

April 24, 1956

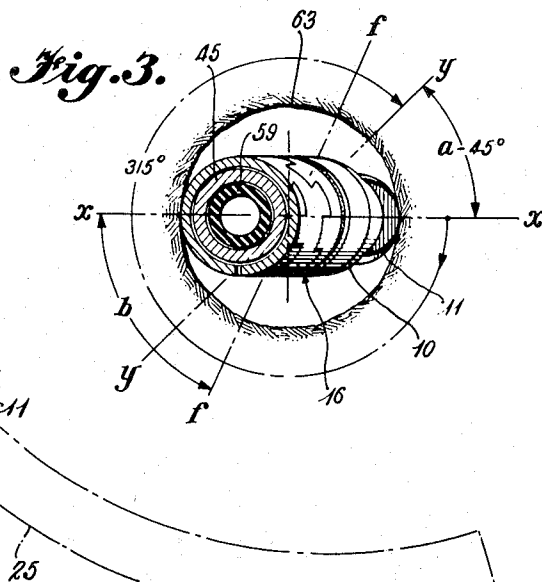
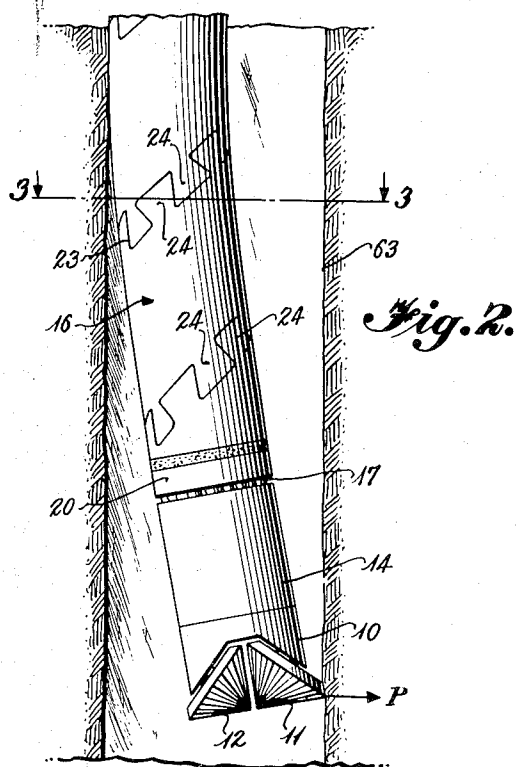
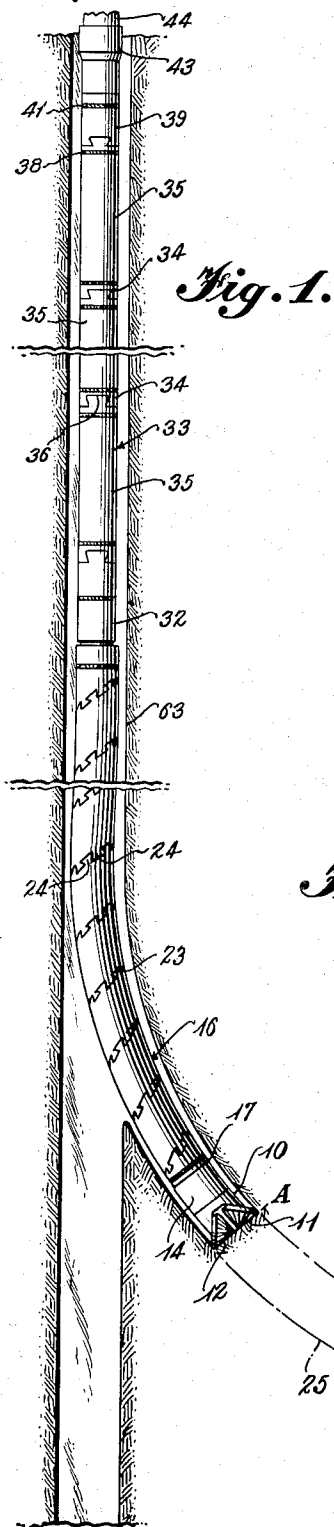
J. A. ZUBLIN

2,743,082

METHOD FOR DRILLING DEVIATING BORES FROM EXISTING WELL BORES

Filed May 29, 1950

3 Sheets-Sheet 1



INVENTOR.

BY JOHN A. ZUBLIN.

Burns Doane & Benedict

ATTORNEYS

April 24, 1956

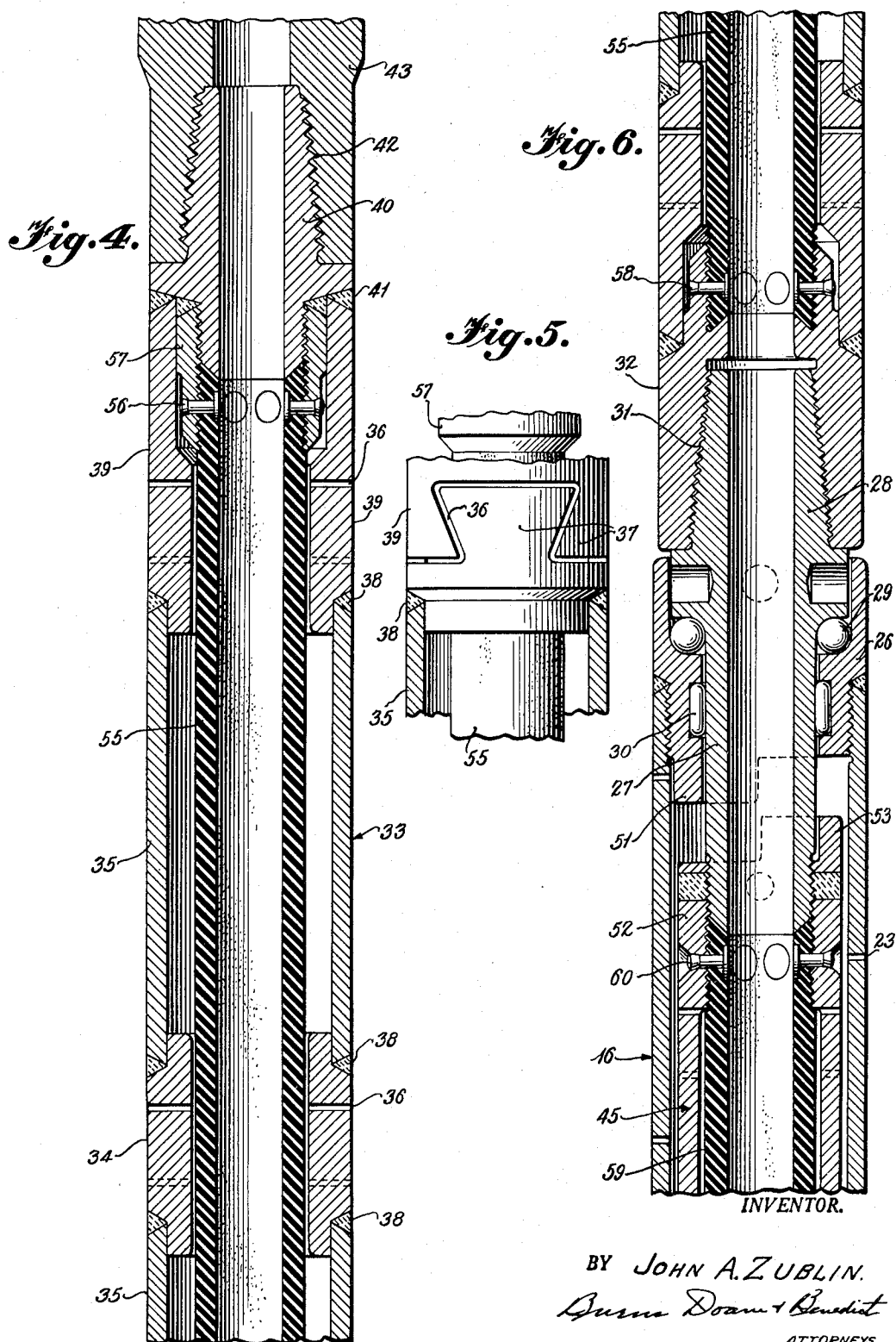
J. A. ZUBLIN

2,743,082

METHOD FOR DRILLING DEVIATING BORES FROM EXISTING WELL BORES

Filed May 29, 1950

3 Sheets-Sheet 2



April 24, 1956

J. A. ZUBLIN

2,743,082

METHOD FOR DRILLING DEVIATING BORES FROM EXISTING WELL BORES

Filed May 29, 1950

3 Sheets-Sheet 3

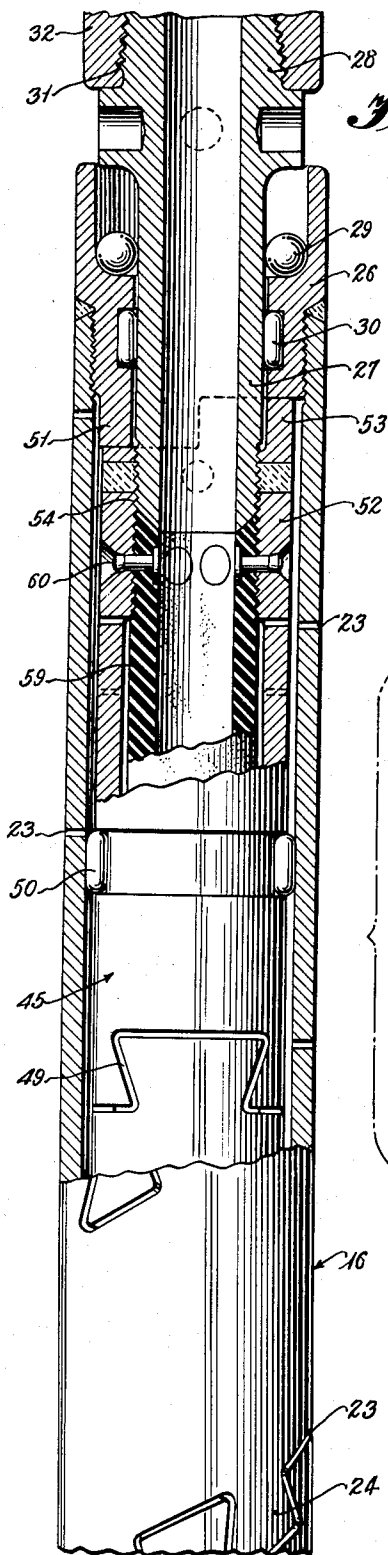


Fig. 7.

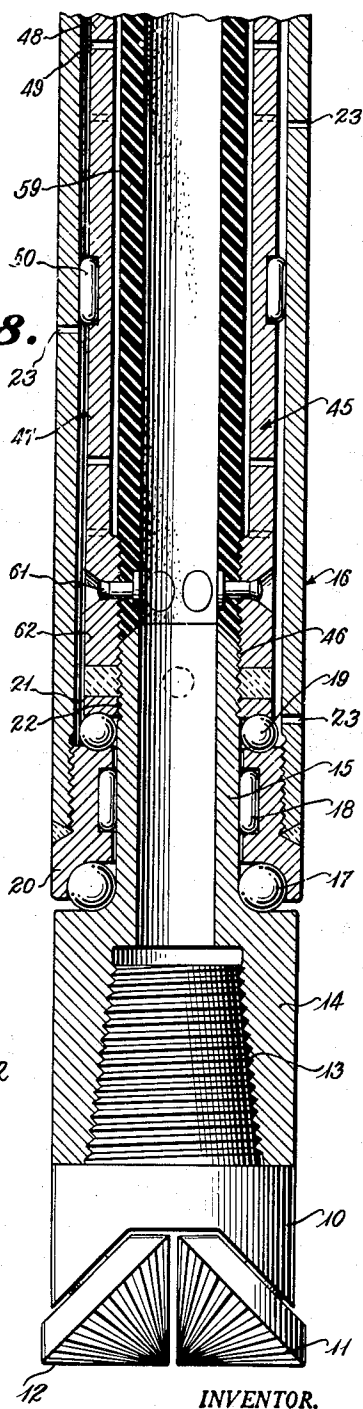


Fig. 8.

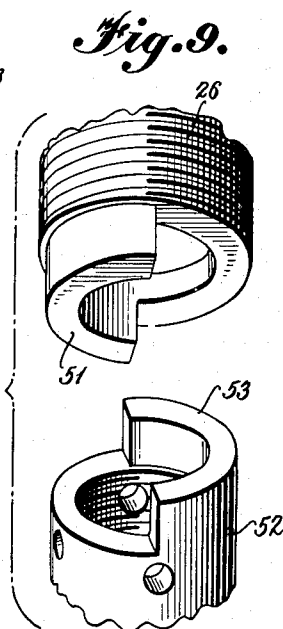


Fig. 9.

INVENTOR.

BY JOHN A. ZUBLIN.
Burns Doane & Benedict.
ATTORNEYS

1

2,743,082

METHOD FOR DRILLING DEVIATING BORES FROM EXISTING WELL BORES

John A. Zublin, Los Angeles, Calif.

Application May 29, 1950, Serial No. 165,081

3 Claims. (Cl. 255—1.6)

This invention relates to a method for drilling deviating bores from existing well bores through rotary drilling in which the drilling mud fluid is circulated down through the drill stem out through the bit and back to the surface of the well through the annular space surrounding the drill string, all in a continuous cycle.

The drilling of deviating bores extending laterally from existing well bores is not broadly new, having been heretofore made the subject matter of several of my prior patents, for example Patents Nos. 2,336,338, 2,344,277 and 2,382,933.

The method of the present invention constitutes a decided improvement over the earlier procedures developed by me.

In my original proposals the drilling bit in the drilling of deviating bores was advanced through the action of the turbine drive. The turbine could either be constructed as a unit with the bit as a component of the unit, or, according to certain of my proposals, the turbine might be interposed in the drill string at a point where it could always remain in the vertical well bore with a hollow flexible drive tube extending through the normally curved resilient guide to the bit. In some of these proposals the hollow flexible tube is in the nature of a heavy hose which could extend from the rotating bit to a point up the drill string where the driving turbine might be conveniently accommodated within the larger diameter of the vertical well bore.

While these were practical and feasible proposals of demonstrated value, they represented a substantial departure from conventional rotary drilling practices in that the drill string was stationarily held in the well. Certain disadvantages flow from any operation in which a very substantial amount of drill string is stationarily held within the well. For example, in intervals when there is a cessation in the circulation of the drilling fluid it has a tendency to jell or set in the annular space around the drill string and often acts to freeze the drill string in the well.

When a deviating bore of substantial length is drilled from an existing vertical well bore through the employment of a rigid drill string carrying at its lower end several sections of non-resilient flexible drill string which immediately follow the normally curved resilient flexible drill guide, such non-rotating drill string sections tend to lie on the bottom of the elongated deviating bore and to become lodged and frozen therein.

It is among the purposes and objects of the present invention to provide a method for drilling deviating bores from existing vertical well bores that is entirely compatible with accepted rotary drilling practices, and a method which permits of the effective advancing of a rotary bit in the drilling of elongated deviating bores without encountering the danger and disadvantage of drill string freezing in the bore.

One form of apparatus capable of being employed in the practice of the method of the present invention is dis-

2

closed in my copending application Serial No. 64,524, filed December 10, 1948, now Patent No. 2,672,321.

To the end that the method of the present invention may be exemplified with reference to a practical apparatus suitable for practicing the invention, such apparatus is herein described for purposes of exemplification of the invention.

The apparatus is disclosed in 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 copending application Serial No. 738,335, filed March 31, 1947, entitled "Flexible Drill Pipe," now Patent No. 2,515,365. 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 unstressed 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 unstressed 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 27 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 copending application Serial No. 25,037, filed May 4, 1948, for "Heavy Duty Flexible Drill Pipe," now Patent No. 2,515,366. The flexible drill pipe comprises a pipe having generally circumferential slots through its walls at longitudinally spaced zones 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 interengaging 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 application Serial No. 25,037, now Patent No. 2,515,366, is formed by cutting the slots through the walls of an initially unitary 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 36 cut therein to form the loosely intermeshing and interengaging 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 in turn threadedly 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 threadedly connected at 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 application Serial No. 25,037 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 interengaging 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 36 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. The character of the drive member 45 is such 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 interengaging and interlocking teeth between adjacent sections and no deformation of the metal of the sections is necessary.

The width of the slot 49 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 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 45 to assume different lengths permits engagement and disengagement of the teeth 51 and 53 in spite of the fact that the drive member is secured to the deflector pipe 16 at the lower end thereof.

A central longitudinal passageway extends through all portions of the apparatus for conducting drilling mud through the apparatus to the drilling bit 10. 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 56 to a coupling member 57 which in turn is screw-threaded to the lower end of the connector member 40. 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 59 extends through the interior of the flexible drive member 45. The upper end of the hose 59 is secured by means of rivets 60 to the uppermost section 52 of the drive member. The lower end of the hose 59 is secured by means of rivets 61 to the lowermost section 62 of the drive member 45. The hose 59 prevents loss of drilling mud through the slots in the walls of the drive member 45 and of the deflector pipe 16.

In the operation of the device the deflector pipe 16 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 16 and the drilling bit 10 will exert lateral pressure on the wall of the well bore as indicated by the arrow P in Figure 2.

By reference to Figure 3 it will be seen that when the apparatus is in the position there shown the drilling bit 10, when rotated without rotation of the deflector pipe, will drill a bore which deviates laterally from the well bore 63 in the plane $x-x'$. This rotation of the drilling bit 10 can be accomplished merely by rotating the drill pipe 44 at the surface of the well while the clutch is disengaged.

5

However it will usually be found that when the apparatus is lowered into the well it will not be properly oriented to drill a 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 16 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 16. 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 $x-x$ 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 53 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 maximum 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 interengaging teeth between sections of the flexible drill pipe 33 are tightly pressed against each other and to make certain that the deflector pipe 16 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 drill pipe lowered at the surface of the well to disengage the clutch and to apply drilling pressure to the bit 10.

6

The drill pipe is then rotated from the surface of the well and the bit 10 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 25 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 unstressed 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.

For efficiency in practicing the method of the present invention it is recommended that a flexible, curved resilient guide such as the deflector pipe 16 be provided having an over-all length of about 16 feet and a curvature in unstressed condition on a radius of approximately 16 feet so that the height of the arc formed when the guide is in unstressed position is about 30 inches. These dimensions have been found appropriate to perform properly any straight vertical bore having an entire diameter ranging from 6 inches to 18 inches.

In the drilling of an extended deviating bore the normally curved resilient drill guide has a tendency to flatten out under its own weight after the initial portion of the deviating bore has been drilled.

In the drilling of the deviating bore the rotating bit is positively driven and the entire drill string, including the rigid drill string and the flexible, non-resilient drive section immediately following the normally curved resilient drill guide, undergoes continuous rotation from the surface of the well. In this way the drill string with the exception of the relatively short, normally curved resilient guide is maintained in motion and no opportunity is afforded the drilling mud to set about the drill string and freeze the same.

In the practice of the method it must be observed that the drill bit is pressed sidewardly into the wall of the existing vertical bore by energy furnished through the reaction of the relatively short, normally curved resilient guide when it is forcibly flexed to a lesser curvature and held against rotation by the walls of the existing well bore. The bit is advanced through rotating the entire drill string above the normally curved guide and the flexible inner shaft extending through the curved guide to the bit, all this being accomplished pursuant to accepted rotary drilling practice with a continuous circulation of the mud fluid in a conventional manner.

Having thus described my invention, what I claim is:

1. A method of manipulating lateral bore drilling apparatus to drill a lateral bore in a desired azimuth from a vertical bore, said apparatus being in operable association with a rigid rotary drill string and being comprised of a drill bit, a flexible drive member for said bit, guide means for directing said bit and drive member to drill a lateral bore, and means for releasably engaging said guide means to rotate simultaneously with said bit and drive member, which method comprises: (1) lowering the assembly into a vertical well bore to a desired depth, (2) engaging said guide means to rotate with said bit and drive member, (3) applying tension to said drill string and drive member to eliminate slack therein, (4) thereafter determining and locating a desired drilling position for a lateral bore, (5) manipulating said rotary drill string without removing said apparatus from said vertical bore to place said apparatus in said position to drill a lateral bore in a desired azimuth from said vertical bore, (6) releasing said guide means from rotative engagement with said bit and drive member, (7) rotating said drill string, bit and drive member while said guide means remains stationary to drill a lateral bore in the desired azi-

7

muth from said vertical bore, and (8) continuously, during the drilling of said lateral bore, cycling drilling mud through said rotary drill string and flexible drive member out through said bit and back to the top of said vertical bore.

2. A method of manipulating lateral bore drilling apparatus to drill a lateral bore in a desired azimuth from a vertical bore, said apparatus being in operable association with a rigid rotary drill string and being comprised of a drill bit, a flexible drive member for said bit, guide means for directing said bit and drive member to drill a lateral bore, and means for releasably engaging said guide means to rotate simultaneously with said bit and drive member, which method comprises: (1) lowering the assembly into a vertical well bore to a desired depth, (2) raising said apparatus to engage said guide means to rotate with said bit and drive member, (3) manipulating said apparatus by raising and slowly rotating the same, without raising said apparatus substantially from its desired depth within the vertical bore, to place said apparatus in an oriented position, (4) holding the bit of said apparatus without rotation while disengaging the guide means from rotatable connection with said apparatus, and (5) drilling by rotating and lowering said drill string of said apparatus a deviating bore in the desired azimuth.

3. A method of manipulating a lateral bore drilling apparatus to initiate and to continue the drilling of a curved bore deviating from a vertical well bore at a desired depth and in a desired azimuth, said apparatus being in operable association with a rigid rotary drill string extending from said apparatus to the surface of the well and being comprised of a drill bit, a flexible, non-resilient, sectional rotary drill string for driving said bit, said drill string supporting a flexible, normally curved, resilient,

8

tubular, normally non-rotating guide for directing said bit to initiate and to drill a deviating lateral bore, and means for releasably engaging said normally curved tubular guide while said guide is held forcibly straightened within said vertical bore for limited rotation simultaneously with said bit and drill string, which method comprises: (1) lowering said apparatus into a vertical well bore to the desired depth and thereby forcibly straightening said resilient guide, (2) raising said rigid drill string to engage said flexible resilient guide for rotation with said bit and drive member, (3) manipulating said apparatus by raising and slowly rotating the same within said vertical bore to position said apparatus such that said bit will drill a lateral bore at a desired level and in a desired azimuth, (4) maintaining said apparatus in such position while disengaging said guide means from rotational connection with said bit and drive member and (5) initiating and continuing the drilling of the desired lateral bore by rotating said drill bit and by progressively lowering the rotating bit and associated apparatus, said bit being continuously guided by the following non-rotating, oriented, tubular resilient drill guide and being continuously driven by the rotating, flexible, sectional drill pipe to produce a deviating bore having a curvature corresponding substantially to the normal curvature of said guide.

References Cited in the file of this patent

UNITED STATES PATENTS

2,101,185	Monroe	Dec. 7, 1937
2,336,333	Zublin	Dec. 7, 1943
2,336,338	Zublin	Dec. 7, 1943
2,344,277	Zublin	Mar. 14, 1944
2,382,933	Zublin	Aug. 14, 1945
2,585,207	Zublin	Feb. 12, 1952