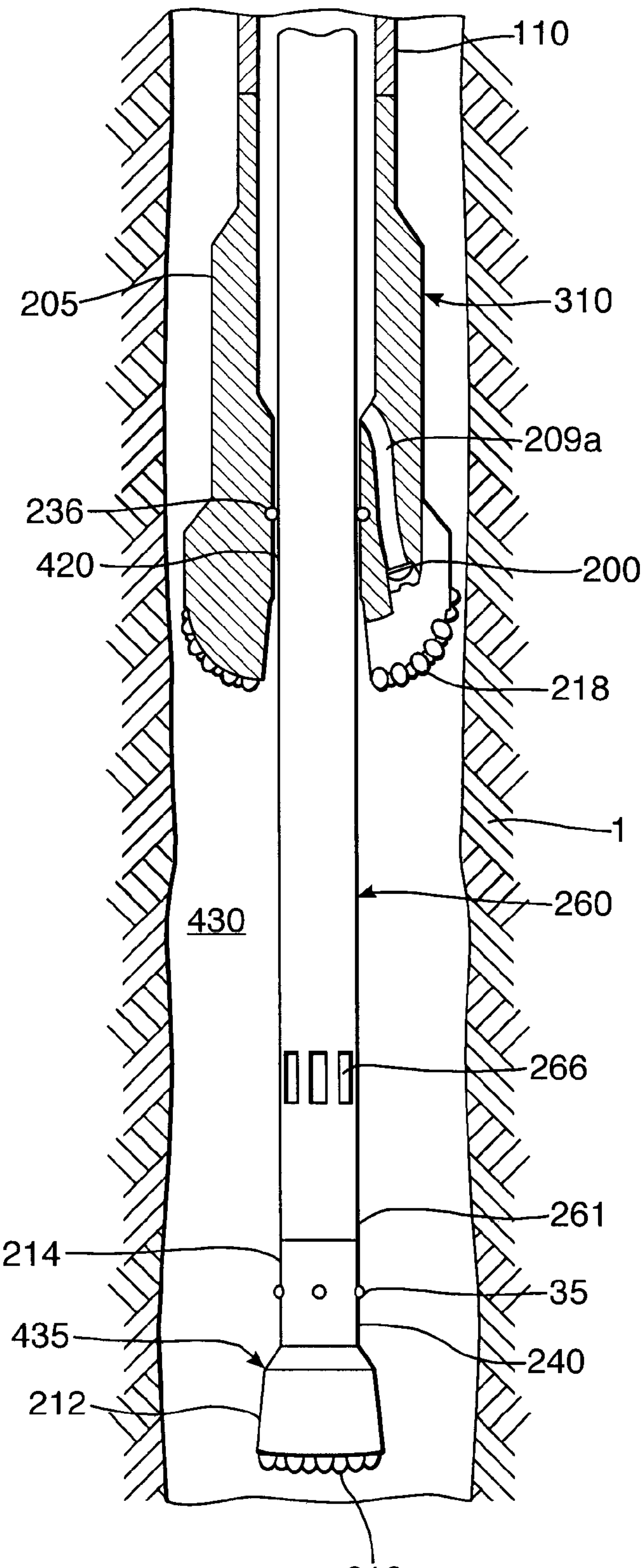
Fig.5.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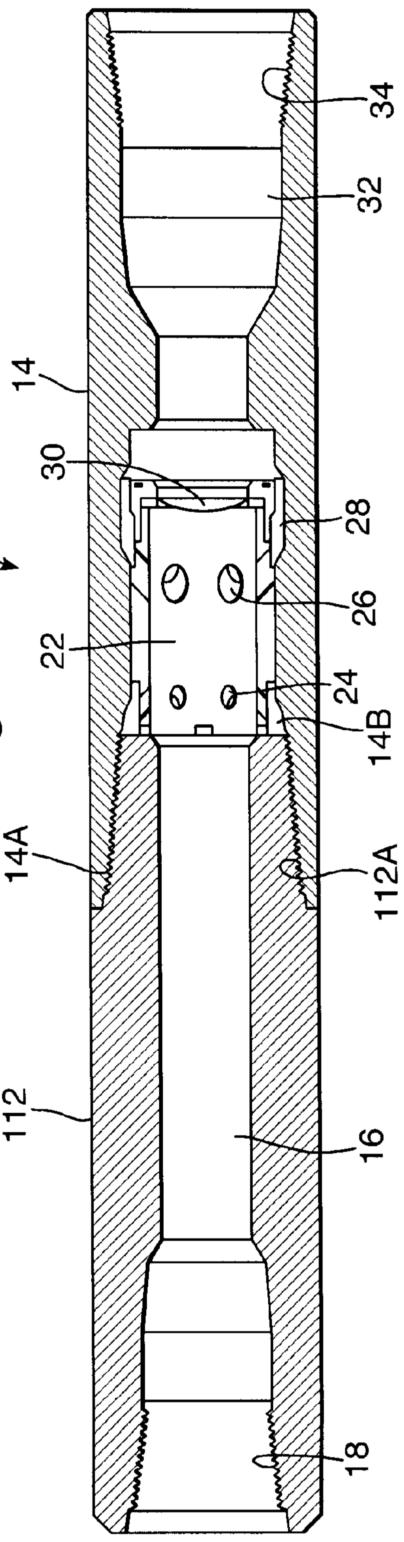
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Fig.6.

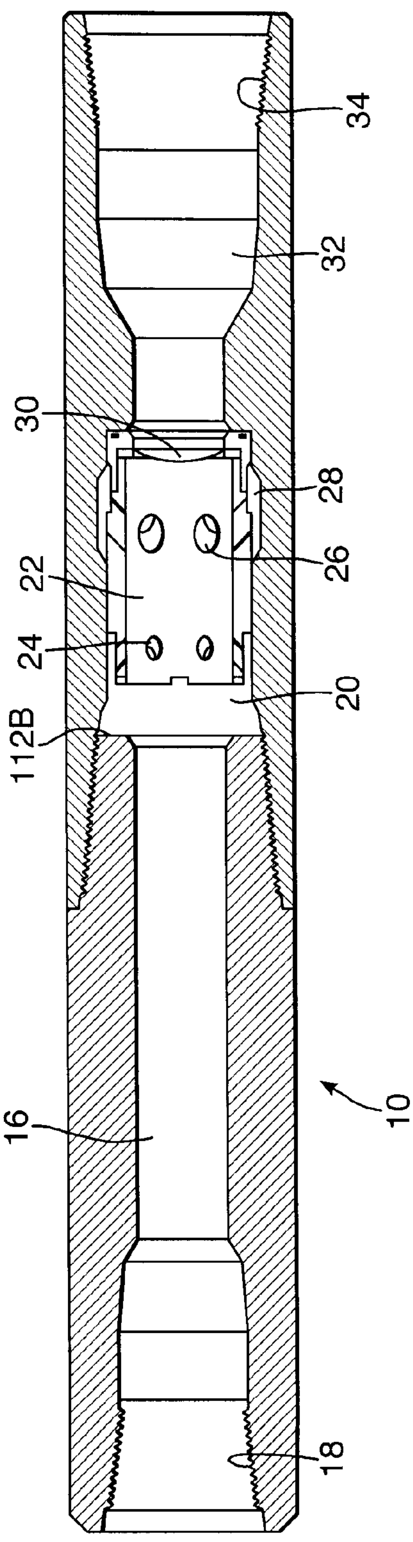
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Fig.7.

European Patent Office

PARTIAL EUROPEAN SEARCH REPORT

which under Rule 45 of the European Patent Convention shall be considered, for the purposes of subsequent proceedings, as the European search report

Application Number
EP 06 12 4022

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 93/11336 A (APPLETON ROBERT P [GB]) 10 June 1993 (1993-06-10) * page 2, paragraph 5 - page 5, paragraph 3 * * figure 1 *	1-6	INV. E21B34/06 E21B4/02 E21B10/18 E21B10/62 E21B47/00
X	US 3 698 411 A (GARRETT WILLIAM R) 17 October 1972 (1972-10-17) * column 4, lines 28-59 * * figure 2 *	1-6	
X	US 3 965 980 A (WILLIAMSON JOSEPH STEPHEN) 29 June 1976 (1976-06-29) * column 10, line 48 - column 11, line 1 *	1-6	
A,D	US 2004/118611 A1 (RUNIA DOUWE JOHANNES [NL] ET AL) 24 June 2004 (2004-06-24) * the whole document *	1,8	
A	US 2005/045327 A1 (WANG DAVID WEI [US] ET AL) 3 March 2005 (2005-03-03) * figures 5,6 *	1,8	TECHNICAL FIELDS SEARCHED (IPC) E21B

INCOMPLETE SEARCH

The Search Division considers that the present application, or one or more of its claims, does/do not comply with the EPC to such an extent that a meaningful search into the state of the art cannot be carried out, or can only be carried out partially, for these claims.

Claims searched completely :

Claims searched incompletely :

Claims not searched :

Reason for the limitation of the search:

see sheet C

Place of search	Date of completion of the search	Examiner
The Hague	23 March 2007	Schouten, Adri

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
& : member of the same patent family, corresponding document

European Patent Office

INCOMPLETE SEARCH SHEET C

Application Number
EP 06 12 4022

Claim(s) searched completely:
1-10

Claim(s) not searched:
11,12

Reason for the limitation of the search:

Claims 11,12 contain a reference to the drawings. According to Rule 29(6) EPC, claims should not contain such references except where absolutely necessary, which is not the case here (see the Guidelines, C-III, 4.10).

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 06 12 4022

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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23-03-2007

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
WO 9311336	A	10-06-1993	AU	2952592	A	28-06-1993
			CA	2124676	A1	10-06-1993
			DE	69214963	D1	05-12-1996
			EP	0613514	A1	07-09-1994
			US	5479988	A	02-01-1996
US 3698411	A	17-10-1972	NONE			
US 3965980	A	29-06-1976	NONE			
US 2004118611	A1	24-06-2004	NONE			
US 2005045327	A1	03-03-2005	CA	2479478	A1	03-03-2005
			GB	2405653	A	09-03-2005

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- US 20040118611 A, Runia **[0002] [0012]**
- US 20050029017 A, Berkheimer **[0044]**
- US 20060118298 A, Millar **[0044]**
- US 6443247 B **[0045]**