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OBTAINING UNALTERED CORE SAMPLES OF SUBSURFACE EARTH FORMATIONS

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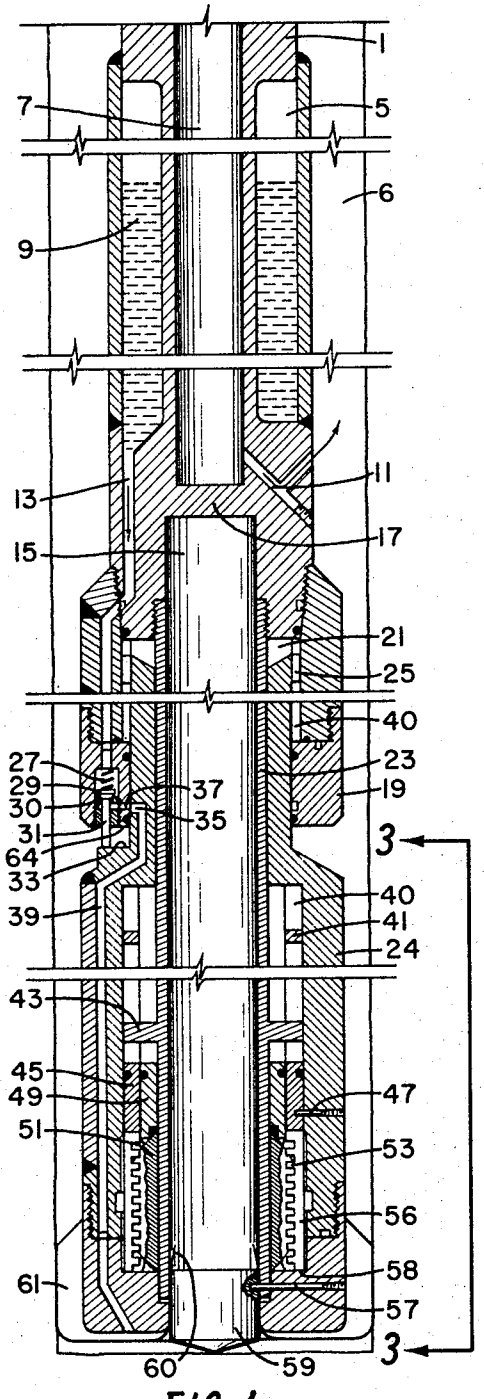

FIG. 1

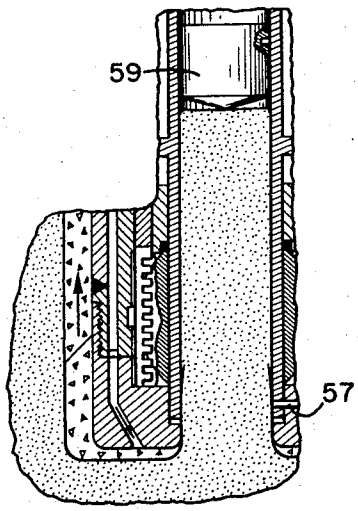

FIG. 2

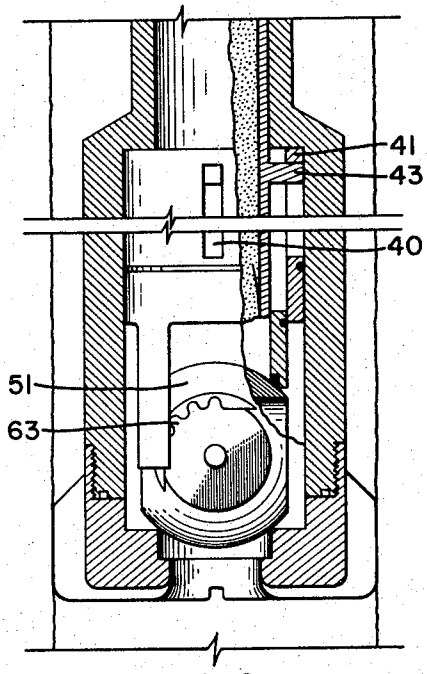

FIG. 3

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OBTAINING UNALTERED CORE SAMPLES OF SUBSURFACE EARTH FORMATIONS

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ABSTRACT OF THE DISCLOSURE

Apparatus at lower end of drill string for obtaining earth formation core uses liquid that does not penetrate earth formation. Liquid is ejected from gas-charged chamber to surround bit head and core at higher pressure than earth formation pressure. Regular circulating fluid flows into annulus above bottom of hole. Earth cuttings driven into circulating fluid by now penetrating liquid. Special valve permits liquid to be ejected from gas-charged chamber only when core is being cut.

Background of the invention

This invention relates to the obtaining of core samples from subsurface earth formations and more particularly to obtaining core samples from boreholes drilled using drilling liquids that contaminate earth formations penetrated by the borehole.

The customary current practice for drilling boreholes involves the use of the rotary drilling technique wherein an annular drill string terminated at its lower end by a drilling bit is used in connection with drilling fluids which are circulated down the bore of the drill string and up the annulus thereabout. The drilling fluids ordinarily used in connection with the drilling of such boreholes penetrate the earth formations around the boreholes to a greater or lesser degree and displace the natural earth fluids contained therein. It is desirable from time to time to obtain samples of the earth formations penetrated by the borehole to obtain geologic information. Manifestly it is desirable that the samples, or cores, that are obtained be as much as possible in their natural condition and more especially in formations containing hydrocarbons, to determine the correct percentages of oil, gas, and water contained in the pores of the rock in its natural state. Various techniques and apparatuses have been used in the past to achieve this end which have been successful to a greater or lesser degree. One technique that has been suggested in the prior art is to substitute for at least a portion of the regular drilling fluid in the bottom of the borehole, a drilling fluid that will not penetrate the formation being cored. A core can thereby be cut by the drilling bit in the presence of a drilling fluid that will not penetrate the formation. Such drilling fluids are revealed in U.S. Patents 3,302,733 and 3,314,489 and will not be described in detail herein. However, the expense of these drilling fluids is so great that it is impractical to fill the borehole with them. This invention presents a mechanical apparatus that maintains a small amount of these noncontaminating fluids around the core while it is being cut but permits the remainder of the hole to be filled with the regular drilling fluid in order to circulate the drill cuttings out of the well in the normal manner.

Cores are usually cut to evaluate hydrocarbon producing formations that may have pressures high enough to displace drilling fluid and allow the wells to blow uncontrolled unless the drilling fluid pressure is greater than that in the formation. The regular drilling fluid is therefore usually of sufficient density (weight) to create a hydrostatic pressure greater than that in the formation. The apparatus of the present invention is designed to provide a constant pressure source within the core barrel that is capable of driving a core-sealing, noncontaminating fluid around the core bit at a higher pressure than that of the regular drilling fluid; thus isolating the coring bit and the core from contamination by the regular coring fluid and simultaneously carrying the noncontaminated drill cuttings upward to commingle with the regular drilling fluid to be circulated from the well. In prior art devices as exemplified by U.S. Patents 2,862,691, 2,880,969, and 3,064,742, this has been achieved by using the core itself as a piston to create the required driving pressure to move the noninvading fluid to the core bit, but such devices lack accurate control of the pressure driving the noninvading fluid. Manifestly the pressure generated by the core as a piston will vary with rate of coring and can fall low enough that the fluid will be displaced by the conventional drilling fluid thereabove so that the core would be contaminated.

Summary of the invention

The apparatus of the present invention is adapted for use at the bottom end of an annular drill string and includes a bit, an elongated outer barrel **24** connected to the bit, and an elongated inner barrel **23** for receiving a core cut by the bit. Connected to the inner barrel is an upper pipestring member for telescopically moving the inner barrel relative to the outer barrel when the bit is supported by the earth, and adapted for connection to the upper portion of the drill string. The upper pipestring section has an annular upper portion through which drilling fluid may be circulated. In the upper pipe section above the inner barrel there is located an annular reservoir for receiving a nonpenetrating fluid in sufficient quantity for drilling a core of desired length. Located in the outer barrel there is a first passageway for fluid communication between the lower end of the outer barrel and a location near the upper end of the outer barrel. An annular section of the upper pipestring member extends downwardly around the upper portion of the outer barrel to form a cavity with the inner barrel for receiving the upper end of the outer barrel in splined driving engagement so that the outer barrel is rotated with the pipestring. A second passageway means in the upper drillpipe member extends through the annular section to said first passageway so that fluid in the reservoir may flow through the first and second passageways to the lower end of the bit when the annular section and the outer barrel are in predetermined relative positions. Located in the upper drillpipe member there is a valve means for closing the second passageway until the annular section and the outer barrel telescope together and engage shoulder to shoulder, thereby moving the valve stem and opening said valve. This action occurs when the bit engages the bottom of the hole and the weight of the drillpipe member causes shoulder to shoulder engagement. Thus the nonpenetrating fluid is confined in the annular reservoir until the drill bit is in position to cut a core. Third passageway means in the upper drillpipe member is provided for fluid communication between the annular bore and the exterior of the upper drillpipe section above the lower end of the annular section. During coring operation conventional drilling fluid is circulated down the pipestring through the annular upper portion of the upper pipe string section and through the third passageway means into the annulus around the drill string. The nonpenetrating fluid in the reservoir is pressurized by means of compressed gas therewith to provide the driving pressure for lifting cuttings from beneath the drill bit and up to commingle into the circulating stream of conventional drilling fluid and rise to the surface of the well. The com-

pressed gas may be separated from the sealing fluid by a piston if so desired.

Brief description of the drawing

Objects and features of the invention not apparent from the above discussion will become evident upon consideration of the following detailed description thereof wherein FIG. 1 is a cross-sectional view of a preferred embodiment of the invention; FIG. 2 is a partial view of the apparatus of FIG. 1 showing proportions of the component parts thereof during coring operations; and FIG. 3 is a broken-away view of a portion of the apparatus in FIG. 1 illustrating other component parts thereof in relative positions that they will assume after coring operations have been completed.

Description of preferred embodiments

With reference now to FIG. 1, there is illustrated a coring apparatus in accordance with the invention which includes an inner barrel **23**, an outer barrel **24**, and a drill bit **61** connected to the lower end of the outer barrel. Adapted to be connected to the lower end of a drillstring (not shown) there is provided an upper pipe string section **1** affixed to the inner barrel **23** such that a bore **15** is provided which is common to the lower portion of the upper pipe string section **1**, the inner barrel **23**, and the drill bit **61**. Separated from the bore **15** by a wall **17** is a bore **7** which is in communication with the bore of the drill string such that conventional drilling fluid can pass thereinto. Surrounding the bore **7** is an elongated reservoir **5** in the wall of the pipe string section **1** for receiving a pressurized drilling fluid which is substantially nonpenetrating or nonimbibable into earth formations. The upper pipe string member may be terminated at its upper end by a threaded adapter member (not shown) for connection to the lower end of a string of drill pipe in the conventional manner.

At the lower end of the pipe string section **1** there is an annular section that extends downwardly over the upper portion of the outer barrel **24** for a short distance so as to form a cavity or recess **21** therebetween. Annular section **19** has a number of vertical keyways **40** therein for receiving splines **25** at the upper end of the outer barrel **24** so that the pipe string section **1** and the outer barrel are in driving relationship; in other words, as the pipe string section **1** is rotated by the drill string, outer barrel **24** and the drill bit **61** rotate therewith through the splined driving connection. An upper passageway **13** extends downwardly through the annular section **19** so as to interconnect with a passageway **39** that extends from near the upper end of the outer barrel **24** down through the outer barrel and the drill bit **61** to open at the lower end of the drill bit. The passageways have openings **37** and **35** so as to be in fluid communication when the annular section **19** and the outer barrel **24** are in predetermined contact; specifically, the passageways are in fluid communication when the annular section **19** extends downwardly as far as possible over the upper portion of the outer barrel **24** and shoulder **64** engages shoulder **33**. The upper passageway **13** is normally closed by a valve including a movable valve member **29** that is normally urged against a valve seat **30** by a coil spring **27**. An actuating rod **31** is affixed to the movable valve member **29** and extends downwardly through the lower end of the annular section **19** so as to engage a shoulder **33** on the outer barrel **24** to lift the movable valve member **29** from its seat **30** and open the passageway **13**. Manifestly this can be done only when the annular member extends substantially as far as possible over the upper portion of the upper barrel **24** so that the passageway **13** is in fluid communication with the upper opening **35** of the passageway **39** through annular passage **65**. Engagement of shoulder **64** with shoulder **33** and resultant opening of valve member **29** can occur only when bit **61** engages the bottom of the hole and the weight of pipe section **1** causes section **19** to move downward.

For the purpose of sealing the lower end of the bore **15** after a core has been taken, there is provided a core catcher **60** and a ball valve **51**, portions of the surface of which are geared as at **63** so as to engage racks **53** in member **56**. Member **56** is, in effect, a segment of a cylinder which is held rigidly by the shoulder **58** of the coring head in the lower end of the barrel **24**. A rack **53** along each side of member **56** engages a separate geared portion **63**. Valve **51** has a port extending therethrough which, when the valve is open, enables the barrel **23** to move therethrough. The valve seat for the valve **51** is located at the lower end of the main body of an auxiliary sleeve member **49**. To close the ball valve, the inner barrel **23** is raised so that lug **43** thereon engages annular member **41** which is connected to member **56**. Lug **43** will not engage annular member **41** until the barrel **23** is clear of the valve. The valve **51** will thereupon rotate to close the lower end of the bore **15**. A core catcher is provided for the purpose of holding the core in the bore **15**. Apparatus of this general nature is described in U.S. Patent 3,064,742 and will not be further described herein.

The overall operation of the apparatus described above is as follows. Let it be assumed that the borehole has been drilled to a desired depth using a conventional drilling fluid and that it is now desired to obtain a core. The drill string is retracted from the borehole and run again into the borehole with the apparatus described above at the lower end thereof. The reservoir **5**, while at the earth's surface, is partially filled with a fluid that will not invade or be imbibed into earth formations such as an aqueous dispersion of oil-resistant polymeric elastomers, as described in U.S. Patent 3,302,733, including natural and synthetic rubber latices, both virgin and reclaimed. Other fluids that may be used are oil-base coring fluid containing Gilsonite with an oil base having aniline point of at least 175° F. and having a viscosity within the range of 10 to 100 centipoises at 100° F., the fluid being preferably composed of Gilsonite in the range of 20 to 45 percent by weight. Such a coring fluid is described in greater detail in U.S. Patent 3,314,489. Other coring fluids known to the art may be used. After reservoir **5** is partially filled with the noninvading fluid chosen, the remaining volume of chamber **5** is filled with a gas such as nitrogen or carbon dioxide so that the portion of the reservoir above the liquid level will be at a pressure in excess of the pressure of the earth formation even when the reservoir **5** is virtually depleted of liquid. The pressure inside the reservoir must be greater than the precalculated pressure of the conventional drilling fluid discharged from passage **17**, based on the hydrostatic pressure of the fluid column in the drill string, the fluid density, and pump pressure required to lift circulation from the well before coring operations are begun. A plug **59**, the lower end of which extends below the bit **61**, is affixed to the inner barrel by means of a shear pin **57** and the member **45** is affixed to the outer barrel **24** by means of a shear pin **47**. When the lower end of the drill string strikes the bottom of the borehole, shear pin **57** will immediately shear to permit the plug **59** to move upwardly within the inner barrel **23**. Setting down on the drill pipe will cause the annular member **19** to move downwardly to engage shoulder **33** so that valve **29** is lifted off of its seat **30**. The charged liquid **9** in the reservoir **5** will flow through passageways **13** and **39** so that as the drill string is rotated liquid will flow underneath the drill bit and up the annulus **6** to displace the conventional drilling fluid in the bottom of the borehole. Conventional drilling fluid is circulated down the drill string and out the passageway **11**. Cuttings produced by bit **61** will be lifted by the drilling fluid from reservoir **5** until they reach the level of the opening of passageway **11** into the annulus **6**, at which time the mixture of the conventional drilling fluid and the nonpenetrating drilling fluid will continue to lift the cuttings up the borehole. As the drilling progresses, a core will be formed which will protrude into the inner barrel **23** as illustrated in FIG. 2. When the core has been cut to the desired length it is broken by conventional techniques so as to be retained

within the inner barrel by means of the core catcher. The drill string is lifted to close valve **29** and to withdraw the inner barrel **23** from the ball valve **51**. Further lifting of the drill string will cause lug **43** to engage annular member **41** and close the ball valve as described above. The drill string may then be withdrawn from the borehole with an uncontaminated earth core within the inner barrel **23** at formation pressure.

Manifestly various modifications to the apparatus above may be advantageously effected. Under certain circumstances for example, it may be desirable to cut the core with a roller bit rather than the diamond bit illustrated. Further, the bit may be thread-connected to outer barrel **24** rather than being an integral portion of it as illustrated. Other modifications may be made within the scope of the invention.

Having described the principle of the invention and the best mode in which we have contemplated applying that principle, we wish it to be understood that the apparatus described is illustrative only and that various modifications thereto may be employed without departing from the true scope of the invention.

What is claimed is:

1. In a coring apparatus including a bit, an elongated outer barrel connected to the bit, an elongated inner barrel for receiving a core cut by said bit, and an upper pipe string member connected to said inner barrel for reciprocally moving said inner barrel relative to said outer barrel when said bit is supported by the earth, said upper pipe string section having an annular upper portion, the improvement comprising:

an annular reservoir for pressurized, nonpenetrating drilling fluid in said upper drill pipe section above said inner barrel;

first passageway means in said outer barrel for fluid communication between the lower end of said outer barrel and a location near the upper end of said outer barrel;

an annular section of said upper pipe string member extending around the upper portion of said outer barrel to form a cavity with the inner barrel for receiving the upper end of said outer barrel in driving engagement;

second passageway means in said upper drill pipe member extending through said annular section to said first passageway means whereby fluid in said reservoir may flow through said first and second passageway means to the lower end of said bit when said annular section and said outer barrel are in predetermined relative positions;

valve means in said upper drill pipe member for closing said second passageway until said annular section and said outer barrel are in said predetermined relative positions; and

third passageway means in said upper drill pipe member for fluid communication between the annular bore and the exterior of said upper drill pipe section above the lower end of said annular section.

2. The apparatus of claim **1** further including a gas-pressurized fluid in said reservoir having low penetration into earth formations.

3. The apparatus of claim **1** further including valve means within said outer barrel having a bore therethrough to receive said inner barrel, and means for closing said valve means when said inner barrel is withdrawn from bore of said valve means.

4. The apparatus of claim **1** wherein said valve means comprises a valve seat in said passageway means, a movable valve member including an actuating rod positioned to engage said outer barrel when said first and second passageways are juxtaposed to unseat said movable valve member.

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