

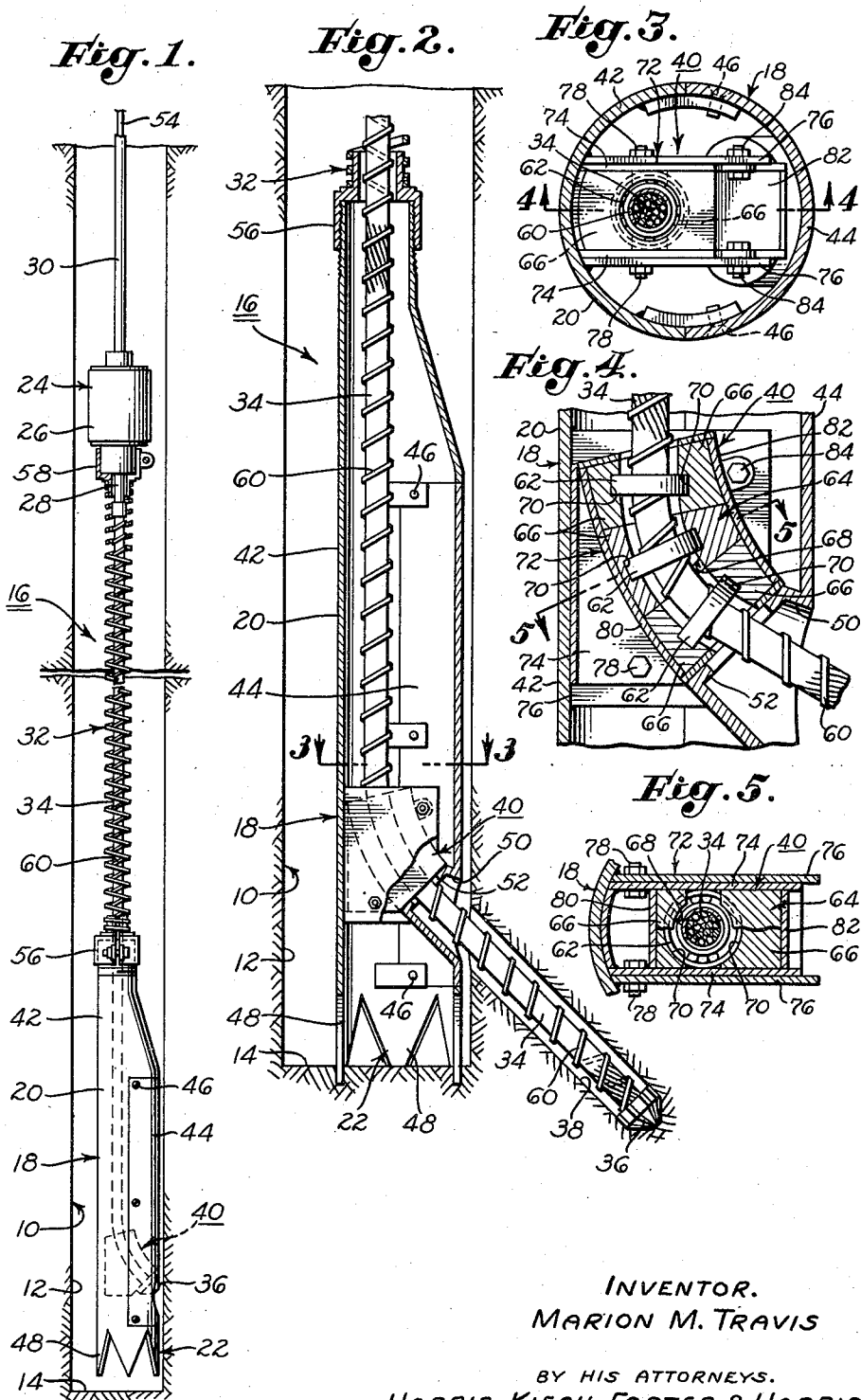
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M. M. TRAVIS

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DIRECTIONAL DRILLING APPARATUS

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INVENTOR.
MARION M. TRAVIS

BY HIS ATTORNEYS.
HARRIS, KIECH, FOSTER & HARRIS

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DIRECTIONAL DRILLING APPARATUS

Marion M. Travis, Beverly Hills, Calif.

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The present invention relates in general to drilling apparatus and more particularly, to an apparatus for directionally drilling one or more lateral bores from a main well bore, or the like. For convenience in disclosing the invention, it will be considered herein as applied to an apparatus for directionally drilling one or more relatively small lateral bores from a larger, main well bore for the purpose of, for example, tapping formations which do not communicate with the main bore, thereby increasing the production of the well. However, it will be understood that the invention may be utilized in other environments and for other purposes without departing from the spirit thereof.

In general, the present invention contemplates a directional drilling apparatus which includes: a whipstock; means on the whipstock for anchoring it relative to the main well bore; a flexible shaft extending through the whipstock and having a drill bit at its lower end; directional guiding means in the whipstock for guiding the flexible shaft in such a manner as to cause the bit to drill a lateral bore in the desired direction; a motor having a housing suspended in the main well bore by a cable, or the like, and having a rotor connected to the upper end of the flexible shaft; and means for anchoring the motor housing against rotation in the main well bore, a primary object being to provide a directional drilling apparatus of this general nature.

An important object of the invention is to provide a directional drilling apparatus wherein the whipstock and the motor are flexibly interconnected, the invention providing flexible means for suspending the whipstock from the motor as the apparatus is lowered into and removed from the main bore.

More particularly, an object of the invention is to provide an apparatus wherein the flexible shaft itself serves to suspend the whipstock from the motor as the apparatus is run in and out of the well, whereby no auxiliary supporting connection between the whipstock and the motor is required.

A further object is to provide a whipstock including a housing having an external bit cavity in one side thereof which provides a bit seat, the drill bit at the lower end of the flexible shaft being retracted into the bit cavity and being seated on the bit seat as the apparatus is run into and out of the well so that the flexible shaft supports the whipstock under such conditions.

Another important object is to provide flexible means interconnecting the motor housing and the whipstock housing for preventing rotation of the motor housing in response to rotation of the rotor of the motor.

More particularly, an important object of the invention is to provide a helical spring surrounding the flexible shaft and having its lower end connected to the whipstock housing and its upper end connected to the motor housing, such spring preventing rotation of the motor housing in response to rotation of the rotor of the motor. This spring contracts as lateral, directional drilling progresses, and expands as the drill bit at the lower

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end of the flexible shaft is withdrawn from the lateral bore, but at all times prevents rotation of the motor housing by anchoring it to the whipstock housing, which, in turn, is anchored to one wall of the main well bore.

5 The foregoing flexible interconnection between the motor housing and the whipstock housing provided by the helical spring encircling the flexible shaft results in a compact, lightweight directional drilling apparatus by eliminating any necessity for heavy, rigid connections between the motor housing and the whipstock housing, which is an important feature.

Another object of the invention is to provide the flexible shaft with a helical rib thereon extending from the drill bit at the lower end thereof to the connection to the rotor of the motor at the upper end hereof. This helical rib serves to convey cuttings from the lateral bore into the main well bore, thereby avoiding any necessity for a pump, or the like to convey cuttings out of the lateral bore, which is an important feature.

20 Another object of the invention is to provide directional guiding means for the flexible shaft which is adjustable to vary the angle which the lateral bore makes with the main bore. This angle may be varied between zero degrees and 90°, or even more in some instances.

25 Another object of the invention is to provide an adjustable directional guiding means for the flexible shaft which includes a plurality of ball bearings and which includes adjustable means for positioning the ball bearings on paths of different curvatures, the adjustable positioning means preferably comprising interchangeable spacer blocks for positioning the bearings on paths of any desired curvatures to attain any desired angles between the lateral bore and the main bore.

30 The foregoing objects, advantages, features and results of the present invention, together with various other objects, advantages, features and results thereof which will be apparent to those skilled in the art in the light of this disclosure, may be attained with the exemplary embodiment of the invention which is illustrated in the accompanying drawing and which is described in detail hereinafter. Referring to the drawing:

Fig. 1 is an elevational view of the directional drilling apparatus of the invention as the apparatus is lowered into or removed from a main well bore;

35 Fig. 2 is an enlarged, vertical sectional view of a whipstock of the invention anchored relative to one wall of the main well bore, Fig. 2 also showing a lateral bore being drilled from the main well bore;

Fig. 3 is an enlarged, transverse sectional view taken along the arrowed line 3—3 of Fig. 2;

40 Fig. 4 is a longitudinal sectional view of a directional guiding means incorporated in the whipstock of the invention, Fig. 4 being taken along the arrowed line 4—4 of Fig. 3; and

45 Fig. 5 is a transverse sectional view of the directional guiding means taken along the arrowed line 5—5 of Fig. 4.

In the drawing, the numeral 10 designates a main well bore having a side wall 12 and a bottom wall 14, the latter either being the actual bottom of the main bore, or being formed by a plug in the main bore. In the main bore 10 is a directional drilling apparatus 16 of the invention comprising: a whipstock 18 having a whipstock housing 20; anchor means 22 on the whipstock housing for anchoring the whipstock relative to the main bore; a motor 24 having a housing 26 and a rotor 28; means, such as a cable 30, connected to the motor housing for supporting the motor; flexible means 32 interconnecting the whipstock housing and the motor housing for preventing rotation of the motor housing in response to rotation of the rotor (after sufficient rotation of the motor housing to stress the flexible means); a flexible shaft 34 extending through-

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the whipstock housing and through the flexible means 32, this shaft being connected at its upper end to the rotor of the motor and being provided at its lower end with a suitable drill bit 36 for drilling a lateral bore 38; and, finally, directional guiding means 40 in the whipstock housing for guiding the flexible shaft in a manner to produce the desired angle between the lateral bore and the main bore.

Considering the directional drilling apparatus 16 in more detail, the whipstock housing 20 comprises a barrel 42 having a removable panel 44 secured in place by screws 46, or the like, this removable panel providing access to the directional guiding means 40 in a manner which will be apparent. The anchor means 22 is carried by the lower end of the barrel 42 and, in the particular construction illustrated, comprises triangular teeth 48 insertable into the bottom wall 14 of the main well bore 10 to prevent rotation of the whipstock 18. However, it will be understood that anchor means of other types, engageable, for example, with the side wall 12 of the main well bore 10, may be utilized.

The removable panel 44 of the barrel 42 is provided therein with an external recess or cavity 50 adapted to receive the bit 36 therein and providing a seat 52 for the bit. When the bit 36 is retracted into the cavity 50, it is entirely within the confines of the whipstock housing 20 and is seated on the bit seat 52. With this construction, as the directional drilling apparatus 16 is run into and out of the main bore 10, the whipstock 18 is supported by the motor 24 through the flexible shaft 34, thereby avoiding any necessity for any rigid structural connection between the whipstock and the motor, which is an important feature of the invention.

The motor 24 is preferably a vertical electric motor of the submersible type so that it may be operated in the drilling mud, or other fluids, which may be present in the main well bore 10. The supporting cable 30 for the motor 24 is connected to the motor housing 26 and may have as its core electrical conductors 54 for supplying power to the motor. As the apparatus 16 is run into and out of the well, the cable 30 may be unwound from and wound onto a suitable drum, or the like, not shown, at the surface, as is well known in the art.

The flexible means 32 for preventing rotation of the motor housing 26 in response to rotation of the rotor 28 of the motor comprises a simple helical spring which surrounds the flexible shaft 34, the lower end of this spring being rigidly connected to an adapter 56 which is threaded on, or otherwise rigidly connected to, the upper end of the whipstock housing barrel 42, and the upper end of the spring being rigidly connected to an adapter 58 threaded on, or otherwise secured to, the lower end of the motor housing 26. The helical spring 32, which may be many feet in length, automatically shortens as the bit 36 drills the lateral bore 38, and automatically lengthens as the bit is withdrawn from this lateral bore. At the same time, however, the helical spring 32 effectively prevents rotation of the motor housing 26 in response to rotation of the rotor 28, the anchor means 22 thus serving to anchor both the whipstock 18 and, through the spring 32, the motor 24. Thus, a compact, lightweight apparatus 16 results and no heavy, rigid structural interconnection between the whipstock and the motor is required, which is an important feature.

The flexible shaft 34 may be of any suitable construction, it being shown as a woven wire shaft. Similarly, the drill bit 36 may be of any suitable type. An important feature of the flexible shaft 34 is that it is provided thereon with an external helical rib 60, which may take the form of a helical wire welded to the flexible shaft, for conveying cuttings out of the lateral bore 38 into the main bore 10. Thus, cuttings are automatically conveyed into the main well bore without resort to a pump, or other equipment, for removing the cuttings from the lateral bore by fluid circulation, or the like.

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Considering now the directional guiding means 40, it includes a plurality of bearings 62 and adjustable spacing means 64 for positioning the bearings along a path of any desired curvature to direct the drill bit 36 along a path at any desired angle to the main well bore 10. The bearings 62 are preferably ball bearings to minimize friction, and the internal diameter of the inner races thereof is slightly larger than the external diameter of the helical rib 60 on the flexible shaft 34 so that the shaft may pass through the guiding means 40 easily. The adjustable spacing means 64 includes a number of pairs of spacing blocks 66 corresponding to the number of bearings 62, each pair of spacing blocks retaining one of the bearings in the desired position. The complete set of paired blocks is provided with a passage 68 therethrough for the flexible shaft 34, and the blocks of each pair are provided with semicircular grooves 70 therein which receive and retain one of the bearings 62. The complete set of blocks is retained in a guiding means housing 72 comprising two parallel, spaced flat plates 74 secured to brackets 76 on the barrel 42 by bolts 78. The guiding means housing also includes two curved plates 80 and 82, the former being welded, or otherwise secured, to the flat plates 74 and the latter being removably secured to the brackets 76 by bolts 84.

As will be apparent the blocks 66 retain the bearings 62 in such positions as to produce a predetermined degree of curvature of the flexible shaft 34, thereby producing a predetermined angle of divergence of the lateral bore 38 from the main bore 10. By removing the panel 44 of the whipstock housing 20 and the plate 82 of the guiding means housing 72, the blocks 66 may be removed and a different set of blocks substituted therefor to hold the bearings 62 in different positions providing a different degree of curvature for the flexible shaft 34, and thereby providing a different angle of divergence of the lateral bore 38 relative to the main bore 10. Thus, by a simple substitution of one set of the blocks 66 for another, the angle of the lateral bore relative to the main bore may be varied readily, which is an important feature of the invention. The blocks 66 may be made of any suitable material, although wood is an ideally suitable material.

Considering the over-all operation of the apparatus 16, it is first lowered into the main well bore 10 with the whipstock 18 suspended from the motor 24 through the flexible shaft 34 in the manner hereinbefore described, the bit 36 seating on the bit seat 52 in the cavity 50 to accomplish this. Thus, no separate suspension system for the whipstock 18 is required, which is an important feature. When the apparatus reaches the bottom of the well bore 10, the triangular teeth 48 forming the anchor means 22 penetrate the bottom wall 14 of the well bore due to the weight of the whipstock 18. If the weight of the whipstock is insufficient to accomplish this, the apparatus may be dropped a short distance to obtain adequate penetration by the teeth 48. Of course, if some other type of anchor means is used, a different setting procedure is necessary.

With the whipstock 18 set in the foregoing manner, the motor 24 is energized through the electrical conductors 54 incorporated in the cable 30 to rotate the flexible shaft 34 and the drill bit 36, the latter drilling into the side wall 12 of the main well bore, and through any casing therein, to form the lateral bore 38, the angle of divergence of which from the main well bore is determined by the directional guiding means 40 hereinbefore described. Any tendency of the motor housing 26 to rotate due to torque reaction is opposed by the spring 32, which prevents rotation of the motor housing after perhaps a few revolutions thereof to stress the spring. As will be apparent, the spring automatically contracts as drilling of the lateral bore 38 progresses, whereby shortening of the distance between the motor 24 and the whipstock 18 is accommodated without any necessity for elaborate guides, or the like, for the motor. When it is desired to run the ap-

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paratus 16 out of the well bore 10, the spring 32 automatically lengthens until the bit 36 engages the bit seat 52 to suspend the whipstock 18 from the motor 24.

As will be apparent, the bit pressure may be readily controlled by controlling the proportion of the weight of the motor 24 which is applied thereto through the flexible shaft 34. The bit pressure may readily be controlled by controlling the tension in the supporting cable 30 in a manner which will be apparent to those skilled in the art.

During the drilling of the lateral bore 38, the helical rib 60 on the flexible shaft 34 continuously conveys cuttings out of the lateral bore into the main bore. Since the helical rib extends from the bit 36 substantially to the rotor 28 of the motor 24, the helical rib is effective for its intended purpose even when the motor 24 has been lowered substantially to the whipstock 18 to extend the flexible shaft the maximum distance into the lateral bore.

After the lateral bore 38 has been completed, or after the desired number of such bores has been completed, the apparatus is returned to the surface merely by reeling in the cable 30, the drill bit 36 automatically retracting into the cavity 50 and engaging the seat 52 so that the whipstock 18 is supported by the motor 24.

Although I have disclosed an exemplary embodiment herein for purposes of illustration, it will be understood that various changes, modifications and substitutions may be incorporated in such embodiment without departing from the spirit of the invention as defined by the claims hereinafter appearing.

I claim as my invention:

1. In an apparatus for directional drilling, the combination of: a whipstock including a housing having directional guiding means therein and having an external bit cavity in one side thereof which provides a bit seat; means for anchoring said whipstock in a well bore; a flexible shaft extending through said directional guiding means into said bit cavity; a bit connected to the lower end of said flexible shaft and adapted to seat on said bit seat within said bit cavity so that said flexible shaft supports said whipstock; a motor including a housing and including a rotor connected to the upper end of said flexible shaft so as to support said whipstock through said flexible shaft when said bit is seated on said bit seat, said flexible shaft having a helical rib thereon which extends from said bit to said motor; means for suspending said motor in a well bore; and a helical spring surrounding said flexible shaft and connected at its upper end to said motor housing and at its lower end to said whipstock housing.

2. In an apparatus for directional drilling, the combination of: a whipstock including a housing having directional guiding means therein and having an external bit cavity in one side thereof which provides a bit seat; a flexible shaft extending through said directional guiding means into said bit cavity; a bit connected to the lower end of said flexible shaft and adapted to seat on said bit seat within said bit cavity so that said flexible shaft supports said whipstock; a motor including a housing and including a rotor connected to the upper end of said flexible shaft so as to support said whipstock through said flexible shaft when said bit is seated on said bit seat; means for suspending said motor in a well bore; a helical spring surrounding said flexible shaft and connected at its upper end to said motor housing and at its lower end to said whipstock housing; and means on said whipstock housing engageable with one wall of a well bore for anchoring said whipstock housing relative to such wall.

3. In an apparatus for directional drilling, the combination of: a whipstock including a housing; means for anchoring said whipstock in a well bore; a motor including a housing and a rotor; means for suspending said motor in a well bore; a flexible shaft connected at its upper end to said rotor and extending through said whip-

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stock housing; a bit on the lower end of said flexible shaft; and a helical spring surrounding said flexible shaft and connected at its upper end to said motor housing and at its lower end to said whipstock housing.

4. In an apparatus for directional drilling, the combination of: a whipstock including a housing; a motor including a housing and a rotor; means for suspending said motor in a well bore; a flexible shaft connected at its upper end to said rotor and extending through said whipstock housing; a bit on the lower end of said flexible shaft; a helical spring surrounding said flexible shaft and connected at its upper end to said motor housing and at its lower end to said whipstock housing; and anchor means on said whipstock housing and engageable with a wall of a well bore.

5. In an apparatus for directional drilling, the combination of: a whipstock including a housing; a motor including a housing and a rotor; means for suspending said motor in a well bore; a flexible shaft connected at its upper end to said rotor and extending through said whipstock housing; a bit on the lower end of said flexible shaft; a helical spring surrounding said flexible shaft and connected at its upper end to said motor housing and at its lower end to said whipstock housing; anchor means on said whipstock housing and engageable with a wall of a well bore; and adjustable directional guiding means for said flexible shaft in and connected to said whipstock housing.

6. In an apparatus for directional drilling, the combination of: a whipstock including a housing; a motor including a housing and a rotor; means for suspending said motor in a well bore; a flexible shaft connected at its upper end to said rotor and extending through said whipstock housing; a bit on the lower end of said flexible shaft; a helical spring surrounding said flexible shaft and connected at its upper end to said motor housing and at its lower end to said whipstock housing; anchor means on said whipstock housing and engageable with a wall of a well bore; and adjustable directional guiding means for said flexible shaft in and connected to said whipstock housing, said directional guiding means including a plurality of ball bearings arranged along a curved path and including a plurality of blocks for supporting said bearings on said path.

7. In an apparatus for directional drilling, the combination of: a whipstock including directional guiding means and provided with a bit seat; means on said whipstock for anchoring same in a well bore; a motor having a housing and a rotor therein; means for suspending said housing of said motor in the well bore; flexible means for suspending said whipstock from said motor, including a flexible shaft connected at its upper end to said rotor of said motor and having at its lower end a bit seatable on said bit seat, said flexible shaft extending through said whipstock and through said directional guiding means thereof; and flexible, extensible and contractible means connected to said housing of said motor and to said whipstock.

8. In an apparatus for directional drilling, the combination of: a whipstock including directional guiding means and provided with a bit seat; means on said whipstock for anchoring same in a well bore; a motor having a housing and a rotor therein; means for suspending said housing of said motor in the well bore; flexible means for suspending said whipstock from said motor, including a flexible shaft connected at its upper end to said rotor of said motor and having at its lower end a bit seatable on said bit seat, said flexible shaft extending through said whipstock and through said directional guiding means thereof; and flexible, extensible and contractible means connected to said housing of said motor and to said whipstock, said flexible, extensible and contractible means surrounding said flexible shaft.

(References on following page)

References Cited in the file of this patent

UNITED STATES PATENTS

1,595,922	Prindle	Aug. 10, 1926
1,970,761	McVicar	Aug. 21, 1934
2,101,185	Monroe	Dec. 7, 1937
2,198,016	Rogers et al.	Apr. 23, 1940
2,252,620	De Long	Aug. 12, 1941

2,296,161
2,345,816
2,425,132
2,516,421
2,539,047
2,579,712
2,669,430

5

Hall	Sept. 15, 1942
Hays	Apr. 4, 1944
Stokes	Aug. 5, 1947
Robertson	July 25, 1950
Arutunoff	Jan. 23, 1951
Tilden	Dec. 25, 1951
Zublin	Feb. 16, 1954