APPARATUS FOR DRILLING AND RECOVERING SIDE WALL CORES

John A. Zublin, Los Angeles, Calif.

Application August 23, 1948, Serial No. 45,752

5 Claims. (Cl. 255—1.4)

1. This invention relates to improved apparatus for drilling and recovering side wall cores. Much valuable information regarding the nature of the formations traversed by a well bore can be obtained by taking cores from those formations. The axis of a well bore is substantially vertical and it is desirable for the side wall core to be taken in a direction as nearly horizontal as possible. It is not possible in actual practice to drill and recover a core the axis of which extends horizontally or at a right angle to the axis of the well bore. Limitations of apparatus herefore used have permitted the taking of side wall cores having an axis extending downwardly and outwardly from the axis of the well bore at an angle not greater than about 25 to 30 degrees. Such cores do not extend far enough laterally into the formation surrounding the well bore to give accurate information regarding the nature of the formation and as a matter of fact such cores often consist mostly of rotary drill mud which has been deposited on the walls of the well bore.

Side wall coring apparatus generally consists of some type of flexible core barrel which extends through the drill pipe and a deflector positioned in the drill pipe for deflecting the core head laterally toward the side wall of the well bore. The core barrel must be raised and lowered through the interior of the drill pipe and this requirement limits the maximum outside diameter of the core barrel to less than the smallest inside diameter of the drill pipe, which usually occurs at the joints. A core of large diameter is most desirable from a geological standpoint. Most of the prior art core barrels have provided for the circulation of drilling fluid through the core barrel to the bottom of the core hole for the purpose of removing cuttings from the core hole and this provision of means for circulating fluid coupled with the limitation on the maximum diameter of the core barrel has resulted in obtaining cores of diameters which are too small to be of great geological value. Roller type core heads have heretofore been used for drilling hard formations and the use of rollers has further limited the diameter of the cores which could be obtained.

The core barrel must be flexible so that it can be deflected from the vertical axis of the well bore into the formation surrounding the well bore. This flexibility of the core barrel has made it difficult to drill a straight core hole extending at the desired angle from the axis of the well bore. This disadvantage has been a serious one in those instances where the operator has desired to orient the cores in order to obtain an indication of the angle and the direction of any dip of the underground strata under consideration. In such core orientation, a method has been developed in which several side wall cores are taken at the same depth in the well bore but in different oriented directions. If three side wall cores are taken 120 degrees apart, they may be removed from the well and set up on a table in the relative positions which they occupied within the formation. The cores will then indicate by their structure the angle and the direction of any dip in the underground strata from which they were taken. The accuracy and dependability of the information thus obtained is dependent however on the straightness of the core holes from which the cores were obtained and is particularly dependent on the uniformity and accuracy of the angles which the core holes make with the axis of the well bore.

One of the important objects of the present invention is to provide apparatus for side wall coring which is capable of taking a core by drilling a core hole which extends at a substantial angle from the vertical axis of the well bore. With my apparatus I am able to make the angle between the axis of the core hole and the vertical axis of the well bore at least 35 degrees and I have successfully increased this angle to 45 degrees.

Another important object of the invention is to provide side wall coring apparatus which is capable of obtaining a core of a larger diameter than has heretofore been considered possible.

A further object of the invention is to provide side wall coring apparatus which eliminates the need for fluid circulation into and out of the core hole.

Still another object of the invention is to provide apparatus which is capable of drilling core holes in all types of formations and which is capable of recovering both hard and soft cores.

An important object of the invention is to provide apparatus which is capable of drilling side wall core holes which are not only straight but which are of greater depth than has heretofore been considered possible. The drilling of deeper core holes makes it possible to obtain longer cores.

Another object of the invention is to provide side wall coring apparatus which includes a
coring head which will readily penetrate the wall of the well bore at the desired location and which is self-centering so that it has no tendency to depart from a straight line as the drilling of the core hole proceeds.

Another object of the invention is to provide side wall coring apparatus which utilizes the cuttings from the core hole to assist in retaining the core within the well barrel.

Other objects and advantages of the invention will be referred to in the following detailed description of exemplary forms of the invention. This detailed description has reference to the accompanying drawings wherein:

Figure 1 is a view partly in section and partly in side elevation illustrating my improved side wall coring apparatus positioned within a well bore.

Figure 2 is a side-elevation view of the deflector portion of the apparatus shown in Figure 1;

Figure 3 is a sectional view taken in the direction of the arrows along the line 3-3 of Figure 1;

Figure 4 is a sectional view taken in the direction of the arrows along the line 4-4 of Figure 1;

Figure 5 is a side elevation view of a portion of the flexible core barrel;

Figure 6 is a longitudinal-sectional view of the lower end of the flexible core barrel and its associated coring head positioned in a core hole and showing the core being produced;

Figure 7 is a view similar to Figure 6 but illustrates a modified form of the invention;

Figure 8 is a fragmentary view of the trailing edge of one of the teeth on the coring head; and

Figure 9 is a fragmentary view showing the configuration of the cutting teeth in side-elevation, this view showing the inner face of two of the teeth.

A well bore is designated by the reference numeral 10. The deflector portion of the apparatus is designated generally by the reference numeral 11. Threads 12 are positioned in an upper collar 13 which has its lower side surfaces flattened as indicated at 14. Heavy steel plates 15 and 16 are welded to the flat faces 14 of the collar 13. These plates extend downwardly in parallel relationship and have their lower ends welded to the flat faces 17 of a lower collar 18. The plates 15 and 16 may be secured to the collars 13 and 18 by drilling holes 19 in the plates and depositing welding material in those holes. This welding material is indicated by the reference numeral 20 in Figure 4.

The upper collar 13 has a central longitudinal passage-way 21 extending therethrough. A guide and deflector tube 22 is secured between the plates 15 and 16 by having its outer surface welded to those plates as indicated at 23. The upper end of the tubular guide and deflector 22 abuts the lower end of the upper collar 13. The passageway through the tubular member 22 is in alignment with the passage 21 through the collar 13. The passage 21 and the upper end of the tubular member 22 are centrally positioned within the well bore and are retained in such position by the edges of the plates 15 and 16. The tubular guide and deflector member 22 has a double or reverse curvature. As is most clearly shown in Figure 1, this member curves toward the wall of the well bore then curves in the opposite direction toward the diametrically opposite wall of the well bore. This double or reverse curvature permits the flexible core barrel to enter the formation at a greater angle to the axis of the well bore than would otherwise be possible.

The deflector member 22 is preferably a seamless tube of high grade alloy steel which has been heat treated to maximum hardness. The plates 15 and 16 may be of heavy boiler plates of a character which provides maximum strength and toughness.

The flexible core barrel is designated generally by the reference numeral 24. This core barrel is similar to the flexible drill pipe described and claimed in my pending application Serial No. 35,097 filed May 4, 1948, entitled "Heavy Duty Flexible Drill Pipe" now Patent No. 2,515,266. It consists essentially of a plurality of short tubular links loosely joined together by interengaging and interlocking teeth of dovetail configuration. The arrangement is best illustrated in Figure 5 and a description of two cooperating links will be sufficient. The short tubular link 25 is provided with diametrically opposed teeth 26 of dovetail configuration. These teeth 26 loosely interengage and interlock complementarily shaped recesses 27 of dovetail configuration in the tubular link 28. The tubular link 28 is provided with diametrically opposed teeth 29 of dovetail configuration which loosely interengage and interlock recesses in the next adjacent tubular links. The links and their cooperating teeth and recesses are so proportioned that limited relative axial, radial, and rotational movement is permitted between each link. The links are not, however, capable of being completely separated from each other. This arrangement provides an extremely rugged core barrel of great flexibility. The flexibility of the core barrel permits it to follow the curved path assumed by the deflector member 22 and permits the core barrel to enter the formation surrounding the well bore at an angle as great as 40 degrees or more to the vertical axis of the well bore. The outer surface of the core barrel is provided with a helical groove 30 for purposes which are hereinafter described.

An important feature of the core barrel 24 is its inherent tendency to assume a straight configuration when subjected to compressive stresses. This tendency is of great importance because it overcomes the difficulties which have heretofore been encountered in efforts to drill core holes which are straight. This feature of the invention is discussed in greater detail hereinafter.

The deflector portion 11 does not rotate during operation of the apparatus. The upper end of the core barrel 24 is secured to the drill pipe and is rotated thereby. The deflector portion is supported by suitable swivel means between the drill pipe and the deflector portion which permits the drill pipe and the core barrel 24 to rotate while the deflector portion 11 remains stationary. One form of suitable swivel means is shown in my co-pending application Serial No. 769,954 filed August 21, 1947, now abandoned, entitled "Apparatus for Drilling Deviating Bores from an Existing Well Bore." The reaction to pressure of the coring head against the wall of the well bore forces the remote edges of the plates 15 and 16 against the opposite wall of the well bore and prevents rotation of the deflector portion during initial starting of the core hole. As soon as the coring head and the core barrel have entered the core hole the deflector portion is prevented from rotating by the core barrel.
The coring head is designated generally by the reference numeral 31. In the form of the invention illustrated in Figure 6 this coring head is in the form of a drag type bit of novel construction. This bit 32 is screw threaded at 33 to the lowermost link 34 of the flexible core barrel. A portion of this link 33 is clamped between the bit 32 and the link 34.

The configuration of the cutting teeth on the bit 32 is best illustrated in Figures 6, 8, and 9. The cutting edges 36 converge downwardly and inwardly at angles of approximately 36 degrees to the longitudinal axis of the bit and terminate in points 37. The outer peripheral surfaces 38 of the teeth lie in a circle which has a diameter equal to the maximum outside diameter of the core barrel. The inner peripheral surfaces 39 lie in a circle which has a diameter approximately equal to the diameter of the core 40 which is cut by the bit.

The teeth curve upwardly and outwardly at 41 to provide an annular space between the core 40 and the inner surface of the body of the bit 32. This annular space is designated in Figure 6 by the reference numeral 42. The upper ends 43 of the notches between the teeth provide passages through which loose cuttings may find access to the annular space 42. I have found that the loose cuttings entering the annular space 42 will work their way upwardly through this annular space between the outer surface of the core 40 and the inner periphery of the core barrel 24, and will become tightly packed. This packing of the loose cuttings around the core greatly assists the core catcher 50 in retaining the core within the core barrel when the apparatus is withdrawn from the well. This packing of the loose cuttings around the core also enables me to use the same core catcher 35 irrespective of whether the core is being taken from a hard or a soft formation.

The cutting teeth on the bit 32 converge upwardly and inwardly at 44 to provide an annular space 45 between the outer surface of the body of the bit 32 and the walls of the core hole. This annular space 45 is in communication with the lower end of the helical groove 30 on the outer surface of the core barrel 24. Loose cuttings will therefore be able to enter this groove 30 and will be carried upwardly by the helical groove 30 during rotation of the core barrel. When power is being transmitted through the core barrel 24 to rotate the bit 32, the loose connection between the tubular links of the core barrel creates gaps 46 between the dovetail teeth and the cooperating recesses on the tubular links. Certain of the gaps 46 lie in the helical groove 30. These gaps thus provide additional passages through which loose cuttings being conveyed upwardly in the helical groove 30 may find access to the interior of the core barrel. The loose cuttings thus introduced into the interior of the core barrel also accumulate and pack around the core 40 and assist in retaining the core within the core barrel during withdrawal of the apparatus from the well.

The helical groove 30 about the outer surface of the core barrel 24 is disposed along the periphery by which well fluids may seep to the bottom of the core hole. These well fluids serve to cool and to lubricate the bit 32.

The form of the invention illustrated in Figure 7 differs from the arrangement shown in Figure 6 primarily in the provision of a core retaining bag within the core barrel. The bit 32 has teeth similar to those on the bit 32 and is screw threaded to the lowermost link 48 of the core barrel as indicated at 49. A core catcher 50 and a ring 51 at the open end of the core receiving bag 52 are clamped between the bit 41 and the link 48. The core receiving bag 52 may be of rubber or rubberized fabric which is impermeable to liquids and it has an open end secured to a flange 53 on the ring 51 by any suitable means such as rivets 54. A ball check valve 55 in the upper closed end of the bag 52 permits fluid to escape from the bag as the core enters the bag but prevent flow of fluid in the opposite direction.

My invention makes it possible to obtain a core of substantial length and of substantial diameter from a core hole which has been drilled in a straight line at a desired angle from the vertical axis of the well bore. The core head 31 is very short and the tubular links which constitute the core barrel are also very short. It is thus possible for the core head and the core barrel to be deflected by the deflector member 22 in a curve which has a small radius and this permits a core hole to be drilled at an angle to the axis of the well bore much greater than has heretofore been possible. The configuration of the cutting teeth on the core head 31 makes the core head self-centering so that the core head penetrates the wall of the well bore at the prescribed location and has no tendency to depart from a straight line once it has entered the formation surrounding the well bore. The short core head and the short tubular links of the core barrel have an inherent tendency to assume a straight configuration when compressive stresses necessary for proper drilling are applied. This tendency, in combination with the self-centering character of the coring head, cause the coring head to follow a straight line from the point at which it enters the formation to the bottom of the core hole. It is thus possible to obtain cores of maximum length which are straight and which are taken from core holes extending at the desired angle to the axis of the well bore.

It will be apparent that the cores obtained with my apparatus will be several times as long as the core head 31 or the individual tubular links of the core barrel. It also be apparent that the core will be broken into several short sections when the core barrel and the core head are withdrawn from the core hole and pulled through the deflector member 22 to the surface of the well. These clean breaks in the core do not reduce its value for the reason that geologists customarily break cores into small sections.

The use of the drag type bit and the absence of any need for fluid circulation within the core hole enable me to obtain cores of substantially greater diameter than has heretofore been considered possible in side-well coring operations.

The core holes which remain in the formation after the cores have been removed form drain holes from the oil bearing formation to the well bore. These core holes also provide convenient openings into the formation for the insertion of apparatus for drilling extensions of the core holes for hydraulic fracturing and the like.

The forms of the invention which have been specifically illustrated and described are to be considered as exemplary only. Various modifications of the invention may be resorted to without departing from its broader scope as defined by the following claims.

Having thus described my invention I claim:

1. In apparatus for side wall coring a flexible
core barrel, a deflector member having a reverse curvature for deflecting said core barrel from approximately the axis of a well bore toward the wall of the well bore and thence toward the diametrically opposite wall of the well bore at a substantial angle to the axis of the well bore, said core barrel comprising a plurality of tubular links loosely connected at their ends by means of interlocking teeth of dovetail configuration in a manner to permit relative movement between the ends of connected links to provide flexibility of said core barrel and to cause said core barrel to assume a rigid, straight configuration when compressive stresses are applied thereto, a coring bit on the lower end of said core barrel, said bit having cutting teeth the outer surfaces of which taper inwardly toward the tips thereof to give said bit a self-centering action and a tendency to cut a straight core hole at said substantial angle to the axis of the well bore, said core bit being constructed to cut a core of less diameter than the inside diameter of said core barrel and to permit cuttings from the formation to be delivered to the annular space between said core barrel and said deflector.

2. Apparatus as described in claim 1 in which the outer surface of said core barrel is provided with a groove extending helically around and along said core barrel to convey loose cuttings from the bottom of the core hole to the well bore.

3. Apparatus as described in claim 1 in which the outer surface of said core barrel is provided with a groove extending helically around and along said core barrel for conveying loose cuttings from the core hole and there being open spaces between the interlocking teeth on said tubular links of said core barrel to permit loose cuttings being conveyed in said groove to enter the core barrel and to accumulate between the inner wall of the core barrel and the periphery of the core being cut.

4. Apparatus as described in claim 1 in which a flexible liquid impervious core receiving bag is positioned within said core barrel with the open mouth of the bag being secured adjacent the axial passage through said coring bit.

5. In apparatus for side wall coring, a deflector comprising a pair of substantially parallel plates adapted to be lowered longitudinally into a well bore, a continuous tubular deflector tube secured between said plates, said tubular deflector tube having its upper end positioned to be held at approximately the center of a well bore by said plates, an intermediate portion of said tube curving toward a wall of the well bore, and the lower portion of said tube curving toward the opposite wall of the well bore at a substantial angle to the axis of the well bore, and means for securing the upper end of said deflector to a string of drill pipe.

JOHN A. ZUBLIN.

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