ABSTRACT OF THE DISCLOSURE

A sidewall coring tool for incorporation in a drill stem which utilizes the drilling fluid to propel a coring tube transversely from the sub into the wall of a borehole, including means for positively retracting the coring tube using the drilling fluid.

This invention relates generally to the art of earth boring, and more particularly relates to the art of obtaining rock and fluid samples from the wall of a borehole.

When drilling a borehole to recover petroleum products, it is very desirable and helpful to obtain small samples of the earth formations and fluids in place in the formation so that the quantity, recoverability and other data relating to the production of the petroleum can be determined. At present, it is common practice to sample the formation as the borehole is drilled by means of a bit which cuts an annulus about a central core. The core is then received and retained in a long core barrel and catcher disposed above the bit. The equipment required for this purpose is relatively expensive and the rate of penetration of a coring bit is usually somewhat slower than that of a conventional bit.

It is also common practice to take core from the wall of a completed borehole. This is customarily accomplished by a mechanism lowered into the borehole by a wire line or pipe string after the drill string has been removed. These devices employ various mechanisms for penetrating the sidewall and retaining and recovering a sample of the formation, the most common device being a tubular coring tube which is merely driven into the sidewall by a suitable power supply, such as a hydraulic piston. However, these tools all require that the drill stem be first removed from the borehole and then the sampling tool lowered into the well bore either by wire line or a pipe string. Also, these devices are generally relatively complex and usually require some type of control means extending through the wire line to the surface for actuating the sampling mechanism at the desired depth.

A principal object of this invention is to provide a sidewall coring tool which may be incorporated in a conventional drill stem without interfering with normal drilling operations, yet which can be selectively actuated using the power of the drilling fluid to take a core sample during each trip of the drill stem.

Another object of the invention is to provide a coring tool which has a positive power mechanism for withdrawing the sampling tube from the wall of the borehole.

A further object is to provide such a tool which permits at least limited circulation of the drilling fluid after actuation of the tool so as to facilitate removal of the drill stem in the event of complications.

Another object of the invention is to provide a fluid powered sampling tool which impacts the wall of the borehole after a predetermined pressure is applied.

Still another object of the invention is to provide a novel valve mechanism for actuating at the surface when the tool has accomplished a sample-taking stroke.

Yet another object of the invention is to provide such a tool which also functions as a float valve.

Another object is to provide such a tool which also functions as a stabilizer.

A further object of the invention is to provide such a tool from which the sample may be easily taken and which may be easily and economically manufactured and serviced.

In accordance with an aspect of the present invention, the tool comprises a sub for incorporation in the drill stem having a longitudinally extending primary fluid passageway for passing drilling fluid through the sub. A fluid cylinder is disposed transversely of the sub and a fluid piston is reciprocally disposed within the cylinder. A sampling tube is connected to the piston and extends through the second end of the cylinder for penetrating the formation adjacent the sub. A valving means is provided to selectively divert pressure from the primary fluid passageway to the first end of the cylinder to drive the piston and sampling tube on a core-taking stroke.

In accordance with a more specific aspect of the invention, the valving means comprises an annular, upwardly facing seat in the primary fluid passageway, a first fluid passageway providing fluid communication between the primary fluid passageway above the annular seat and the first end of the cylinder, and a valve member adapted to be lowered through the drill stem and seated on the annular seat to restrict flow through the primary passageway and thereby increase the fluid pressure applied to the first end of the cylinder.

In accordance with another aspect of the invention, valving means is also provided for selectively applying fluid pressure to the second end of the cylinder to retract the sampling tube. More specifically, the valving means may comprise a check valve located in the primary fluid passageway below the point of communication between the primary and first fluid passageway, and a second fluid passageway providing fluid communication between the second end of the cylinder and the primary fluid passageway at a point below the check valve. Reverse circulation of the drilling fluid through the primary fluid passageway then retracts the piston and sample tube.

In accordance with another aspect of the invention, the coring tube is retained in retracted positions within the sub by shear means so that a substantial pressure is built up behind the piston prior to shearing the shear means so that the coring tube will be impacted against the wall of the borehole.

In accordance with a further aspect of the invention, the valve which is seated on the upwardly facing annular seat has a secondary valve means which opens after the pressure differential applied across the valve exceeds the pressure differential required to drive the sample tube on a sample-taking stroke to produce a sharp pressure drop and indicate when the sample-taking stroke is completed.

In accordance with still another aspect of the invention, the tool is provided with stabilizer fins to position the sampling tube close to the wall of the borehole and also increase the length of the sample-taking stroke, as well as function as a conventional stabilizer.

Additional aspects, objects and advantages of the invention will be evident to those skilled in the art from the following detailed description and drawings, wherein:

FIGURE 1 is a longitudinal sectional view of a sidewall sampling tool constructed in accordance with the present invention;

FIGURE 2 is a sectional view taken substantially on lines 2--2 of FIGURE 1;

FIGURE 3 is a sectional view taken substantially on lines 3--3 of FIGURE 2;

FIGURE 4 is an enlarged longitudinal sectional view of a novel valving device used in the tool of FIGURE 1; and
FIGURE 5 is an enlarged longitudinal sectional view of the typical check valve used in the tool of FIGURE 1. Referring now to the drawings, and in particular to FIGURE 1, a corning tool constructed in accordance with the present invention is indicated generally by the reference numeral 10. The corning tool 10 is comprised generally of a sub body 12 which may be connected in a conventional drill stem by means of a conventional box 14 at the lower end for receiving a bit 15, and a pin 16 at the upper end for connection to the lowermost drill collar 17 of the drill stem. Of course, it is to be understood that the tool 10 can be used at any point along the drill string.

A primary fluid passageway is formed longitudinally through the body 12 to pass the drilling fluids from the drill stem to the bit in the conventional manner. The fluid passageway is formed by an upper bore portion 18 and a lower bore portion 20 which are interconnected by four bypass passageways 22 which, as can best be seen in FIGURES 2 and 3, pass on either side of a drill stem section. A number of fins 28, 29, 30 and 31 extend longitudinally of the body 12 and are disposed at radial offset positions.

A fluid cylinder, indicated generally by the reference numeral 40, is disposed substantially normal to the longitudinal axis of the tool 10. The fluid cylinder 40 is formed by a bore 42 in a bore 43 which extends through the pin 31, the center portion 24 of the body 12, and the pin 29. A second counterbore 44 provides an annular shoulder 46 and receives a fulcrum slide block 48 and end plug 50 which forms a first end of the fluid cylinder 40. A pair of O-rings 52 positioned in grooves in the end plug 50 provides a fluid-tight seal. One or more pins 54 extend through the walls of the stabilizer fin 31 and through the plug 50 to secure the fulcrum slide block 48 and the end plug in position. The ends of the pins 54 are preferably braded at 54a and 54b to prevent loosening. It will be noted that the combined use of the O-rings 52 and the pins 54 eliminates a threaded connection which would tend to loosen when subjected to the intense vibrations inherent in the drilling operation. A second end of the fluid cylinder 40 is formed by the bottom 56 of the counterbore 42.

A fluid piston 60 is reciprocally disposed in the fluid cylinder 40 and is sealed to the cylinder by O-rings 62 disposed in annular grooves in the piston 60. A core sampling tube 64 is connected to the piston 60 by the threaded coupling 66 and extends through the bore 43 through the stabilizer fin 29. A pair of O-rings 69 provide fluid seals between the body 12 and the core tubing 64. The end 70 of the core tubing 64 is beveled to provide a sharpening edge to penetrate the earth formation adjacent the borehole as will presently be described. The inside diameter at the end of the sampling tube is preferably slightly smaller than the inside diameter of the remaining portion of the sample tube, but the difference in diameter is so slight as not to be discernible from the diagram. Annular grooves 72 extend longitudinally along the inside surface of the sample tube 64 and communicate with a number of peripheral spaced ports 74 which extend through the walls of the core tubing adjacent to the outer end of the core tubing so that the fluid may pass along the grooves and exit through the ports 74 as a core plug enters the tube. One or more shear pins 76 extend through cordal bores in the wall of the core tubing 64 and through the stabilizer fin 29 and are bradded at 76a and 76b. The shear pins 76 have shear strengths selected as hereafter described.

The piston 60 is spring biased toward the first end of the cylinder 40 by means of a flexible tension member 78 such as a cable, and a compression spring 80 extending generally longitudinally down through the stabilizer fin 31. The cable 80 may be connected to the piston 60 by means of a ball 83 which is crimped onto the end of the cable and which is inserted in a suitable keyway 84 formed in the piston. The cable 80 engages the fulcrum slide block 48 and slides along the fulcrum portion 86 and passes through a bore 87. The upper end of the cable 80 is connected to the upper end of the compression spring 81 by means of a second crimped ball 88 and a washer 90 having a keyway for receiving the cable. The upper end of the bore 82 is closed by means of a plug 92 which is sealed by O-rings 94 and secured in place by a suitable pin 96 extending through the fin 31.

Drilling fluid is applied from the primary fluid passageway to the first end of the cylinder 40 to move the piston 60 outwardly on a sample-cutting stroke, as will hereafter be described, by means of a first fluid passageway comprised of a bore 98, the bores 82 and 87 and the opening through the fulcrum member 48. Power fluid is selectively diverted to the first fluid passageway by a valve means comprised of an annular valve seat 100 formed around the passageway 18 by a counterbore 101 and a novel valve member indicated generally by the reference numeral 102 which is dropped through the primary fluid passageway extending through the drill stem. The valve member 102 is comprised of a tubular body 106 greater than the diameter of that of the seat 100 and having a tapered portion 108 adapted to mate with and form a fluid seal with the seat 100. The body 104 also has a restricted neck portion 112 which forms a downwardly facing annular seat 114 internally of the tubular body. A secondary valve member 116 has a longitudinally extending fluid passageway 117 and an annular flange 118 sized and formed to mate with the downturned seat 114 when in the upper position illustrated in solid line in FIGURE 4. The body of the secondary valve member 116 is of substantially constant diameter and is slidable received in a turned annular flange portion 120 of the valve body 104. A plurality of apertures 122 (indicated in dotted outline) extend through the annular flange 120 and have a total cross section substantially greater than the cross section of the passageway 117 through the tubular secondary valve member 116. The secondary valve member 116 is held in the upper position by a shear pin 126 which may conveniently extend through the flange portion 120 and the secondary valve member 116. The shear pin 126 is selected to shear at a pressure drop across the secondary valve member 116 greater than that required to shear the pins 76 as will hereafter be described in greater detail.

The upper end of the neck portion 115 may conveniently toe flared at 121 of a conventional survey instrument. A number of spring wires 130 may protrude from the neck portion 112 in the conventional manner to slow the descent of the valve through the mud standing in the drill stem and also insure that the valve properly mates with the seat 100.

Fluid pressure is applied to the other end of the hydraulic cylinder 40 by means of a fluid passageway 132 which communicates with the primary fluid passageway at a point below an upwardly closing check valve indicated generally by the reference numeral 134. The check valve 134 may comprise any commercially available check valve of the type referred to as a float valve, and may generally comprise a tubular body 136 received in a counterbore 138 which forms an annular shoulder 140 to prevent the upward travel of the check valve. The body 136 may conveniently be held in place by a snap ring 142 or any other suitable means. The body 136 has an inwardly directed flange portion 144 which forms a downwardly facing annular seat 146 around an aperture 148 which forms a passageway for the fluid.

A valve locator 150 is adapted at the upper end 152 to mate with the downwardly facing seat 146 and form a fluid seal. A number of centralizing fins 154 are disposed around the periphery of the enlarged end 152 to maintain the valve centered within the body 136. The
stem 156 of the valve 150 is slidably received in the central aperture of a spider 158 which is connected to the lower end of the body 136 and has a plurality of apertures 160 spaced around the periphery thereof to pass fluid. A coil spring 162 is disposed around the stem 156 between the spider 158 and the fins 154 to continuously bias the extended portion 164 against the annular seat 146. A restricted fluid port 164 extends through the center of the valve member 150 to permit restricted fluid circulation in the reverse direction for purposes which will hereafter be described in greater detail.

Operation

In operation, the tool 10 is connected in the drill stem, preferably by threading the bit into the box 14 and threading the pin 16 into the box of the lowermost drill collar. Stopping the drilling operation, when it is desired to take a core sample, the valve member 102 is dropped into the passageway through the drill stem and permitted to pass downwardly by gravity to the seat 100. The spring wires 130 slow the rate of descent of the valve so as to prevent the valve from banging against the seat 100. If desired, the valve 102 can be pumped down the valve stem at a greater rate. However, it will usually be desired to take a core sample several hundred feet above so that the valve 102 can be settling downwardly as the upper joints of the drill stem are disconnected.

After the valve 102 has seated on the seat 100, the drill bit is advanced through the formation 60 and the core 62. A core sample can be cut and removed from the drill stem through the open end of the core barrel 80 and 90. The pressure differential across the piston 60 is progressively increased until the pins 76 are sheared. The coring tube 64 then impacts and penetrates the formation forming the wall of the borehole. As the formation closes around the sample tube, the well fluids in the tube pass out through grooves 72 and ports 74. Penetration to a depth of only a few inches is all that is required to obtain a useful sample. The portion of the formation that enters the sample tube is retained in the tube by reason of the slight constriction at the end of the tube.

Since the tool is downhole, there is no way to be certain when the pins 76 have been sheared and the sample taken. The novel valve construction 102 provides a means for determining when the sampling stroke is completed. As the pressure is increased, the pins 76 are sheared at a lower pressure. The pressure is continually increased and monitored at the surface until the pin 126 in the valve 102 is sheared at a substantially higher pressure. The inner valve 116 then falls to the lower position shown in dotted outline in FIGURE 4 and thereby instantly increases the cross-sectional area of the fluid passageway through the valve 102. This results in a discernible pressure drop at the surface which signals that a sufficient pressure differential has been obtained to first shear the pins 76 and take the sample, then shear the pin 126.

Again it will be appreciated that there is no way to monitor whether or not the spring 81 retracts the sample tube after the fluid pressure is equalized by stopping the flow of drilling fluid. This cannot be tested by raising the drill stem because the slightest bend in the sampling tube will prevent retraction. Accordingly, it is highly desirable to positively retract the sample tube which is accomplished by pumping drilling fluid down the annulus and back up through the drill stem, i.e., reverse circulating. As the drilling fluids rise through the drill stem, the check valve 134 is closed and the fluid passageway through the seat 136 is closed except for the restrictive port 164. The pressure drop across the valve member 150 is then applied across the piston 60 to positively retract the coring tube 64 back into the tool, the high pressure fluid being applied through the port 132 and the fluid being vented through the port 104 to low pressure. After the coring tube 64 has been retracted, the spring 82 insures that the coring tube remains retracted as the tool 10 is withdrawn from the borehole.

The core sample cut and transported to the surface by the coring tube 64 may then be recovered by unscrewing the coring tube 64 from the piston 60 and removing the coring tube from the tool. This may be easily accomplished by specially designed tools which will be obvious to those skilled in the art. The core sample can then be forced through the threaded end of the coring tube 64, and the tool 10 refurbished for another trip by merely threading the coring tube 64 back onto the piston 60 and inserting the shear pins 76. Similarly, the valve member 102 may be refurbished by a new shear pin 126.

It will be noted that even though valve means are provided to first essentially block the downward flow of fluid and then to block the upward flow of fluid through the tool, limited circulation is possible in both directions through the tool at a cut rate as to assist in withdrawing the drill stem in the event a caving-in or other complication is encountered after the sample is taken.

Although a particular novel valve 102 has been illustrated to establish a pressure drop through the tool 10, it is to be understood that within the broader aspects of the invention other devices may be utilized. The construction of the check valve 134 is preferred, but it permits some upward passage of fluid, but other check valve constructions can be employed such as the conventional ball float valve. It will also be appreciated that although only one fluid cylinder 40, piston 60 and coring tube 64 have been illustrated, more than one such combination can be provided in a coring tool 10 at longitudinally spaced points and oriented to take core samples.
in different directions from the borehole. Such sampling devices may be operated simultaneously by a single valve, or may be operated sequentially, either singly or in groups, by utilizing a series of progressively smaller valve seats 100 down the well bore and progressively larger valve members 102. This permits, if economically justified, a number of different core samples to be taken at one or more points within the borehole during a single round trip of the drill bit. The core sample cut by the tool can be oriented by a conventional survey instrument having a pointed nose which may be received in and centered by the flat portion 128 of the valve member 102. Although a preferred embodiment of the invention has been described in detail, it is to be understood that various changes, substitutions and alterations can be made in the specific parts and in the combination of parts without departing from the spirit and scope of the appended claims which are intended to constitute the sole limitation upon the scope of the present invention.

What is claimed is:

1. In a side wall sampling tool, the combination of:
   a sub for connection in a drill stem having a primary fluid passageway extending longitudinally through the sub for passing drilling fluid through the sub, a fluid cylinder formed in the sub having first and second ends, a fluid piston reciprocally disposed in the cylinder, a sampling tube connected to the piston and extending through the second end of the cylinder for engaging the wall of a borehole when extended and collecting a sample, a first fluid passageway providing fluid communication between the primary fluid passageway and the first end of the fluid cylinder, and a second fluid passageway providing fluid communication between the primary fluid passageway and the second end of the fluid cylinder, and second valve means for selectively directing fluid pressure from the primary fluid passageway to the second fluid passageway for driving the piston and sampling tube on a sample-taking stroke, a second fluid passageway providing fluid communication between the primary fluid passageway and the second end of the fluid cylinder, and second valve means for selectively directing fluid pressure from the primary fluid passageway to the second fluid passageway to drive the piston in a direction to retract the sampling tube.

2. The combination defined in claim 1 further characterized by:
   - spring biasing means operatively connected to the fluid piston for biasing the piston toward the first end of the fluid cylinder and retracting the sampling tube.

3. The combination defined in claim 1 further characterized by:
   - a bore in the sub oriented generally longitudinally of the sub and having one end disposed adjacent the first end of the cylinder, a compression spring disposed in the bore, and a flexible tension member connected to the piston and extending through a passageway in the first end of the cylinder and through the bore to the other end of the bore and connected to the end of the spring adjacent the other end of the bore.

4. The combination defined in claim 3 wherein the bore and passageway form a portion of the first fluid passageway.

5. The combination defined in claim 1 wherein the sub is further characterized by a plurality of longitudinally extending stabilizing fins.

6. The combination defined in claim 5 wherein:
   - there is a pair of oppositely disposed stabilizer fins, the bore extends from one of the fins toward the other, and the sampling tube extends from said other fin.

7. The combination defined in claim 5 further characterized by:
   - means for retaining the sampling tube in the retracted position until a predetermined pressure differential is established across the piston, then for suddenly releasing the tube.

8. In a side wall sampling tool, the combination of:
   - a sub for connection in a drill stem having a primary fluid passageway extending longitudinally through the sub for passing drilling fluid through the sub, a fluid cylinder formed in the sub having first and second ends, a fluid piston reciprocally disposed in the cylinder, a sampling tube connected to the piston and extending through the second end of the cylinder for engaging the wall of a borehole when extended and collecting a sample, a first fluid passageway providing fluid communication between the primary fluid passageway and the first end of the fluid cylinder, and first valve means for selectively directing fluid pressure from the primary fluid passageway to the first fluid passageway for driving the piston and sampling tube on a sample-taking stroke, a second fluid passageway providing fluid communication between the primary fluid passageway and the second end of the fluid cylinder, and second valve means for selectively directing fluid pressure from the primary fluid passageway to the second fluid passageway to drive the piston in a direction to retract the sampling tube.

9. The combination defined in claim 8 wherein the sampling tube is a core cutter.

10. The combination defined in claim 8 wherein the second valve means comprises:
    - an upwardly closing check valve disposed in the primary passageway at a point above the point where the second fluid passageway communicates with the primary fluid passageway.

11. The combination defined in claim 8 wherein:
    - the check valve has a restrictive fluid passageway there-through to permit some reverse fluid circulation through the drill stem.

12. The combination defined in claim 8 wherein the first valve means comprises:
    - an annular seat formed around the primary fluid passageway at a point below the point where the first fluid passageway communicates with the primary fluid passageway, the diameter of the seat being less than the minimum diameter of the drilling fluid passageway through the drill stem above the sub, and the valve member sized to pass downwardly through the drill stem and engage the seat to increase the pressure drop across the seat.

13. The combination defined in claim 12 wherein the valve member has a restricted fluid passageway there-through to establish a pressure drop across the valve means as drilling fluid is pumped through the restricted fluid passageway.

14. The combination defined in claim 12 further characterized by:
    - means for retaining the sampling tube in retracted position against pressure applied to the first end of the cylinder until a predetermined pressure differential across the piston is reached, then for releasing the sampling tube for a sample taking stroke, and wherein the valve member includes means for at least partially reopening the primary passageway after a predetermined pressure differential is established across the valve member in excess of the pressure differential required to drive the sampling tube through a sample-taking stroke.

15. In a side wall sampling tool, the combination of:
    - a generally cylindrical sub for connection in a drill stem having a primary fluid passageway extending longitudinally through the sub for normally passing drilling fluid, a plurality of elongated stabilizer fins disposed on opposite sides of the sub having a diameter corresponding approximately to the diameter of the borehole being drilled,
a fluid cylinder formed in the sub by a bore extending transversely of the sub through one fin and a plug secured and sealed in the bore, a fluid piston reciprocally disposed in the fluid cylinder, a sampling tube connected to the fluid piston and extending through one end of the fluid cylinder, and means for selectively directing power fluid from the primary fluid passageway to the fluid cylinder to drive the piston and sampling tube on a sample-taking stroke.

16. The combination defined in claim 15 wherein: the plug is secured in the bore by a pin extending transversely through the fin.