SLOTTED CORE LIFTER APPARATUS
12 Claims, 4 Drawing Figs.

ABSTRACT: Core barrel apparatus for drilling core from an earth formation, for receiving core as it is drilled, breaking the drilled core from the earth formation, and retaining the core as the core is retracted through the drill hole, said apparatus including a core lifter having a plurality of axially elongated circumferentially spaced slots, some of the slots opening to the top edge and others the bottom edge of the core lifter.
SLOTTED CORE LIFTER APPARATUS

BACKGROUND OF THE INVENTION

This invention relates to core drilling apparatus that has a core lifter mounted in a core lifter case for limited relative axial movement for breaking a core from an earth formation and retaining the core as the core is retracted through a drill hole.

In core drilling art, it is common to provide a drill stem having a core barrel outer tube at the inner axial end thereof with a core barrel inner tube within the outer tube for receiving the core as it is produced by the drilling operation. For purposes of breaking a drill stem from the earth formation, when the core barrel inner tube is filled, it is conventional to provide a core lifter case on the inner axial end of the core barrel inner tube, and a core lifter in the form of a small axially split ring having an exterior tapered or conical surface which bears upon a corresponding surface of the core lifter case and an interior toothed surface for gripping the core. The aforementioned type core lifter apparatus has been used both with wire line core barrel inner tube assemblies which are retractable independent of and through the drill stem, and core barrel inner tubes that are mounted in the drill stem in a manner such as disclosed in U.S. Pat. No. 2,522,399 in which the entire drill stem has to be removed from the hole in the earth formation in order to retrieve the core. In order to retrieve the core, whether it be with wire line equipment or the type in which the entire drill stem has to be retrieved, usually a substantial pulling force has to be exerted on the drill stem and thus to the core lifter apparatus in order to initially break the core after it has been drilled from the earth formation. After the core has been broken, thence the core barrel inner tube is retracted in order to retrieve the core.

SUMMARY OF THE INVENTION

According to this invention, a core lifter is mounted in a core lifter case for limited axial movement, the core lifter having circumferentially spaced, axially elongated slots and a smooth interior surface. The slotted type core lifter of this invention has a better gripping action and a longer life than conventional core lifters. Further the cost of manufacturing is lower i.e. less special tooling is required.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is illustrated with reference to the drawings wherein:

FIG. 1 is a fragmentary longitudinal cross-sectional view of the inner axial end of the drill stem and core barrel inner tube, together with core lifter apparatus attached to said inner tube;

FIG. 2 is a transverse cross-sectional view of the core lifter and core lifter case, said view generally being taken along the line and in the direction of the arrows 2-2 of FIG. 1;

FIG. 3 is a perspective view of the core lifter of this invention; and

FIG. 4 is a view of the core lifter that is generally taken along the line and in the direction of the arrows 4-4 of FIG. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENT

For purposes of facilitating the description of the invention, the term “inner” refers to the portion of the drill stem or of the assembly, or an element being described which in its position “for use” in the drill stem is located closer to core bit on the drill stem than any other portion of the apparatus being described, except where the term clearly refers to a transverse circumference, direction or diameter of the drill stem or other apparatus being described. The term “outer” refers to that portion of the drill stem, or of the assembly, or element being described which in its position “for use” in the drill stem is located closer to the mouth of the drill hole than any other portion of the apparatus being described, except where the term clearly refers to a transverse circumference, direction or diameter of the apparatus being described.

Referring now to FIG. 1, there is illustrated the inner end portion of a drill stem 11, the portion illustrated constituting a portion of what is frequently referred to as the core barrel outer tube. To the inner end of the drill stem there is threadedly connected a rotary core bit 12 that is rotated by the drill stem to drill a core. The core bit has a central aperture 13 that is provided for boring the core in an earth formation 14. Located within the drill stem in a position to receive core as it is being drilled is a core barrel inner tube assembly 15, a core lifter case generally designated 18 being threadedly connected to the inner axial end of the inner tube and a core lifter 19 slidably retained in the core lifter case. It is noted that the only portion of the core barrel inner tube assembly illustrated is the inner axial end of the inner tube the core lifter case and the core lifter; however, it is to be understood the core barrel inner tube assembly be of a wire line type that is retractable through a drill stem, the core barrel inner tube assembly disclosed in U.S. Pat. No. 2,829,868 being one example of such type; or a core barrel inner tube assembly that is not retractable independent of the drill stem, U.S. Pat. No. 2,522,399 being one example of this type.

The outer end portion 21 of the core lifter case 18 has inter threaded 18c that form a matching fit with the external threads of the core receiving tube. The case 18 has an internal annular groove or recess 20 that is located a short distance axially inwardly of the threads 18c and has an outer transverse annular edge 20a that is located in a plane normal to the central axis L-L of the core barrel inner tube interior and exterior surfaces, and the tapered surface 21, the beveled surface 24, the generally cylindrically exterior surface 18a and the conical or tapered surface 18b of the core lifter case. The recess 20 has an axial surface 20c that is centered with reference to the axis L-L and a generally annular edge 20b.

The core lifter case has an axially elongated, gradually tapered axial inner surface 23 that at its outer axial edge joins with the inner radial edge of the surface 20b and at its opposite end joins with the beveled surface 24. The taper is such that the diametric dimension adjacent surface 24 is less than that at any axial position more closely adjacent groove 20.

The core lifter case at its inner axial end has the beveled surface 24 that is of progressively increasing diameters in an axial direction toward the core bit aperture and a transverse beveled surface 18b of an angle of taper to form a mating fit with the inclined shoulder 12c of the core bit. Advantageously during the drilling operation, surface 18b is spaced relative to surface 12a such as illustrated in FIG. 1; however, it is to be understood that insofar as the invention is concerned, these surfaces may be in abutting relationship at the time core is being drilled and appropriate fluid channels provided for conducting fluid from the annular space between the drill stem and the core lifter case to aperture 13 or to the core bit face 13b.

The core lifter case mounts for axial movement relative thereto, the core lifter 19 for grippingly holding and breaking a core as the drill stem is retracted. That is, the core lifter comprises a resilient split steel ring having a smooth, cylindrically transverse inner surface 19a at that the outer end terminates at the outer edge 19b. Surface 19a extends substantially the entire axial length of the case, surface 19a at its axial inner edge intersecting the smooth transverse inner conical surface 19c which at its inner end terminates at the inner edge 19d of the core lifter. The central axis L-L of the core lifter, the inner tube and the core lifter case is equably spaced from said inner surface 19a throughout the axial length of said inner surface while the inner conical surface 19c is tapered to in an inner axial direction be progressively further axially spaced from said axial core. The core lifter 19 also has a smooth, transverse outer axial conical surface 19e that is tapered to mate with the core lifter case surface 18b that extends axially from edge 19b to edge 19d in a plane containing the central axis L-L, surfaces 19c, 19e meet at a point. Additionally, the core lifter is longitudinally split at 29 so as to
permit it to assume a shape of a smaller diameter or a larger diameter depending on whether it is moved in the core lifter case and relative thereto in an outer direction or an inner direction.

The core lifter has a plurality of equally circumferentially spaced, axially elongated slots 30 that open to the outer edge 19b. The axial edge portions 30a, 30b of each slot 30 are parallel to one another and to a diameter of the core lifter while the axial inner edge portion 30c that extends between edge portions 30a, 30b is located more than two-thirds of the axial distance from edge 19b to edge 19d. The core lifter also has a plurality of equally circumferentially spaced (other than for the most two closely circumferentially adjacent slot 29), axially elongated slots 31 that open to the inner edge 19d. The axial edge portions 31a, 31b of each slot 31 are also parallel to one another and to a diameter of the core lifter case while the axial inner edge portion 31c that extends between edge portions 31a, 31b is located more than two-thirds of the axial distance from edge 19d to edge 19b. In any plane perpendicular to the core lifter axis that passes through both sets of slots 30, 31 circumferentially spacing of one slot 31 from the adjacent slot 30 on each side thereof is two slots 30 that are circumferentially on either side of slot 29 are equally spaced therefrom.

The general radius of curvature R of the cylindrical inner surface 19a of the core lifter, when the core lifter abuts against edge 20b, or abuts against a stop ring (not shown) if such is provided in recess 20 as disclosed in U.S. Pat. No. 3,340,939, is substantially the same as the inner radius of inner tube surface 17a.

The structure of the apparatus of this invention having been described, the use thereof will now be set forth. For purposes of facilitating description of operation of the apparatus of this invention, it will be assumed that the drill stem is extended into a hole in an earth formation in a generally downward direction even though the use of the and the core drilling operation is not limited to drilling in a downward direction, and a core barrel inner tube assembly is located in the drill stem in a position to receive core as it is being drilled. Normally, at this time, the core lifter case is a substantial distance axially inwardly of recess 20 such as illustrated in FIG. 1. Now the drill stem is moved axially inwardly to have the core bit face 13b abut against the annular groove in the earth formation and the core drilling operation is started whereby the cutting of core is begun. Because of the annular shape of the core bit, an ever deepening hole is cut with a rod like core being produced. As the drilling continues, the drill stem, including the core bit, move relative to the core whereby the core extends through the core bit aperture and thence into the core lifter case to abut against the adjacent surface of the core lifter. As the axial length of the core increases, the core lifter case moves relative the core lifter until the core lifter abuts against the annular edge 17b of the inner tube (if no stop ring is provided, or if a stop ring is provided in recess 20 against the stop ring). Thereafter, the core lifter case, the core lifter and the core receiving tube together move axially as a unit relative the core. In this connection, it is to be mentioned that in both conventional core drilling apparatus particularly of the type for deep hole drilling, a core barrel inner tube assembly is connected to a swivel so that the rotary motion of the drill stem is not imparted to the core barrel inner tube but rather the inner tube and core lifter case usually only move axially relative the core as the drill stem is rotated.

When a high pressure signal is provided at the surface through conventional structure, the drilling is stopped and the drill stem is pulled outwardly a short distance. Pulling the drill stem outwardly results in the drill stem moving axially outwardly relative the core lifter case until surface 12a abuts against surface 18b, provided appropriate conventional type of core drilling apparatus is used whereby the core lifter case is normally retained out of contact with the core bit. Assuming the core lifter case is movable relative the drill stem in the above manner, after surfaces 12a, 18b are in abutting relationship, further axially outward movement of the drill stem results in the core lifter case moving axially relative the core and the core lifter whereby through the drag of the core lifter on the core, the core lifter 19 is further axially spaced from groove 20 and is transversely compressed (due to tapered surfaces 23, 19e) to grippingly hold the core and break the core. After the core has been broken, either the core barrel inner tube assembly is retracted relative the drill stem, or both the drill stem and core barrel inner tube assembly are retracted, depending upon the type of core drilling apparatus being used.

As an example of one embodiment of the invention, but not otherwise as a limitation in the invention, the following dimensions are given. The outside diameter for surface 19a at edge 19b is approximately 1.58 inches, and at edge 19d is approximately 1.49 inches. The inside diameter for surface 19a is approximately 1.42 inches. The length X of the core lifter as measured along axis L-L is one inch while the corresponding length of surface 19c is three sixty-fourths of an inch. The spacing W of the most adjacent portion of edge portion 30c from edge 19d is approximately 0.250 inch while the spacing Z of the most adjacent portion of edge portion 31c from edge 19b is approximately .187 inch. The circumferential dimension C between each of edge portions 30a and 30b, and edge portions 31a and 31b, for each of the respective slots is, in a core lifter relaxed condition, approximately .094 inch. The circumferentially spacing of the edges defining slot 29 in a core lifter relaxed condition is approximately .125 inch.

1. Claim: For an axially elongated core receiving tube, core lifter apparatus comprising a core lifter case connected to one axial end of said core receiving tube to extend axially away therefrom, said core lifter case having a radially outer surface, a gradually tapered radially inner surface portion that diverges in a direction toward said core receiving tube, said outer surface and tapered inner surface portion each having a central axis and a plurality of axially elongated circumferentially spaced slots opening to said opposite edge that extends axially to terminate intermediate said edges.

2. The apparatus of claim 1 further characterized in that said slots extend more than two-thirds of the distance from said opposite edge to said annular edge.

3. The apparatus of claim 1 further characterized in that said core lifter has a second plurality of axially elongated, circumferentially spaced slots opening to said first annular edge and terminating axially intermediate said edges.

4. The apparatus of claim 3 further characterized in that each of the second slots is circumferentially offset from the first slots.

5. The apparatus of claim 3 further characterized in that each slot is of an axial length that is substantially greater than one-half of the axial length of the core lifter.

6. The apparatus of claim 5 further characterized in that the core lifter exterior surface is of a constant taper from the first annular edge to the opposite edge and that the core lifter has a cylindrical transverse inner surface that extends axially from the first annular edge to axially adjacent the opposite edge.

7. For an axially elongated core receiving tube, core lifter apparatus comprising an axially core lifter case having an end portion connectable to one end of said tube, a radially outer surface and a transversely inner conical surface portion of a generally cylindrical inner surface that is of a smooth continu-
5. Ous curvature for at least a major portion of the axial length of the core lifter, a first annular edge, an opposite second annular edge, and a plurality of circumferentially spaced, axially elongated slots opening to the first annular edge.

8. The apparatus of claim 7 further characterized in that said core lifter has a second plurality of circumferentially spaced, axially elongated slots opening to the second annular edge.

9. The apparatus of claim 8 further characterized in that each of said slots is of an axial length that is more than one-half the axial length of the core lifter.

10. The apparatus of claim 8 further characterized in that said core lifter is an axially split steel ring.

11. The apparatus of claim 8 further characterized in that the core lifter has a central axis and that the core lifter interior surface has a substantially constant radius curvature throughout substantially its entire axial length.

12. The apparatus of claim 8 further characterized in that said core lifter case end portion is threaded and that the core lifter has at least six slots.