April 7, 1953 J. A. ZUBLIN 2,634,097

APPARATUS FOR DRILLING CURVED LATERAL BORES DEVIATING FROM AN EXISTING WELL BORE

Filed Jan. 17, 1951

Fig. 1.

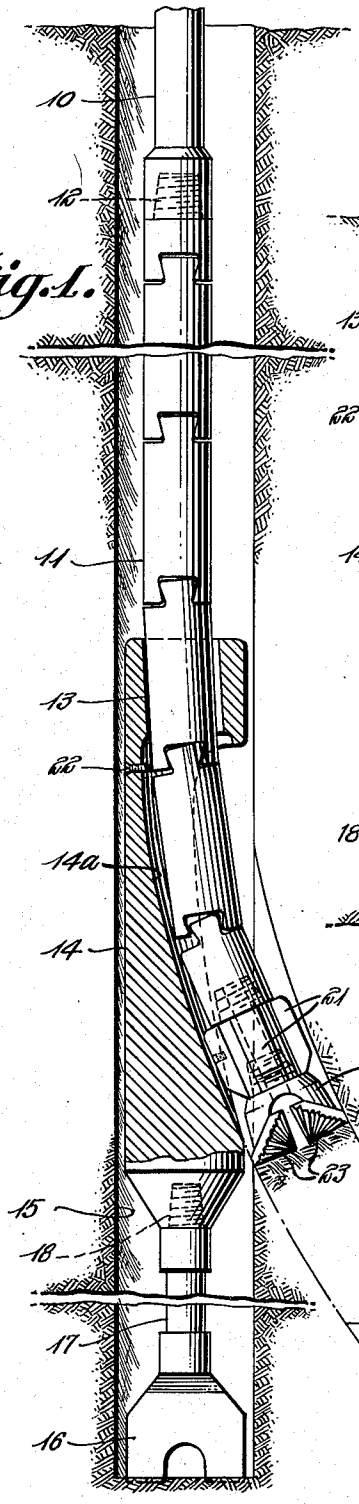


Fig. 2.

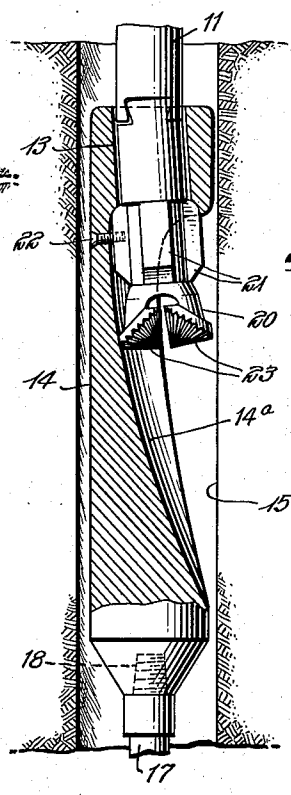


Fig. 3.

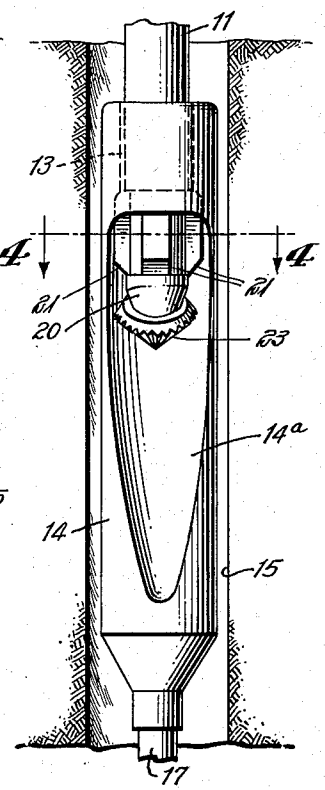
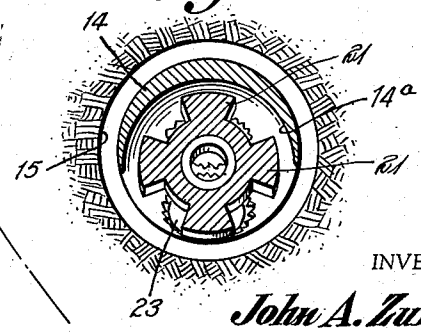


Fig. 4.



INVENTOR

John A. Zublin

BY Burns, Doane & Benedict

ATTORNEYS

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APPARATUS FOR DRILLING CURVED LATERAL BORES DEVIATING FROM AN EXISTING WELL BORE

John A. Zublin, Los Angeles, Calif.

Application January 17, 1951, Serial No. 206,365

3 Claims. (Cl. 255—1.6)

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This invention relates to an apparatus for drilling a curved lateral bore deviating from an existing well bore. It is an object of the invention to provide a cooperating coordinated combination of integrated apparatus elements especially effective in the drilling of a lateral bore deviating from an existing vertical well bore in hard formations such as limestone and the like.

More especially it is an object and purpose of the invention to provide a combination of coordinated and integrated apparatus elements for drilling a lateral bore deviating from an existing vertical well bore which lend themselves to use in association with conventional rotary drilling equipment and by following the usual rotary drilling practices.

In a more specific aspect the invention contemplates a specially interrelated whipstock and drilling unit assembled in a unitary combination and cooperating to effectively initiate the drilling of a lateral bore deviating from an existing well bore into hard formations.

In still more specific aspects the invention contemplates the employment in combination of a flexible drill string section that is flexible in all directions and is of special construction to provide the same with a degree of flexibility which will not permit the flexible drill string section to assume a curvature on a radius below a specified minimum radius and to associate such a flexible drill string section with a whipstock having a curved deflecting face, the curvature of which lies on a radius of the same magnitude as the minimum radius of curvature that the flexible drill string section is capable of assuming, all in combination with a bit carried at the lower end of the flexible drill string section, and capable of rotation therewith through the medium of the rotating drill string secured to the upper end of the flexible drill string section and extending to the well surface.

Further and more detailed objects and advantages of the invention will become apparent as the description thereof proceeds which will be given by reference to the accompanying drawings wherein:

Figure 1 is a view in side elevation with parts shown in section illustrating the position of the elements of the combination when the bit has travelled over the length of the curved deflecting face of the whipstock.

Figure 2 is a fragmentary view with parts shown in section illustrating the position of the elements of the combination during the insertion into and withdrawal of the apparatus from an existing well bore.

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Figure 3 is a fragmentary side elevational view at right angles to Figure 2, and

Figure 4 is a cross-sectional view on the line 4—4 of Figure 3.

The entire apparatus of the present invention is adapted to be suspended from a conventional rotary drill string, the lower end of which is indicated at 10 in Figure 1. The flexible drill string section indicated generally at 11 is threadedly received in the lower end of the roary drill string 10 as indicated at 12. The flexible drill string section 11 is made up of a series of individual members interconnected together so as to provide a predetermined flexibility for the flexible drill string section. This flexible drill string section 11 is constructed according to the teachings of my prior U. S. Patent 2,515,366 issued July 18, 1950, it being understood that the degree of flexibility and therefore the minimum radius of curvature that can be assumed by the flexible drill string section is determined by the degree of relative movement permitted by each flexible coupling and the length of the respective members making up the over-all length of the flexible drill string section 11.

By way of example, and not in limitation, it may be pointed out that when the flexible drill string section 11 is constructed pursuant to the teachings of my prior Patent 2, 515,366 in such a manner as to insure an angular movement between each pair of members making up the flexible drill string section of 3.6 degrees with an assumed length of each coupling member of one foot, the minimum radius of curvature of the entire flexible drill string section may be determined for all practical purposes by calculation pursuant to the following formula:

$$\frac{360 \times L}{3.6 \times 2\pi}$$

in which L represents the length of the individual coupling member which in this case is 1. It will be observed that this formula, when solved, gives a radius of curvature for the flexible drill string section of about sixteen feet which is a very practical minimum radius of curvature for the flexible drill string section 11 employed pursuant to the present invention.

It will be appreciated that by varying the maximum angular movement between adjacent coupling members and by varying the length of the coupling members, the minimum radius of curvature which the flexible drill string section is capable of assuming may be varied. For all practical purposes, the minimum radius of curvature which the flexible drill string section should

be capable of assuming according to the present invention should lie within a radius of from five feet to forty feet and should preferably lie within the limits of a radius of from fifteen feet to thirty feet. The flexible drill string section 11 is adapted to pass through the collar 13 of the whipstock 14 which has a curved channelled deflecting face 14a extending from immediately below the collar 13 to a point adjacent the lower end of the whipstock 14. Usually the curved channelled deflecting face 14a of the whipstock 14 will have a length lying within the limits of from four feet to eight feet, though its length may vary somewhat from these preferred limits, depending on such factors as the diameter of the existing well bore, the diameter of the flexible drill string section 11 and the diameter of the deviating bore desired to be drilled. The whipstock 14 in the embodiment illustrated is adapted to be supported from the bottom of the vertical well bore indicated generally at 15 by a fishtail bit 16 and a coupling of variable length 17 threadedly received into the lower end of the whipstock 14 as indicated at 18. The length of the coupling 17 will determine the point in the vertical bore 15 at which the deviating bore indicated generally at 19 will be drilled laterally from the existing bore 15. A roller type bit 20 is carried at the lower end of the flexible drill string section 11 and immediately above the bit 20 there is positioned a sub having a series of laterally projecting ribs 21 which serve a twofold purpose. First, these ribs 21 are adapted to engage the lower face of the collar 13 so as to permit withdrawal from the well bore of the whipstock 14 and the flexible drill string section 11 as a unit and, second, the ribs 21 ride on the curved channelled deflecting face 14a of the whipstock and insure complete freedom of flexibility of the couplings between the individual members of the flexible drill string section 11 and also permit freedom of movement of the bit 20 carrying cones 23 downwardly over the curved channelled deflecting face 14a. The upper end of the rib 21 in contact with the surface 14a tends to open the coupling between the bit-carrying sub and the lowermost unit of the drill string section 11 and thus prevent the teeth of the bit from gouging into the surface 14a. A shear pin 22 is adapted to interlock the flexible drill string section 11 and the collar 13 of the whipstock 14 as more particularly shown in Figure 2. This arrangement permits the ready insertion of the apparatus into an existing well bore with the bit 20 held in a position such that it does not gouge into the wall of the existing vertical well bore. When the fishtail bit 16 is seated on the bottom of the bore hole 15 the weight of the drill string will shear the pin 22 and free the flexible drill string section 11 and bit 20 for rotation.

An important feature of the invention resides in the fact that the curved deflecting face 14a of the whipstock 14 has a radius of curvature of substantially the same magnitude as the minimum radius of curvature which the associated flexible drill string section 11 is capable of assuming. Thus, if the flexible drill string section 11 is capable of assuming a minimum radius of curvature of, say, sixteen feet, the curved channelled deflecting face 14a of the whipstock 14 will likewise lie on a radius of curvature of sixteen feet. Because of this interrelationship of the minimum radius of curvature of the flexible drill string section and the curved deflecting face of the whipstock, the deviating bore will always be initiated on a path corresponding to the minimum radius of curvature which the flexible drill string section is capable of assuming.

This interrelationship insures that maximum force will be imparted to the drill 20 during the initiation of the drilling of a deviating bore and the drill 20 is positively rotated through the conventional rotary drill string extending down from the surface of the well.

When the apparatus of the present invention is lowered into an existing well bore, it may, if desired, be oriented with respect to the circumference of the existing well bore 15 so as to insure the drilling of the deviating bore 19 in any desired azimuth. As hereinabove indicated, by varying the length of the coupling 17 between the whipstock 14 and the fishtail bit 16 the deviating bore 19 can be drilled into the formation at any desired point above the bottom of the existing well bore.

In the operation of the apparatus, when the fishtail bit 16 is seated on the bottom of the well bore 15 the release of weight of drill string at the surface of the well will readily shear the shear pin 22 and thereafter rotation of the drill string 10 at the surface of the well will transmit rotary movement to the flexible drill string section 11 and the bit 20. The deflecting bore 19 is initiated in a direction tangentially from the existing bore on a curvature having a radius equal to the radius of the curved channeled deflecting face 14a of the whipstock 14. After the drilling of the deviating lateral bore has been initiated on continued drilling by the bit 20, the flexible drill string section 11 will, depending on the speed of drilling and weight on the bit, tend to assume either a straight or a curved line and the result will be an extension of the initiated curved bore. Frequently this type of deviating bore will be entirely satisfactory for the purpose of extending the area of oil recovery in the formation. It may, however, in some instances be desirable to withdraw the apparatus of the present invention from the vertical well bore after a deviating bore has been drilled and to continue the drilling by extending the deviating bore through the employment of other drilling tools such as the flexible resilient normally curved drill guide and associated elements more particularly described in my application Serial No. 206,364 filed of even date herewith.

It will be appreciated that pursuant to the present invention the flexible drill string section 11 through which the power for rotating the bit 20 is transmitted in the drilling of the bore may be the full diameter of the drill string or even slightly enlarged to insure great ruggedness in the transmission of the required force to the drill bit.

The flexible drill string section 11 is preferably of conventional drill string section length of the order of from sixteen to twenty feet though it will be appreciated that in special instances and where desired flexible drill string sections of greater or lesser length may be employed. However, the flexible drill string section should, for all practical purposes, have a length lying within the limits of from ten feet to forty feet.

I am fully aware that whipstocks have heretofore been employed for insuring the drilling of a well bore at an angle to the already drilled portion of the well bore. However, the angle of deflection provided by any of the commercially acceptable prior art types of whipstock construction employed in connection with regular drill pipe is usually less than about three degrees for whipstocks of eight feet length. The smallest

radius of curvature obtainable thus requires setting one whipstock immediately below another and even this expedient will provide a deflection on a radius of curvature of about 1520 feet. Such operations are not feasible since in order to properly penetrate the oil bearing strata of the formation, deflecting bores are usually required to have a curvature on a radius of the order of sixteen feet since many of the oil sands do not exceed a thickness of twenty feet.

The apparatus of the present invention furthermore lends itself to employment in wells where the casing sizes are of the order of seven inches outside diameter or even smaller. Through the employment of the apparatus of the present invention it is entirely feasible to drill deviating bores from existing well bores which have diameters as small as five inches.

Having thus described my invention, what I claim is:

1. An apparatus assembly attachable to the lower end of a rotary drill string for drilling curved lateral bores deviating from an existing well bore, comprising in combination a rotary tubular flexible drill string section adapted to be secured to and rotate with the lower end of the rotary drill string, said flexible drill string section embracing a plurality of interconnected hollow substantially cylindrical units capable of limited relative angular movement in all directions, a whipstock, means for supporting the whipstock in an existing well bore, interengaging means carried by said flexible drill string section and said whipstock operative to permit insertion into a well bore and withdrawal therefrom as a unit, a bit secured to and rotatable with the lower end of said flexible drill string section, said whipstock having a contact face for rotatably supporting and guiding said flexible drill string section during rotation thereof, said contact face having its points of contact with said flexible drill string section lying in a curve, the radius of curvature of at least a substantial portion of said curve and the minimum radius of curvature which said flexible drill string section is capable of assuming being of substantially the same magnitude.

2. An apparatus assembly attachable to the lower end of a rotary drill string for drilling curved lateral bores deviating from an existing well bore, comprising in combination a rotary tubular flexible drill string section adapted to be secured to and rotate with the lower end of the rotary drill string, said flexible drill string section embracing a plurality of interconnected hollow substantially cylindrical units capable of limited relative angular movement in all directions, a whipstock, means for supporting the whipstock in an existing well bore, interengaging means carried by said flexible drill string section and said whipstock operative to permit insertion into a well bore and withdrawal therefrom as a unit,

a bit secured to and rotatable with the lower end of said flexible drill string section, said whipstock having a curved channelled face for rotatably supporting and guiding said flexible drill string section during rotation thereof, the radius of curvature of at least a substantial portion of said curved face of said whipstock and the minimum radius of curvature which said flexible drill string section is capable of assuming being of substantially the same magnitude, said bit being effective to drill a bore of greater diameter than the diameter of said flexible drill string section.

3. An apparatus assembly attachable to the lower end of a rotary drill string for drilling curved lateral bores deviating from an existing well bore, comprising in combination a rotary tubular flexible drill string section adapted to be secured to and rotate with the lower end of the rotary drill string, said flexible drill string section embracing a plurality of interconnected hollow substantially cylindrical units capable of limited relative angular movement in all directions, the length of each unit being a multiple of its diameter, a whipstock, means for supporting the whipstock in an existing well bore, interengaging means carried by said flexible drill string section and said whipstock operative to permit insertion into a well bore and withdrawal therefrom as a unit, a bit secured to and rotatable with the lower end of said flexible drill string section, said whipstock having a curved channelled face for rotatably supporting and guiding said flexible drill string section during rotation thereof, the radius of curvature of at least a substantial portion of said curved face of said whipstock and the minimum radius of curvature which said flexible drill string section is capable of assuming being of substantially the same magnitude, said bit being effective to drill a bore of greater diameter than the diameter of said flexible drill string section and a sub immediately above said bit having radially extending ribs to insure freedom of movement of said bit downwardly over the curved face of said whipstock as said bit is rotated and advanced over said curved face.

JOHN A. ZUBLIN.

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