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APPARATUS FOR DRILLING ORIENTED DRAIN HOLES

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3 Sheets-Sheet 1

Fig. 1.

Fig. 2.

Fig. 3.

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APPARATUS FOR DRILLING ORIENTED DRAIN HOLES

Fig. 4.

Fig. 5.

Fig. 6.

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This invention relates to apparatus for drilling individually oriented bores which deviate from an existing well bore into the surrounding oil sand or other formation. The invention is more particularly concerned with apparatus for drilling drain holes into the oil sand surrounding an existing well bore.

Laterally extending drain holes are advantageous for the purpose of increasing the recovery of oil from a well. The drain holes extend laterally into the surrounding oil sand and provide channels of low resistance to flow through which the oil within the sand can travel to the well bore where it may be recovered. Proper and symmetrical drainage of oil from an oil sand into a well bore is possible only when the azimuth of the drain holes is carefully controlled. Conditions sometimes exist which make it advisable to increase the drainage from the oil sand within a specific sector and this is possible only by carefully selecting the azimuth of the drain holes.

It is not broadly new to provide apparatus for drilling bores which deviate laterally from an existing well bore. I have heretofore suggested the use of a normally curved, flexible, resilient drill pipe immediately above the drilling bit to cause the drilling bit to be deflected laterally from an existing well bore. The purpose and nature of this normally curved drill pipe make its rotation impractical during drilling and with such apparatus it is necessary to provide some independent means for rotating the bit. Turbine bits which are caused to rotate by circulation of the drilling mud are available but the characteristics of modern weighted drilling muds make them unsuitable or unsatisfactory for driving turbine bits. Certain alternative forms of apparatus described in my patents above mentioned involve the use of a flexible tubing or hose within the normally curved drill pipe for conveying the drilling mud and for rotating the drilling bit. The power which can be transmitted through a flexible tubing such as rubber or reinforced rubber is limited. Neither of these forms of apparatus provide means for orienting the apparatus to cause a drain hole to be drilled in the desired azimuth.

It is a primary object of this invention to overcome the foregoing and other deficiencies in the apparatus which has heretofore been available. Another object of the invention is to provide a simple and effective means for orienting the apparatus within the well bore to permit a drain hole to be drilled in the desired azimuth. Still another object of the invention is to provide apparatus for drilling drain holes which can be used in accordance with existing and conventional drilling practices. Further objects and advantages of the invention are discussed in the following detailed description of an exemplary form of my invention. This description has reference to the accompanying drawings wherein:

Figure 1 is a vertical sectional view of a well bore which diagrammatically illustrates my apparatus in position therein;

Figure 2 is a fragmentary view showing the lower portion of my apparatus in position in a well bore;

Figure 3 is a transverse sectional view looking in the direction of the arrows along the line 3-3 of Figure 2;

Figure 4 is a longitudinal sectional view of a part of the upper portion of the apparatus illustrated in Figure 1;

Figure 5 is a fragmentary view partly in section and partly in side elevation of one of the joints in the portion of the apparatus illustrated in Figure 4;

Figure 6 is a longitudinal sectional view of the central portion of the apparatus illustrated in Figure 1, showing the clutch assembly in disengaged position;

Figure 7 is a view partly in longitudinal section and partly in side elevation of the central portion of the apparatus illustrated in Figure 1 and showing the clutch assembly in engaged position;

Figure 8 is a longitudinal sectional view of the lower portion of the apparatus illustrated in Figure 1; and

Figure 9 is a perspective view of two elements which constitute the clutch assembly.

I have illustrated a drilling bit 10 which is preferably of a conventional cone type having cones 11 and 12 mounted for rotation on intersecting axes in a manner well understood in the well drilling art. The bit 10 is threadedly connected at 13 to a collar 14 having an upwardly extending hollow stem 15. The hollow stem 15 of the collar 14 is rotatably mounted in the lower end of a normally curved, flexible, resilient, deflector pipe 16 which is described in greater detail hereinafter. Ball bearings 17 are arranged to receive both radial and thrust loads in the manner best illustrated in Figure 8 and roller bearings 18 receive some of the radial forces. The hollow stem 15 is prevented from being withdrawn from the lower end of the deflector pipe 16 by means of thrust ball bearings 19 positioned between the upper end of bearing member 20 and
bearing race 21 which is screw-threaded at 22 to the upper end of the hollow spindle 15. The normally curved, flexible, resilient deflector pipe 16 is illustrated as being of the type shown in Figure 3 of my prior U. S. Patent No. 2,515,366. This deflector pipe consists of a tubular metal pipe having a slot through its walls extending in a generally helical path along and around the pipe. However, the slot deviates from a true helical path to provide along its sides intermeshing and interlocking teeth of dovetail configuration. The surfaces of the intermeshing and interlocking teeth are separated by the normal width of the slot while the pipe is in its normal unthreaded configuration and the pipe is flexible within the limit of deformation permitted by the width of the slot. The faces of the teeth engage when the pipe is deformed a predetermined extent in any direction and thus limit the amount of deformation. The generally helically extending slot is designated by the reference numeral 23 and the loosely intermeshing and interlocking teeth are designated by the reference numeral 24. The deflector pipe 16 has a normal configuration which is curved. In its normal unthreaded condition, the deflector pipe has a curvature approximately equal to the curvature at which the drain hole to be drilled is to deviate from the existing vertical well bore. The approximate path of such a drain hole is illustrated in Figure 1 and is designated by the reference numeral 25.

At its upper end the deflector pipe 16 is provided with a bearing race 26. The hollow spindle 21 of a coupling member 28 is mounted for rotational as well as limited longitudinal movement within the bearing race 26. Ball bearings 29 assume both radial and thrust loads during normal drilling of a drain hole and roller bearings 30 are arranged to assume a part of the radial load.

The coupling member 28 is threadedly connected at 31 to the lower collar 32 of a flexible drill pipe 33. This flexible drill pipe 33 embodies the essential features of the flexible drill pipe illustrated and described in my prior U. S. Patent 2,515,366. The flexible drill pipe comprises a pipe having generally circumferential slots through its walls along its length. The slots divide the pipe into sections. The slots are not truly circumferential in that they deviate from a true circumference to define the edges of loosely inter-engaging and intermeshing teeth of dovetail configuration. The dimensions and configuration of the teeth are such as to prevent separation of the sections by relative movement in any direction. The flexible drill pipe shown in my above mentioned Patent 2,515,366 is formed by cutting the slots through the walls of an initially unlivered pipe. The flexible drill pipe shown in the present application consists of a plurality of relatively thick-walled sections 34 of hardened steel joined by relatively thin-walled sections 35. The relatively thick-walled sections 34 have the slots cut therein to form the loosely intermeshing and inter-engaging teeth 37. The sections 34 and 35 are joined by welded seams 38 as best illustrated in Figures 4 and 5. This arrangement facilitates manufacture of the flexible drill pipe and reduces the weight for a drill pipe of a given length and sturdiness.

The uppermost slotted section of the flexible drill pipe 33 is designated by the reference numeral 39 and a threaded connector member 40 is secured thereto by means of welding material 41. The connector member 40 is threadedly connected at 42 to a collar 43 which is in turn rigidly connected to a rigid drill pipe 44 which extends to the top of the well.

Referring again to the lower end of the apparatus as illustrated in Figure 8, it will be seen that a flexible drive member 45 has its lower end threaded to connect 46 to the upper end of the tubular stem 15. The drive member 45 is a flexible tubular member similar to that described in my above mentioned Patent 2,515,366 and to the flexible drill pipe 33 described above. It consists of a plurality of tubular sections or links in end-to-end relationship which are loosely and flexibly connected together by means of inter-engaging and interlocking teeth of dovetail configuration. Figure 8 illustrates one of the tubular sections or links 47 connected to a similar section 48 by means of teeth of dovetail configuration formed by the slot 49 which is similar to the slots 34 in the flexible drill pipe 33. Roller bearings 50 may be provided to reduce friction between the interior surface of the deflector pipe 16 and the exterior surface of the drive member 45 when that drive member is rotating relative to the deflector pipe in such a manner that it can rotate within the deflector pipe 16 while that deflector pipe is in its normally curved condition. The flexibility of the drive member 45 results from the loosely inter-engaging and interlocking teeth between adjacent sections and no deformation of the metal of the sections is necessary.

The width of the slot 45 between sections of the drive member 45 permits considerable alteration in the overall length of the drive member. The drive member 45 will be considerably longer when it is subjected to tension than when it is exposed to compressive stresses. This characteristic of the drive member 45 is important to the functioning of the clutch assembly hereinafter described by which rotation of the deflector pipe 16 within the well bore is effected to secure proper orientation of the apparatus to drill a drain hole in the desired azimuth.

The bearing race 26 at the upper end of the deflector pipe 16 is provided at its lower edge with a single large tooth 51 of generally semi-circular configuration. The tooth 51 always remains stationary with respect to the upper end of the deflector pipe. The uppermost section 52 of the drive member 45 carries at its upper edge a tooth 53 which is complementary in form to the tooth 51. This uppermost section 52 of the drive member 45 is threadedly connected at 54 to the lower end of the hollow stem 27 of the coupling member 28. The tooth 53 is therefore stationary relative to the coupling member 28. It has been pointed out above that the coupling member 28 is free to move longitudinally within the bearing race 26 at the upper end of the deflector pipe 16. It will be apparent from this description that upward movement of the hollow stem 27 and the uppermost section 52 of the drive member 45 relative to the upper end of the deflector pipe 16 will cause the teeth 51 and 53 to engage in the manner illustrated in Figure 7. Downward movement of the stem 27 and section 52 relative to the upper end of the deflector pipe 16 will cause the teeth 51 and 53 to disengage and to occupy the positions illustrated in Figure 6. The engagement and disengagement of the teeth 51 and 53 is accomplished by raising and lowering the drill pipe 44 which extends to the
top of the well. The ability of the drive member 5 to assume different lengths permits engagement and disengagement of the teeth 51 and 52 in spite of the fact that the drive member is secured to the deflector pipe 15 at the lower end therefrom.

A central longitudinal passageway extends through all portions of the apparatus for conducting drilling mud through the apparatus to the drilling bit 16. The flexible drill pipe 33 is provided with a longitudinally extending flexible hose 55 of reinforced rubber or other suitable material. The upper end of the hose 55 is secured by means of rivets 53 to a coupling member 57 which in turn is screw-threaded to the lower end of the connector member 60. The lower end of the hose 55 is secured by means of rivets 58 to the upper portion of the coupling 32. The hose 55 prevents loss of drilling mud through the slots 36 in the walls of the flexible drill pipe 33. A similar flexible hose 65 extends through the interior of the flexible drive member 45. The upper end of the hose 66 is secured by means of rivets 61 to the uppermost section 62 of the drive member. The lower end of the hose 66 is secured by means of rivets 61 to the lowermost section 62 of the drive member 45. The hose 55 prevents loss of drilling mud through the slots in the walls of the drive member 45 and of the deflector pipe 15.

In the operation of the device the deflector pipe 15 is forcibly straightened sufficiently to enable the entire apparatus to be lowered into an existing vertical well bore 63. Energy is thus stored in the resilient deflector pipe 15 and the drilling bit 16 will exert lateral pressure on the wall of the well bore as indicated by the arrow P in Figure 2. The apparatus is illustrated in Figure 1 as having advanced in the initiation of the drilling of the curved bore to the point A.

By reference to Figure 3 it will be seen that when the apparatus is in the position there shown the drilling bit 16, when rotated without rotation of the deflector pipe, will drill a bore which deviates laterally from the well bore 53 in the plane of this. This rotation of the drilling bit 16 can be accomplished merely by rotating the drill pipe 44 at the surface of the well while the clutch is disengaged. However it will usually be found that when the apparatus is lowered into the well it will not be properly oriented to drill the drain hole in the desired azimuth. For example the apparatus may be oriented to drill a drain hole deviating from the well bore in the plane x—x but it may be desired to drill the drain hole in the plane y—y. It will be apparent that the operator must ascertain the existing orientation of the apparatus and must then compute the extent of rotation of the deflector pipe 15 which will be required to orient the apparatus for drilling a drain hole in the desired azimuth.

Several types of orientation determining apparatus are available which can be lowered into the well. Any of these various types of orientation determining devices are suitable and it will be assumed that such a device is used to determine the direction of the line f—f which extends through fixed points on the lower portion of the deflector pipe 15. Let it be assumed that the line f—f extends in the direction indicated in Figure 3 when the apparatus is positioned as there indicated. The angle b between the line f—f and the plane x—x remains constant in the apparatus and the value of this angle is known to the operator before the apparatus is inserted in the well. Upon removal of the orientation determining device from the well the operator can compute that the plane x—y lies at an angle a (assumed to be 45° in Figure 3) from the plane y—y in which it is desired to drill the drain hole. From this information it will be apparent to the operator that the deflector pipe must be rotated in one direction through an angle of 45° or in the opposite direction through an angle of 315° to secure the desired orientation. This rotation of the deflector pipe 16 can be accomplished by raising the drill pipe 44 at the surface of the well a distance sufficient to cause engagement of the teeth 51 and 52 of the clutch. The drill pipe can then be rotated at the surface of the well in a direction and to an extent sufficient to orient the apparatus for drilling a drain hole in the desired azimuth.

The flexible drill pipe 33 is capable of assuming different lengths because of the nature of the loosely interengaging and interlocking teeth which join the sections thereof. The nature of these teeth also permit limited relative rotation between sections of the pipe. However when tension is applied to the flexible drill pipe, as is done to cause the clutch to engage, the flexible drill pipe assumes a definite and fixed minimum length and the possibility of relative rotation of the sections is eliminated. This is due to the fact that the tension on the flexible drill pipe causes the surfaces of the teeth to engage in definite and fixed relative positions. This characteristic of the flexible drill pipe 33 makes it important that tension be applied in an amount sufficient to engage the clutch and to assure that the sections of the flexible drill pipe have assumed their fixed relative positions before the orientation determinations and computations are made. It is not essential, but I consider it advisable to combine the tension in the drill pipe with a limited amount of rotation to make certain that all of the inter-engaging teeth between sections of the flexible drill pipe 33 are tightly pressed against each other and to make certain that the deflector pipe 15 is in a well defined oriented position relative to the conventional rigid drill pipe 44 above the flexible drill pipe 33. When the orientation determinations and computations have been made the orientation of the apparatus to drill in the desired azimuth may be done by rotating the entire apparatus including the deflector pipe while the clutch is engaged. If the tension applied to the drill pipe has been accompanied by limited rotation in a clockwise direction before the orientation determinations have been made, the orienting movement of the apparatus should also be in a clockwise direction.

As soon as the apparatus has been properly oriented the tension may be released from the drill pipe and the pipe lowered at the surface of the well to disengage the clutch and to apply drilling pressure to the bit 18 while the deflector tube 16 remains stationary. When the clutch is disengaged, the deflector pipe 16 is held against rotation by frictional engagement with the wall of the vertical bore and, due to its resiliency, forces the bit 18 into engagement with the wall of the bore at the oriented position. The bit 18, of course, rotates about the center of the lower end of the tube 16 as its axis and thus penetrates into the formation at the preselected point. It follows that when the clutch is disengaged and the drill pipe is rotated from the surface of the well the bit 18 will drill a drain hole in the
desired azimuth. This drain hole will deviate from the existing well bore 63 in the manner indicated by the reference numeral 28 in Figure 1. The curvature of the drain hole will be approximately equal to the curvature of the deflector pipe 16 when that deflector pipe is in its normal unstrained condition.

The deflector pipe 16 is never required to rotate in a curved bore and rotation of this deflector pipe in a straight bore is limited to the slight rotation which is required for orientation of the apparatus. There is thus little likelihood of fatigue failure of the metal of the deflector pipe 16. The conical rolls 11 and 12 on the bit 10 facilitate rotation of the deflector pipe for purposes of orientation when the clutch is engaged.

The lengths of the different portions of the apparatus as illustrated in Figure 1 are not necessarily representative of the relative lengths which are used in actual practice. The length of the deflector pipe 16 is preferably as short as possible consistent with obtaining the desired lateral deviation from the well bore 63. The combined lengths of the deflector pipe 16 and the flexible drill pipe 33 is preferably approximately equal to the depth or length of the deepest drain hole which is to be drilled.

My apparatus permits the drilling of laterally extending drain holes by the use of conventional drilling procedures. No special equipment is required at the surface of the well and it is possible to use any of the commercially available types of swivels and rotary tables. The teeth 81 and 83 of the clutch will remain disengaged at all times during drilling because of the application of weight to the drill bit by the drill pipe extending to the top of the well.

The foregoing detailed description of an exemplary form of the invention has been given to enable others to understand the invention and to obtain the benefits thereof. It is to be understood that the invention is not limited to the exemplified form and that various modifications may be resorted to without departing from the scope of the invention as defined by the following claim.

Having thus described my invention, I claim:

Apparatus for drilling a curved bore deflecting from an existing well bore, said apparatus comprising a normally curved, flexible, resilient deflector tube, a flexible drive member rotatable within said deflector tube, means connecting said deflector tube and said drive member permitting limited axial movement of said deflector tube and said drive member relative to each other, a drilling bit connected to the lower end of said drive member to rotate therewith, means for securing a drill pipe to the upper end of said drive member, and clutch means including a first clutch member carried by said drive member and a second clutch member carried by said deflector tube, said clutch members being engaged by elevation of said drill pipe and being operable, when engaged, to cause said deflector tube to rotate with said drive member to permit angular orientation of said deflector tube.

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