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J. W. GRAHAM

3,123,157

RECOVERY OF DRILL CUTTINGS FROM SUBSURFACE EARTH FORMATIONS

Filed June 15, 1960

3 Sheets-Sheet 1

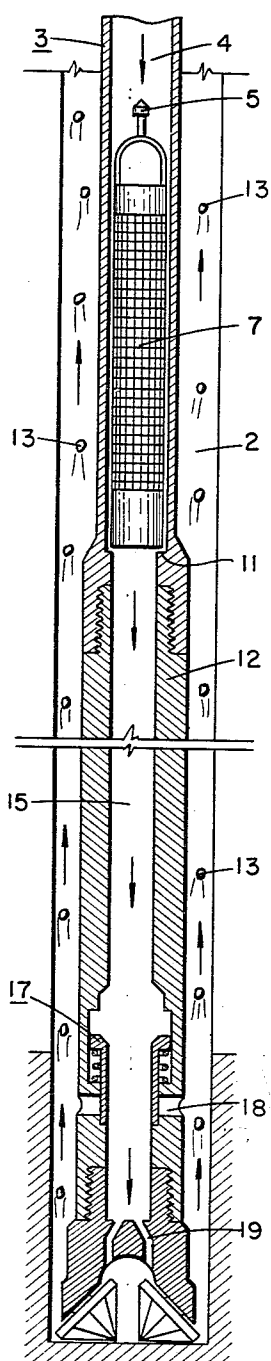


FIG. 1.

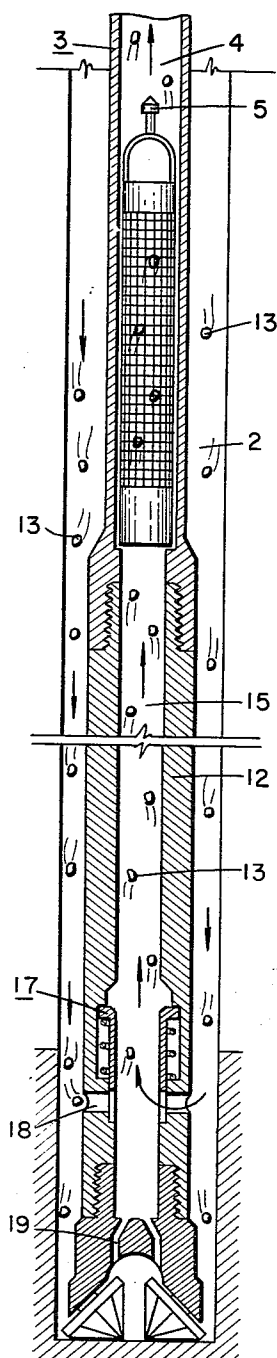


FIG. 2.

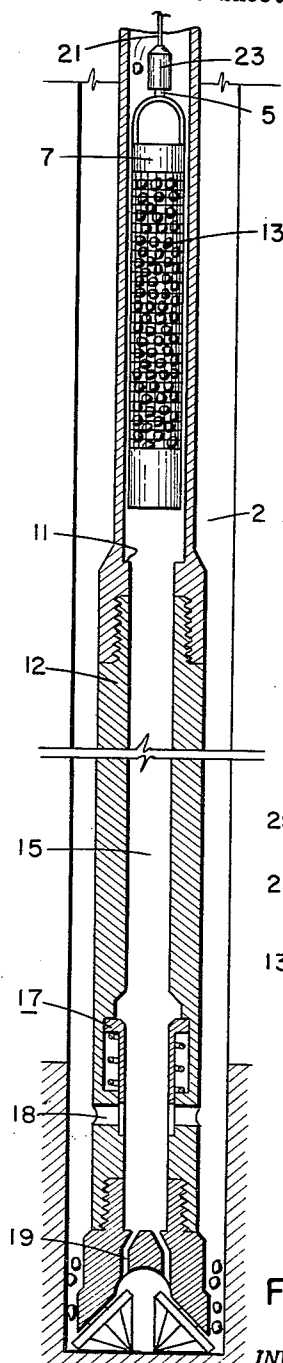


FIG. 3.

FIG. 4.

INVENTOR.

JOHN W. GRAHAM,

BY

*John B. Davidson*

ATTORNEY.

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J. W. GRAHAM

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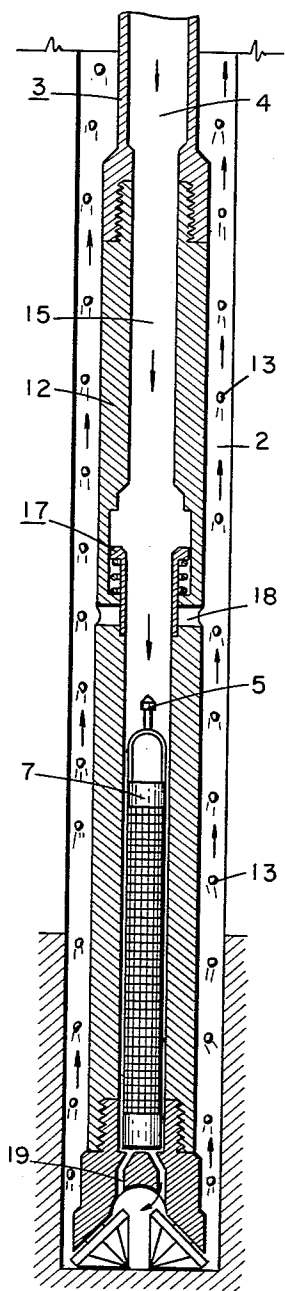


FIG. 5.

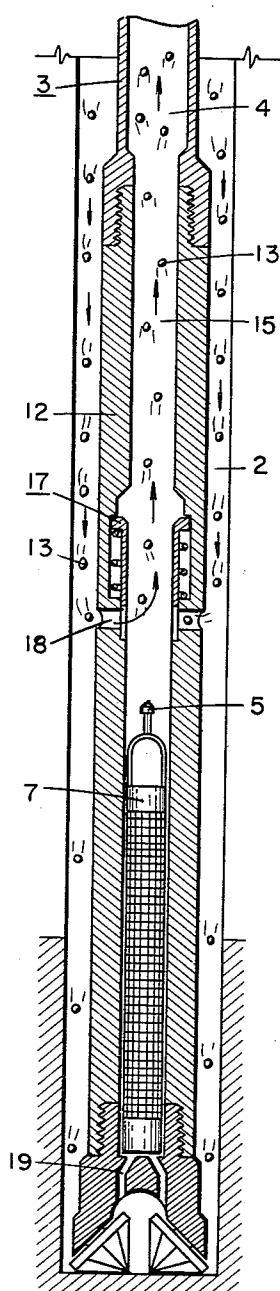


FIG. 6.

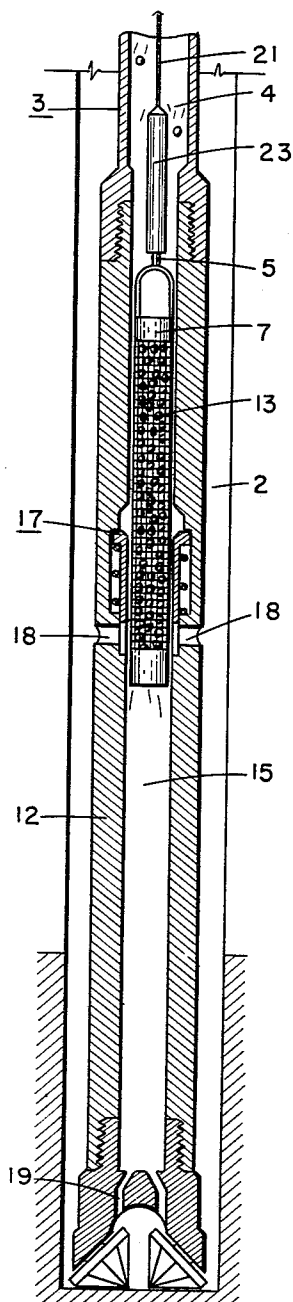


FIG. 7. INVENTOR.  
JOHN W. GRAHAM,

March 3, 1964

J. W. GRAHAM

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RECOVERY OF DRILL CUTTINGS FROM SUBSURFACE EARTH FORMATIONS

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3 Sheets-Sheet 3

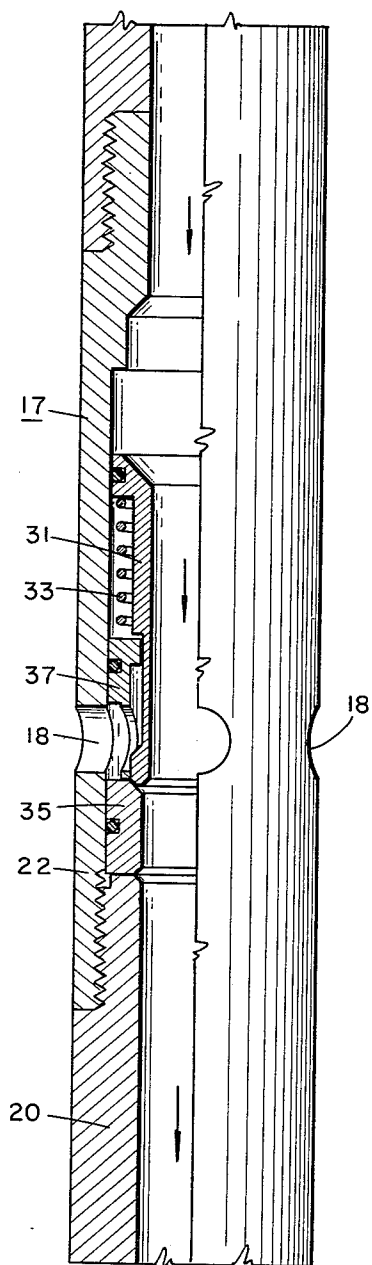


FIG. 8.

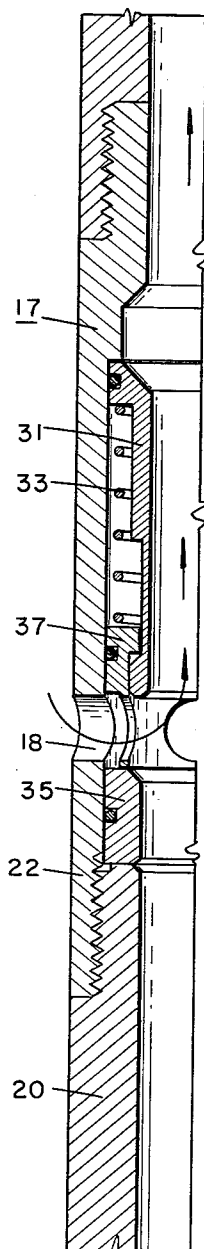


FIG. 9.

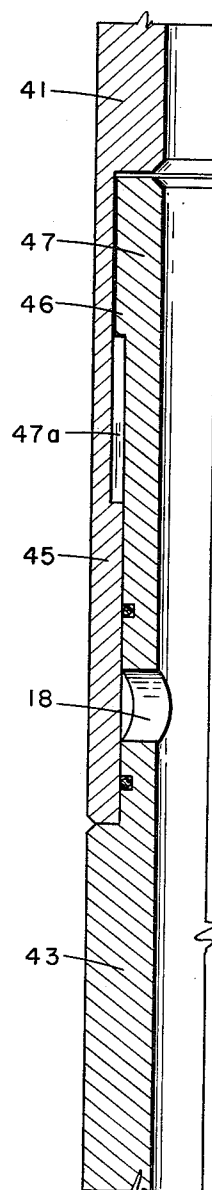


FIG. 10.

INVENTOR.  
JOHN W. GRAHAM,

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3,123,157

## RECOVERY OF DRILL CUTTINGS FROM SUB-SURFACE EARTH FORMATIONS

John W. Graham, Bellaire, Tex., assignor, by mesne assignments, to Jersey Production Research Company, Tulsa, Okla., a corporation of Delaware  
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7 Claims. (Cl. 175—58)

This invention relates generally to rotary drilling of boreholes, and more particularly to the problem of obtaining at the earth's surface chips produced during rotary drilling operations.

During rotary drilling of boreholes in the earth, it is the practice to circulate a drilling fluid down the bore of the drill pipe and up the annulus around the drill pipe. The drilling fluid passes out of the bottom of the drill pipe and around the drill bit to cool the drill bit and to remove rock chips from the bottom of the borehole. The chips are carried to the earth's surface with the drilling fluid. By capturing chips and analyzing them, geologists have been able to obtain much information about the earth formations penetrated by a bit soon after the chips have been cut. This technique has been practiced for many years using liquid drilling fluids of high viscosity. However, when either air or liquids of low viscosity (less than 1 centipoise) and low specific gravity (less than 3) is used as the drilling fluid, it has not been possible to obtain satisfactory earth chips. The drill string acts as a very effective rod mill to pulverize the rock chips during their long journey up the annulus to the earth's surface. When air is used as the drilling fluid, only dust rises from the annulus. In view of the known fact that air and low viscosity liquid drilling fluids are effective to increase drilling rate and prolong drill bit life in areas where such fluids may be used, it is desirable to have a method of capturing useful chips while drilling with such fluids.

Even when heavy liquids are used as the drilling fluid, cuttings from one formation tend to become mixed with cuttings from other formations above or below the one formation. For example, consider a group of cuttings that start the trip up the annulus together. Since the drilling fluid flow in the annulus is frequently laminar, the cuttings in the center of the annulus travel faster than those near the boundaries. Therefore, a cutting which finds itself in the center of the annulus may overtake cuttings from another formation which happen to be traveling near the edge of the annulus. Moreover, the cuttings are generated in a variety of sizes. In laminar flow the cuttings tend to fall or slip back through the drilling fluid with a velocity that can be approximated by Stoke's law. This means that small cuttings have a faster average velocity than large cuttings so that small cuttings from one formation may overtake large cuttings from another formation that was drilled earlier. Hole irregularities which always exist tend to add to this confusion of cuttings. The net result is that a geologist cannot be certain of the origin of the cuttings that he recovers at the surface.

In accordance with the teachings of the present invention, a port is provided in the drill string not far removed from the drill bit. The port is provided with a suitable valve or other means so that it can be closed at the will of an operator at the earth's surface. An open weave basket is placed in the drill string near the bottom end of the string in such a manner as to permit normal circulation of drilling fluid. The port is opened and the direction of fluid circulation is quickly reversed so that rock chips above the port are swept down the annulus, through the port, and up the drill string. Preferably, the direction of circulation is reversed by reducing the pressure in the drill string rather than by placing the

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annulus under pressure although both techniques will be found to be satisfactory. The chips are captured in the basket and the basket is retrieved from the drill string.

The objects and features of the invention will become more apparent upon consideration of the following detailed description thereof taken in conjunction with the accompanying drawings, wherein:

FIGS. 1, 2, and 3 are schematic illustrations of well apparatus showing steps involved in the practice of the invention;

FIG. 4 is an enlarged, elevational view (partially in cross-section) of the chip-catching basket shown in FIGS. 1, 2, and 3;

FIGS. 5, 6, and 7 are schematic illustrations of well apparatus showing the steps involved in another manner of practicing the invention;

FIG. 8 is an elevational view of a valve sub showing the valve mechanism for opening the port in the drill string shown in FIGS. 1, 2, 3, 5, 6, and 7. The valve is shown in its closed or while-drilling position;

FIG. 9 is a fragmentary view of the apparatus of FIG. 8 illustrating the valve in its opened or non-drilling position; and

FIG. 10 is a view of another valve structure that may be used in the practice of the invention.

With reference now to FIGS. 1, 2, and 3, there is shown in each figure a borehole that has been drilled in the earth by rotary drilling apparatus including a drill string 3 having a conventional drill bit at the lower end thereof. The drill bit is provided with nozzles or jets 19. A low viscosity drilling fluid which may be water, air, or a lightly weighted fluid such as is used in drilling operations in west Texas, is shown in FIG. 1 as being circulated down the drill pipe bore 4 and drill collar bore 15 through the bit nozzles 19 and up the annulus 2 around the drill string. A seat 11, which may be annular, is provided in the drill pipe a short distance above the upper end of the drill collar 12. A cuttings retrieving basket 7, which will be described in detail with respect to FIG. 4, is shown in FIGS. 1 and 2 as being landed on the seat 11 and supported thereby. One or more ports 18 are provided in the drill collar which are of sufficient size to allow large cuttings to easily pass therethrough. The port is opened and closed by a valve mechanism which will be described in detail with respect to FIGS. 8, 9, and 10. The port 18 is preferably as close to the drill bit as possible and should not be more than 30 feet away from the bit.

With reference now to FIG. 4, the cutting retrieving basket 7 is shown as including a heavy, annular weight section 9 at the bottom end thereof. The weight section 9 has a bore 29 of sufficient diameter to permit free passage of drilling fluid downwardly therethrough and of rock chips upwardly therethrough. A wire screen 26 is supported by a plurality of ribs 25; the screen should be between 10 and 100 mesh. A conventional fishing head 5 is affixed at the upper end of the ribs 25 so that the basket may be retrieved from the drill pipe by conventional wireline fishing apparatus.

A flapper mechanism 27 is pivotally affixed to the weight section 9 at the upper end of the bore 29. The flapper is normally horizontal so as to prevent rock chips from falling downwardly through weight section 9, and may have a very weak spring mechanism for urging it to its original position. Preferably, the flapper is a screen between 10 mesh and 100 mesh. The function of the flapper is to permit flow of drilling fluid downwardly through the bore 29 and to lift when the direction of drilling fluid flow is reversed so that rock particles may pass up into the basket portion of the apparatus. If the flapper is provided with a spring return, the spring should not be so strong as to seriously impede the passage of rock chips up into the basket.

With reference to FIGS. 8 and 9, there is illustrated one embodiment of a sub including a port 18 and a valve mechanism 17 suitable for use with the invention. The drill string sub may comprise two portions 20 and 22 screw-threaded together as shown. An annular valve seat 35 below the port 18 is supported by the upper shoulder of sub 20. An annular, ported reaction member 37 is provided, the ports of which coincide with the ports 18. The reaction member 37 rests on the annular valve seat 35. A sliding valve member 31 is adapted to slide inside of the reaction member 37 so as to seat on the valve 35 to close the ports 18. A spring 33 urges the valve member 31 upwardly. The valve member 31 projects into the bore of the drill collar far enough so that the pressure of drilling fluid passing downwardly through the drill string pushes valve member 31 down to close the ports 18. The spring should be relatively weak so that light drilling fluids may easily push valve member 31 down. The valve member 31 is shown in its actuated or while-drilling position in FIG. 8, and in its nonactuated position in FIG. 9.

An alternate mechanism for accomplishing the same function is shown in FIG. 10. The drill collar is provided with two sections 41 and 43 which are in telescoping relationship. The lower portion 45 of drill collar section 41 fits around the upper portion 47 of drill collar section 43, and ports 18 are provided in the upper section 47. Splines 46 in the upper portion 47 interconnect with splines 47a in section 41 so that the two sections are mechanically interconnected. When the drill string is picked up, splines 46 support section 43 on annular flange 45 so that the lower section 43 of the drill collar will hang from the upper section 41 and will open ports 18. "Lost motion" couplings of this general nature have been used in the past for other purposes and will not be further described herein. It is apparent that ports 18 will be closed during drilling operations and may be opened at the discretion of the driller during drilling breaks by picking up the drill string.

Port 18 is shown as being of circular cross-section. Manifestly, the port may have other cross-sectional configurations as long as it is sufficiently large to permit free passage therethrough of the largest sized rock chip that may be cut by the drill bit.

With reference again to FIGS. 1, 2, and 3, in FIG. 1 the well apparatus is shown in the while-drilling position. Port 18 is closed by the sliding valve 17, and flapper 27 is in its horizontal position with the basket 7 resting on seat 11. Drilling fluid is circulated down the drill pipe under pressure exerted by pumps at the earth's surface, through basket 7 and screen 27, through the drill collar bore 15, out the drill bit nozzles 19 and up the annulus 2 around the drill pipe to the conventional mud pit at the earth's surface. If air is used as the drilling fluid, the well bore is exhausted to atmosphere. Earth cuttings 13 cut by the drill bit are carried up the annulus 2 by the drilling fluid. As described above, the drill pipe will tend to crush the cuttings as they proceed up the annulus 2 and will gradually decrease their average size as they proceed up the annulus.

At a drilling break when it is desired to retrieve earth cuttings, valve mechanism 17 is opened as soon as possible after drill string rotation has been stopped. The direction of drilling fluid rotation is quickly reversed before the cuttings have had a chance to drop to the bottom of the borehole. This may be done by pressurizing the annulus 2 around the drill string, or, preferably, by connecting the suction end of the drill fluid pumps to the well bore and the exhaust end to the annulus so as to withdraw drilling fluid from the well bore and to inject drilling fluid into the annulus. When well drilling operations are being conducted, the well bore thus will be placed under a partial vacuum, or at least the pressure therein will be reduced below atmospheric pressure. Drilling fluid thus will be directed down the annulus 2 and up the bore

of the drill string. Most of the drilling fluid will pass through port 18, only an insubstantial amount passing through bit nozzles 19 into the drill string bore. The cuttings 13 will be swept through the port 18 into the drill string bore and will be swept up the drill string. When the cuttings strike flapper screen 27 the screen will be raised to permit passage of cuttings into the basket and up into the drill pipe bore 4. After a desired time interval of reversed circulation, the drilling fluid pumps are stopped and the cuttings allowed to fall back into the basket 7. Flapper screen 27 will close so that the cuttings will be held in the basket and will not be permitted to fall to the bottom of the drill string.

As shown in FIG. 3, a fishing mechanism 23 is lowered on a wireline 21 so as to latch on the fishing head 5. The basket is then retrieved from the well bore. Any cuttings up the drill string will be caught in the basket as the basket is retrieved. When the basket has been emptied of its contents at the earth's surface, it may be dropped back into the drill string to land again on seat 11, and drilling operations may be recommenced.

Refer now to FIGS. 5, 6, and 7. Under certain circumstances it is desirable to have the basket as low in the drill string as possible. In order to permit the basket 7 to be as close to the bit as possible, the ports 18 and the valve mechanism 17, as shown, are positioned in the drill collar 12 at a level above the basket. Basket 7 need not have a flapper screen as shown in FIG. 4 when this method is followed. However, the bottom of the basket should be of screen having a mesh between 10 and 100.

As shown in FIG. 5, while drilling, the valve 17 is closed. Drilling fluid will pass down the drill string bore, through the basket and the drill bit, and up the annulus 2. As shown in FIG. 6, the valve 17 opens port 18 at a drilling break. The direction of drilling fluid circulation is reversed so that cuttings are swept through port 18 and up the drill string bore. Valve 17 is then closed and a retrieving tool 23 is lowered into the drill string on a wireline 21. The cuttings will fall into the basket or will be swept into the basket 7 as it is pulled out of the drill string. The basket may then be dropped into the well and drilling operations recommenced.

The time interval over which the circulation of drilling fluid is reversed is preferably between  $\frac{1}{10}$  and 10 minutes. Manifestly, it is desirable to have the cuttings that are retrieved be from the formation currently being penetrated, so it is not desirable to reverse circulation for more than this time interval.

From the above description of the invention it can be readily seen that intermixing of cuttings from different formations is minimized because the cuttings captured are those of the formation that has just been drilled. Furthermore, the cuttings that are recovered will be of a very large size and will be of maximum value to the geologist having cognizance of the well operations. The cuttings remain in the mud stream for a very short time, are not subjected to the pounding that they would receive in annular flow, and the loss of hydrocarbonaceous materials therein due to the washing action of the drilling fluid is minimized. Furthermore, the time for recovering a representative bottom hole sample is very short. It will be found that this time seldom exceeds 20 or 30 minutes. This is short in comparison to the time required to obtain a core, and the cuttings will be found to be almost as valuable as a core in comparison to the value of the cuttings obtained in the manner heretofore practiced.

The objects and features of the invention have been completely described. The invention is not to be restricted to the specific structural details or arrangement of parts herein set forth, as various modifications thereof may be effected without departing from the spirit and scope of the invention.

What is claimed is:

1. In rotary drilling of boreholes in the earth with an

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elongated drill pipe having a drill bit at the lower end thereof and an openable and closable port above the drill bit wherein drilling fluids, including air and liquids of specific gravity less than 3, normally are circulated down the bore of the drill pipe and up the annulus thereabout for the purpose of removing earth cuttings produced during drilling operations, the method of recovering earth cuttings comprising: lowering an open weave basket into the drill pipe bore, stopping drilling operations, opening the port, reversing the direction of drilling fluid circulation to circulate at least a portion of the drilling fluid and earth cuttings entrained therein up the bore of the drill pipe, closing the port, and pulling the basket up the drill pipe to capture earth cuttings entrained in the fluid in the drill pipe bore.

2. In rotary drilling of boreholes in the earth with an elongated drill pipe having a drill bit at the lower end thereof and an openable and closable port above the drill bit wherein drilling fluids, including air and liquids of specific gravity less than 3, normally are circulated down the bore of the drill pipe and up the annulus thereabout for the purpose of removing earth cuttings produced during drilling operations, the method of recovering earth cuttings comprising: lowering an open weave basket in the drill pipe to a position within 30 feet of the drill bit, drilling an interval of a formation, stopping drilling operations, opening a port in the drill pipe above the basket, reversing the direction of drilling fluid circulation to circulate at least a portion of the drilling fluid and earth cuttings entrained therein up the bore of the drill pipe, and pulling the basket up the drill pipe to capture earth cuttings entrained in the fluid in the drill pipe bore.

3. In rotary drilling of boreholes in the earth with an elongated drill pipe having a drill bit at the lower end thereof and an openable and closable port above the drill bit wherein drilling fluids, including air and liquids of specific gravity less than 3, normally are circulated down the bore of the drill pipe and up the annulus thereabout for the purpose of removing earth cuttings produced during drilling operations, the method of recovering earth cuttings comprising: lowering an open weave basket into a drill pipe to a level below the port, stopping drilling operations, opening the port, reversing the direction of drilling fluid circulation to circulate at least a portion of the drilling fluid and earth cuttings entrained therein up the bore of the drill pipe, and pulling the basket up the drill pipe to capture earth cuttings entrained in the fluid in the drill pipe bore.

4. In rotary drilling of boreholes in the earth with an elongated drill pipe having a drill bit at the lower end thereof and an openable and closable port above the drill bit wherein air normally is circulated down the bore of the drill pipe and up the annulus thereabout for the purpose of removing earth cuttings produced during drilling operations, the method of recovering earth cuttings comprising: lowering an open weave basket into the drill pipe to a level below the port, stopping drilling operations, opening the port, placing the drill string bore under partial vacuum to circulate air and at least some earth cuttings

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entrained therein up the bore of the drill pipe, closing the port, and pulling the basket up the drill pipe to capture cuttings dispersed through the drill pipe bore.

5. In rotary drilling of boreholes in the earth with an elongated drill pipe having a drill bit at the lower end thereof and an openable and closable port above the drill bit wherein air normally is circulated down the bore of the drill pipe and up the annulus thereabout for the purpose of removing earth cuttings produced during drilling operations, the method of recovering earth cuttings comprising: lowering an open weave basket into the drill pipe to a level below the port, stopping drilling operations, opening the port, placing the drill string bore under partial vacuum for a period not to exceed 10 minutes to circulate air and at least some earth cuttings entrained therein up the bore of the drill pipe, closing the port, and pulling the basket up the drill pipe to capture cuttings dispersed through the drill pipe bore.

6. In rotary drilling of boreholes in the earth with an elongated drill pipe having a drill bit at the lower end thereof and an openable and closable port above the drill bit wherein drilling fluids, including air and liquids of specific gravity less than 3, normally are circulated down the bore of the drill pipe and up the annulus thereabout for the purpose of removing earth cuttings produced during drilling operations, the method of recovering earth cuttings comprising: lowering an open weave basket into the drill pipe bore, opening the port, reversing the direction of drilling fluid circulation to circulate at least a portion of the drilling fluid and earth cuttings entrained therein up the bore of the drill pipe, and pulling the basket up the drill pipe to capture cuttings entrained in the fluid in the drill pipe bore.

7. In rotary drilling of boreholes in the earth with an elongated drill pipe having a drill bit at the lower end thereof and an openable and closable port above the drill bit wherein drilling fluids, including air and liquids of specific gravity less than 3, normally are circulated down the bore of the drill pipe and up the annulus thereabout for the purpose of removing earth cuttings produced during drilling operations, the method of recovering earth cuttings comprising: lowering an open weave basket into the drill pipe to a level below the port, opening the port, reversing the direction of drilling fluid circulation to circulate at least a portion of the drilling fluid and earth cuttings entrained therein up the bore of the drill pipe, and pulling the basket up the drill pipe to capture cuttings entrained in the fluid in the drill pipe bore.

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