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CORING DRILL

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CORING DRILL

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This invention relates to a coring drill and, more particularly, to a reverse circulation, core drilling attachment adapted to be connected to standard drill pipe for operation by a conventional drill rig for the purpose of retrieving specimen cores from sub-surface formations.

In conventional core drilling attachments, a length of tubing having a central, concentric core barrel and an annular drill bit at the end is attached to the drill string to be rotated thereby. Thus, fluid is circulated around the core barrel which receives the core cut from the annular drill bit. Preferably, the core barrel is rotatable within the housing so that it may grip the core and remain stationary relative thereto as the bit cuts a length of core from the sub-surface formation. Customarily, after a core of certain length has been cut, suitable cutting devices are employed to sever it from the formation and the coring attachment is lifted to the surface. Such coring devices have given reasonably accurate representation of sub-surface formations, but they have serious limitations in practical operation. For example, with the drilling fluid being circulated in the conventional manner down through the drill pipe and up through the annulus around the drill pipe in the well bore the cores being cut are either subjected to erosion by the down coming stream or, if received in a protective core barrel, are subject to fracturing unless they have sufficient mechanical strength to rotate the core barrel relative to the outer tubing.

It is particularly difficult to recover cores from a friable formation, such as porous sand, or from broken formations. Consequently, the cores recovered often represent less than the full depth of formation penetrated by the core drill. When this happens the geologist can not ascertain the characteristics of the portion not recovered and he cannot determine the precise location in the depth penetrated of the cores actually recovered.

In order to minimize core loss and improve the recovery percentage it is often necessary to rotate the drill slowly under low weight, thus minimizing forces on the formation. Obviously this also results in slow and expensive penetration.

Additionally, the core barrels are of limited length so that only a very small depth of sub-surface formation can be sampled before it is necessary to remove the drill pipe from the well a section at a time, remove the coring attachment, inspect the samples and then determine whether or not to replace the conventional drill bit as the drill string is returned to the hole, again a section at a time. Thus a considerable amount of time and cost must be gambled in a decision to recover core samples.

A radical advance in practical and efficient core recovery was made by my provision of a continuous core drilling apparatus comprising concentrically arranged inner and outer pipes which provide a wholly contained reverse circulation system for downward flow between the pipes and upward return flow through the central pipe. Included in this continuous coring apparatus were means for breaking the core off into segments to be carried upward through the central pipe and means for accommodating varying longitudinal relationships between the inner and outer pipes, such as may be occasioned by the differential thermal expansion. Such continuous coring apparatus has been operated very successfully but it suffers a disadvantage in that it is not readily adaptable to existing equipment. Consequently, there is great need in

the industry for a core drilling apparatus which is capable of retrieving cores over an extended length of the well bore and which can be operated with conventional drilling equipment.

It is therefore, an object of this invention to provide a core drilling attachment for standard drill pipe to be operated by conventional drilling rigs.

It is a further object of this invention to provide a core drilling attachment for conventional drill pipe that is capable of achieving a wholly contained reverse circulation and include means for severing cores into lengths to be carried upward by the centrally rising fluid.

It is a further object of this invention to provide a core drilling attachment for conventional drill pipe that can be formed by multiple pipe sections for greater depth of core recovery through reverse circulation.

It is a further object of this invention to provide apparatus for cutting a core in the earth's sub-surface formation; severing the core into lengths which may be projected upwardly by returning drilling fluid, together with means for intercepting and supporting any cores that may drop back in the event that circulation is interrupted.

Others have previously considered the provision of a reverse circulation coring attachment for conventional drill pipe in order to better preserve the core being cut, but while such devices do alleviate some of the above-mentioned coring problems other disadvantages are encountered which render such devices impracticable for use with reverse circulation. When cutting a core while drilling a hole of conventional size the volume of rock ground to chips, i.e., the volume of hole around the core, may comprise from 70 to 95% of the total volume of the hole being cut. Consequently, with reverse circulation, the core barrel will receive a tremendous amount of cuttings compared to the volume of the core, and these cuttings may vary in size from a few microns to as large as can be passed by the water courses around the core bit. Consequently, such cuttings if introduced into the core barrel can quickly clog up perforations provided for circulation of the fluid around the cores and render the core drilling attachment inoperative in a very short time. When a tube is filled with irregularly shaped large pieces of rock, a drilling fluid may easily be pumped through the rock to the surface. If, wherever, the fluid is itself laden with drill bit cuttings the passageway quickly becomes impervious as the cuttings fill the interstices between the rocks. If, on the other hand, the perforations in the core drill were made of sufficient cross-section to pass all cuttings, then large cuttings containing valuable geological information may be lost or small pieces of broken cores would lodge in the perforations to obstruct the passage of cores again to clog up the apparatus.

It is therefore, a further and significant object of this invention to provide a core drilling attachment for conventional drill pipe that permits self-contained reverse circulation, with the cores being carried upwardly in a central core tube but with the bit cuttings being separated from the cores.

It is a further object of this invention to provide a reverse circulation core drilling apparatus wherein reversed core lengths and bit cuttings are elevated upwardly through separate conduits.

It is a further object of this invention to provide a core drilling attachment that is simple in construction and easily installed.

In carrying out this invention I provide a core drilling pipe string made up of longitudinally connected pipe sections, each having concentric inner and outer pipes which form two separate flow passageways, a down flow conduit between the inner and outer pipe and a return flow conduit within the inner pipe or separator tube. Within

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the separator tube is a third tubular member which functions as the core tube to receive the cores as they are cut from the formation and broken off into suitable lengths to be carried upward under fluid pressure. The lower end of the core tube is arranged in close proximity to the drill bit and is formed of small enough diameter to fit the core snugly so that chips cut by the bit from around the core are carried by the water courses upward through the interior of the separator tube but outside the core tube. Perforations in the core tube provide fluid communication throughout the cross-section of the separator tube but are small enough that chips are precluded from entering the central, core tube. Certain of the perforations assume the form of narrow slots in which are carried core dogs which when fluid circulation is stopped, are positioned to extend into the core tube to support any cores that may be positioned above them. However, when normal fluid circulation is resumed vanes on the core dogs are engaged by the rising fluid to move the dogs out of the way.

Other objects and advantages of this invention will become apparent with the accompanying drawings wherein:

FIG. 1 is a vertical section view of core drilling attachment of this invention;

FIG. 2 is a horizontal section view taken along line 2—2 of FIG. 1;

FIG. 3 is partial section view taken along line 3—3 of FIG. 2 showing a core dog forming a part of this invention;

FIG. 4 is a perspective view of the core dog attachment of FIGS. 2 and 3; and

FIG. 5 is a partial section view showing a modified form of core dog.

Referring now to the drawings with greater particularity, there is shown in FIG. 1 a conventional drill pipe 10 within a bore hole 12 on the lower end of which is carried the drill cutting attachment 14 of this invention. The drill cutting attachment is secured to the standard drill pipe by means of a cross-over sub 16 which is threaded at 18 to the conventional pipe 10. The smaller diameter upper portion 20 of the sub 16 is provided with a bore 21 which extends partially through the sub and carries the standard pipe threads 18 for connection to the single drill pipe 10. Below the upper end of the sub the outer surface tapers outwardly at 22 to a large diameter lower portion 24 which is threadedly connected at 25 to the top of the drill pipe 26, the outer pipe of the core drilling attachment 14. Threadedly connected below the top outer drill pipe 26 is a series of drill pipe sections 28 which are threadedly engageable at 30 to form a continuous conduit. Within the top outer pipe section a separator tube 32 is arranged and other separator tubes 33 are contained in outer drill pipe section 28. The separator tubes 32 and 33 are preferably spaced in coaxial relationship within the outer pipe 26 and 28 by means of series of ribs 34 that are attached along the length of each separator tube 32 and 33. Within each outer pipe section 26 and 28 only one set of ribs 34 is welded to the outer pipe to establish a fixed axial relationship between the outer pipe and the separator tube while permitting the remaining ribs to slide freely within the interior of the outer pipe.

At one end of each separator tube 32 and 33 is carried a sleeve coupling 36 which is welded around the outer end of the separator tube and which carries a suitable seal such as an O-ring 37 for sealing engagement with the adjacent end of another inner separator tube 33 to provide sealing connection throughout a limited range of axial movement between the adjacent ends of inner pipes.

Thus, a number of pipe sections may be attached end to end to cut a core of considerable length and any discrepancy or variation in axial alignment such as may be occasioned by tension forces while the pipe is suspended in the well; compression forces while the pipe is drilling;

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differential thermal expansion or variations in thread engagement can be absorbed by the sliding connection between inner and outer pipe and can be accommodated by the telescopic connection between the ends of the inner separator tubes.

As shown in FIG. 1 the lower bore 25 of the cross-over sub is in axial alignment with the outer reverse circulation pipe and a smaller counter bore 39 is provided concentric therewith. A telescopic sealing coupling member 40 is secured to the upper end of the uppermost separator tube 32 so that with a seal ring 41 within the counter bore, a sliding seal connection is provided between the interior of the top separator tube 32 and the small counter bore 39. A series of down passageways 42 are provided from the entrance bore through the cross-over sub to the shoulder 25a at the major transfer chamber bore 25 to provide communication with the downward flow passageway between the outer pipe and the separator tube. A similar series of passageways 44 is provided from the smaller counter bore 39 to the outside of the cross-over sub 16 at the tapered portion thereof 22. Thus, drilling fluid may be circulated from a surface reservoir (not shown) through the conventional drill pipe 10 then through the transfer passageways 42 and into the downward flow passage between the outer pipe 26, 28 and separator tube 32, 33 and then returned up through the separator tube into the reduced bore 39 by way of the transfer coupling 40 and out through the return passageways 44 to the annulus between the drill pipe 10 and the side of the well bore 12.

At the lower end of the lowermost outer pipe 28 is threadedly secured an annular drilling bit 46 which preferably has diamond chip cutting elements and which is threadedly connected at 48 to the outer pipe and slidably sealed at 49 with relation to the separator tube 33. Conduits 50 through the bit direct the fluid and chips cut by the bit around the bit to the interior and up through the water courses into communication with the upward flow passage within the separator tubes 33. For reasons that will become apparent the water courses 52 should be of sufficient cross-section to conduct the complete size range of chips that may be cut by the bit, so that they may pass freely through the water course and up through the separator tube to exit at the transfer passageways 44 of the cross-over sub 16, which passageways are also of sufficient cross-section to pass them. Conversely, any cutting that can pass through the bit water courses 52 will also pass freely through the annulus between pipes 33 and 66 and through the transfer passageways 44.

Centered within the separator tube is the core tube 54 through which the cores are transported upward as they are cut from the sub-surface formation. The core tube sections are attached to each separator tube by means of spacer webs 56 which are welded along the length of the core tube to maintain the desired coaxial relationship and only one set of spacers 56a is welded to the separator tube, again to fix the core tube within the separator tube but to permit relative expansion and contraction between them. There is, however, no sealed connection between adjacent ends of the core tube sections because it is desirable to have fluid communication throughout the separator tube both within and around the core tube. This fluid communication is further facilitated by the provision of a series of perforations, such as slots 58 which are extremely narrow to prevent any core cuttings except the most minute from entering from the exterior thereof.

The lowermost core tube section 60 is arranged so that the lower end thereof 62 extends in close proximity with the drill bit and is of a diameter snugly to embrace the core C being cut. The exceedingly restricted passageway remaining around the core prevent virtually all cuttings from entering into the core tube 60 while the tapered outer wall 62a at the lower end 62 of the core

tube increases the flow path from the drill bit water courses to minimize obstruction to passage of cutting chips flowing through the water course 52 around the cutting bit 46. Thus, at the lower end of the bottom core tube 60, there occurs a separation of cores and cuttings with the cores rising up through the internal bore at the lower end 62 of the core tube and the cuttings ascending through the separator tube 33 around the outside of the core tube 60.

The shoulder 62 at the lower end of the core tube, besides preventing entry of bit cuttings serves an additional purpose in firmly engaging the core being cut so that a cam member 65 disposed within the core tube 60 above the lower end thereof may engage the core C and apply bending stresses thereto until the core is severed from the formation into lengths that may be carried upwardly through the core tube 60 by drilling fluid flowing upward therein. Preferably, above the cam core breaker, the bottom core tube tapers at 66 to the restricted diameter of other core tube sections 54 for more efficient core transmission.

The cores are carried upward due to the differential fluid pressure between the top and bottom of the core. This differential pressure is generated by the ascending drilling fluid and, for a given channel and fluid is proportional to the velocity squared per unit of channel length. The weight of a core is expressed by the formula:

$$W=D(AL)$$

where

W =weight of core;

D =density of rock;

A =cross-sectional area of the core; and

L =length of core.

Similarly, the buoyancy of the core due to fluid may be expressed:

$$B=d(AL)$$

where d =density of the fluid.

From the above formula the force necessary to suspend the core in the fluid, i.e., the weight less the buoyancy of the core ($W-B$) may be expressed by the following formula:

$$F=PA=D(AL)-d(AL)$$

where P =pressure per unit of area.

Therefore, the pressure required to raise the core is expressed by the following formula:

$$\frac{P=D(AL)-d(AL)}{A}=L(D-d)$$

The average specific gravity of sedimentary rocks is about 2.5. Therefore, if the drilling fluid were water, the differential pressure required to suspend the core would equal one-and-one-half times the density of water per foot of length or about 0.65 p.s.i. per foot of length. However, since the core must not merely be suspended but must be accelerated upward, a practical value for differential pressure per foot of length is approximately 1 p.s.i. per foot of length when drilling with a fluid the specific gravity of which is 1.

For hydraulic efficiency, it is desirable to have the core tube 54 fit the core as closely as possible and to make the space between the core tube and separator tube 32, 33 as narrow as possible. The pressure differential, or actually the pressure loss, per unit length varies directly with the friction factor, the velocity squared and the density of the liquid and it varies inversely with the hydraulic radius of the tube. Since for a given pipe surface the friction factor is established and, for a given mud the density is fixed, the only two variable factors are the flow velocity and the hydraulic radius. The volume of drilling fluid required is determined by the diameter and design of the bit, and the dimensions of the space between the outer pipe and separator tube will establish the velocity required for that

minimum volume. Therefore, the only real variable is hydraulic radius and that may be established at a value that will give us the desired pressure differential of one pound per square inch per foot of length.

When there are no cores in the core tube, there is a large hydraulic radius and hence a low pressure drop. However, where there is a core in the tube then the cross sectional area of the flow annulus is greatly reduced and this is the only time the one pound per square inch per foot pressure drop is required. Hence, that is the condition that must be assumed in order to determine the dimensions of the separator tube.

When the core tube is empty of cores the ascending fluid flows freely throughout the separator tube 32, 33, both within and outside the core tube. At that time the differential pressure across the total length of the core tube is at a minimum. However, even if there is only one core of unit length in the core tube, then for that particular unit of length the flow must necessarily be confined around the core, and for a fixed volume of flow the differential pressure across the unit length of the core is maximum. Thus, as an empty core tube is progressively filled with cores, the differential pressure across the full length of the core tube progressively increases for a fixed volume of flow.

It should be noted that it is not absolutely essential that the cores be broken into short lengths inasmuch as the differential pressure required to suspend a length of cores is the same whether the length is continuous or in short segments. For a given pipe and fluid flow condition, both the weight of a length of cores and the differential pressure are directly proportional to the length of cores. If the core breaker 65 is eliminated, a core catcher should be placed above the bit to insure that the cores cut will be retained.

Secured at the upper end of the core tube as by threading, is a perforated cap 68 which permits free flow of fluid through the aperture 69 therein but restrains the cores C and large chunks thereof from moving up into the transfer chamber to clog the passageways.

In order to prevent cores from falling back down through the core tube in the event that fluid circulation is interrupted I provide a series of core dogs 70 which are placed at intervals along the core tube 54, 60 to extend through slots 71 so that in one position the upper surface thereof will support a core. One form of core dog is shown in FIGS. 2, 3 and 4 and in connection therewith, I provide an upwardly and outwardly included slide surface 72 on a bracket 74 which is welded to the outside of the core tube. The core dog itself is in the form of a triangular blade which slides up and down on the inclined face 72 and is supported thereon by depending legs 76 straddle the bracket. The dog blade is disposed so that when the blade is in the uppermost position the point of the blade is still within the slot to prevent it from being carried upwardly in the separator tube, but it is retracted from the core tube so as not to impede the ascending cores.

Attached to the upper edge of the legs 76 are horizontal vanes 78 which are positioned in the stream of the ascending fluid within the annulus outside the core tube 54, 60 so that fluid flowing upward with sufficient velocity to transport the cores react against the vanes 78 to carry the core dogs 70 upward and outward along the inclined slide 72 to the retracted position shown in FIG. 2 and in phantom in FIG. 3. When the fluid flow stops, the core dog slides back down the incline to its lowest position wherein it extends into the core tube to intercept and support any cores that might fall backward to the core tube.

In FIG. 5 I have shown a modified form of core dog 80 wherein the dog blade is pivoted at 82 to a bracket which is welded to the outside of the core tube 54, 60 and light spring 86 normally urges the dog blade 80 radially inward toward the center of the core tube to its intercepting position. A lip 88 on the dog blade engages the upper

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edge of the slot 89 to prevent the dog blade from going too far into the core tube. Vanes 90 on the dog blade are engaged by upwardly flowing fluid to rotate the dog blade clockwise to the position shown in phantom in FIG. 5, out of the path of rising cores. The dog blades 70 and 80 are also formed so that cores themselves cam them out of the path that intercepts only falling cores.

This invention has been described in connection with preferred embodiments thereof, but it is apparent that modifications and changes therein may be made by those skilled in the art without departing from the spirit and scope of this invention which is defined by the claims appended hereto.

Having described my invention I claim:

1. Core drilling apparatus comprising:

an outer pipe,

a separator tube of smaller diameter than said outer pipe secured within said outer pipe to provide a continuous downward flow passage between said outer pipe and separator tube and a continuous upward flow passage through said separator tube,

an annular drill bit secured at the lower ends of said outer pipe and separator tube adapted to cut a core in a subsurface formation of a diameter smaller than said separator tube,

a core tube secured within said separator tube, the lower end of said core tube being of a diameter only slightly greater than said core diameter and extending in close proximity to said drill bit snugly to embrace a core being cut to enable entry of said core into said core tube but to prevent entry of other drill bit cuttings,

means forming perforations in said core tube along the length thereof substantially to equalize pressure between said core tube and said separating tube,

at least one port for conducting fluid from said downward flow passage to the exterior of said drill bit, and

at least one water course formed in said drill bit to conduct fluid from the exterior thereof to the inner opening therein and thence between said core tube and said separator tube below the lower end of said core tube,

said water course being of sufficient cross-section to accommodate drill bit cuttings.

2. The core drilling apparatus defined by claim 1 wherein

the internal diameter of said core tube closely above the lower end thereof is enlarged to form a core breaking chamber,

a wedge member secured within said core breaking chamber to be engaged by a core extending upward through said lower end of the core tube and to apply bending stresses to said core to break it into lengths to be transported upward through said upward flow passage, and

said core tube above said wedge member tapering to a diameter closely accommodating severed cores, and said perforations along the length of said core tube being of a size insufficient to pass drill bit cuttings.

3. The core drilling apparatus defined by claim 1 including

means for severing a core received in said core tube into lengths to be transported upwardly by fluid flowing through said upward flow passage, and said perforations along the length of said core tube being of a size insufficient to pass drill bit cuttings.

4. The core drilling apparatus defined by claim 1 including

a cross-over sub threadedly attached to the upper end of said outer pipe,

means providing a telescopic sealed connection between the interior of said sub and the upper end of said separator tube,

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an upper chamber on said sub, means for connecting said upper chamber to a single drill pipe,

a down passageway connecting said upper chamber and said downward flow passage, and

a return passageway connecting said interior of the sub and the exterior thereof.

5. The core drilling apparatus defined by claim 1 including

a cross-over sub having threads at the upper end for connection to a single drill pipe, threads at the lower end connected to the upper end of said outer pipe

an inlet chamber at said upper end extending partially through said sub for direct communication with the interior of a single drill pipe,

a large bore at said lower end in direct communication with said outer pipe,

a coaxial smaller reduced bore at said lower end in axial alignment with said separator tube,

coupling means providing a sealed connection between said separator tube and said reduced bore,

an inlet passageway through said sub between said inlet bore and the annular space between said large and reduced bores, and

a return passageway through said sub between said reduced bore and the exterior of said sub.

6. The core drilling apparatus defined by claim 1 including

means at the upper end of said core tube blocking passage of cores therein, and

ports through said blocking means for flow of fluid there-through.

7. The core drilling apparatus defined by claim 6 including

a slot in said core tube,

a core dog mounted in said upward flow passage and movable in said slot between a first position extending into said core tube wherein it is conditioned to support a core and a second position retracted from said core tube wherein upwardly moving cores are unobstructed thereby, and

vanes on said core dog operative under action of upwardly flowing fluid impinging thereon to carry said core dog into said second position.

8. The core drilling apparatus defined by claim 1 wherein

said outer pipe comprises a series of pipe sections threadedly connected in end-to-end relationship and, said separator tube comprises a series of tubular sections slidably connected in telescopic relationship, each of said tubular sections being secured concentrically within one of said pipe sections,

and including:

means attaching each of said subular sections within one of said pipe sections in fixed axial relationship at a single location along the lengths thereof, and sealing means in the telescopic connections between separator tube sections to provide fluid tight joints over a limited range of relative axial movement.

9. The core drilling apparatus defined by claim 8 including

a cross-over sub having

threads at the upper end for connection to a single drill pipe,

threads at the lower end connected to the upper end of said outer pipe,

an inlet chamber at said one end extending partially through said sub for direct communication with the interior of said single drill pipe,

a large bore forming a transfer chamber at said lower end in direct communication with said outer pipe,

a coaxial small return bore at said lower end in axial alignment with said separator tube,

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coupling means providing a sealed connection between said separator tube and said reduced bore
 an inlet passageway through said sub between said inlet bore and the annular space between said large and return bores, and
 a return passageway through said sub between said return bore and the exterior of said sub.

10. Core drilling apparatus comprising

an outer pipe,
 a separator tube of smaller diameter than said outer pipe secured within said outer pipe and sealed therefrom to provide a continuous downward flow passage between said outer pipe and separator tube and a continuous upward flow passage through said separator tube,
 an annular drill bit secured at the lower ends of said outer pipe and separator tube adapted to cut a core in a subsurface formation,
 means for severing a core being cut by said drill bit into lengths to be transported upward by fluid flowing through said upward flow passage, and
 a core tube within said separator tube, perforations along the length of said core tube permitting fluid communication but being too small to permit passage of fluid cutting,
 the lower end of said core tube extending in close proximity to said drill bit and being of a diameter closely to embrace a core cut by said drill bit to enable entry into said core tube of said core but to prevent entry of other bit cuttings, and
 water courses extending across said drill bit and into said separator tube outside of said core tube, said water courses being of a size sufficient to accommodate cuttings.

11. Core drilling apparatus comprising

an outer pipe,
 a separator tube of smaller diameter than said outer pipe secured within said outer pipe and sealed therefrom to provide a continuous downward flow passage between said outer pipe and separator tube and a continuous upward flow passage through said separator tube,
 an annular drill bit secured at the lower ends of said outer pipe and separator tube adapted to cut a core in a subsurface formation,
 means for severing a core being cut by said drill bit into lengths to be transported upward by fluid flowing through said upward flow passage, and
 a core dog mounted in said upward flow passage and movable between a first position wherein it extends into the path of travel of core lengths so as to intercept and support a descending core and a second position out of said path of travel,
 said core dog being normally urged into said first position, and
 means responsive to upward flow of fluid to move said core dog into said second position.

12. The drilling apparatus defined by claim 11 including

an upwardly and outwardly inclined slideway in said separator tube,
 said core dog being slidably mounted on said slideway, and
 vanes extending from said dog to be engaged by upwardly flowing fluid to carry said core dog up said slideway to said second position,

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said core dog being carried into said first position by gravity.

13. The drilling apparatus defined by claim 11 including

a coaxial core tube within said separator tube,
 an upwardly and outwardly inclined slideway in the annular space between said core tube and said separator tube,
 a series of apertures in said core tube, one of said apertures forming a slot extending upwards from said slideway, said core dog being slidably mounted on said slideway to extend through said slot,
 vanes extending from said dog to be engaged by upwardly flowing fluid to carry said core dog up said slideway to said second position,
 said core dog being carried into said first position by gravity.

14. Drilling apparatus comprising:

an outer pipe,
 a separator tube of smaller diameter than said outer pipe secured within said outer pipe and sealed therefrom to provide a continuous downward flow passage between said outer pipe and separator tube and a continuous upward flow passage through said separator tube,
 an annular drill bit secured at the lower ends of said outer pipe and separator tube adapted to cut a sample from a sub-surface formation,
 a perforated sample tube within said separator tube, apertures along the length of said core tube permitting fluid communication but being too small to permit passage of fluid cuttings,
 the lower end of said sample tube extending in close proximity to said drill bit and being of a diameter closely to embrace a sample cut by said drill bits to enable entry into said sample tube of said sample but too small to permit entry of other bit cuttings, and
 water courses extending across said drill bit and into said separator tube outside of said core tube, said water courses being of a size sufficient to accommodate cuttings.

15. The drilling apparatus defined by claim 14 including:

a plurality of axially spaced apertures in said core tube,
 a plurality of core dogs mounted in said separator tube, each movable between a first position wherein they extend through one of said apertures so as to support cores above it, and a second position retracted from said core tube.

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65 CHARLES E. O'CONNELL, *Primary Examiner*.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

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It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 9, line 25, for "fluid cutting" read -- bit cutting --; column 10, line 30, for "core" read -- sample --; line 32, for "fluid" read -- bit --.

Signed and sealed this 28th day of November 1967.

(SEAL)

Attest:

Edward M. Fletcher, Jr.

Attesting Officer

EDWARD J. BRENNER

Commissioner of Patents