May 15, 1956 J. A. ZUBLIN 2,745,634

APPARATUS FOR DRILLING WELLS WITH ORIENTED CURVED BORES OR LARGE RADII

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Fig. 1.

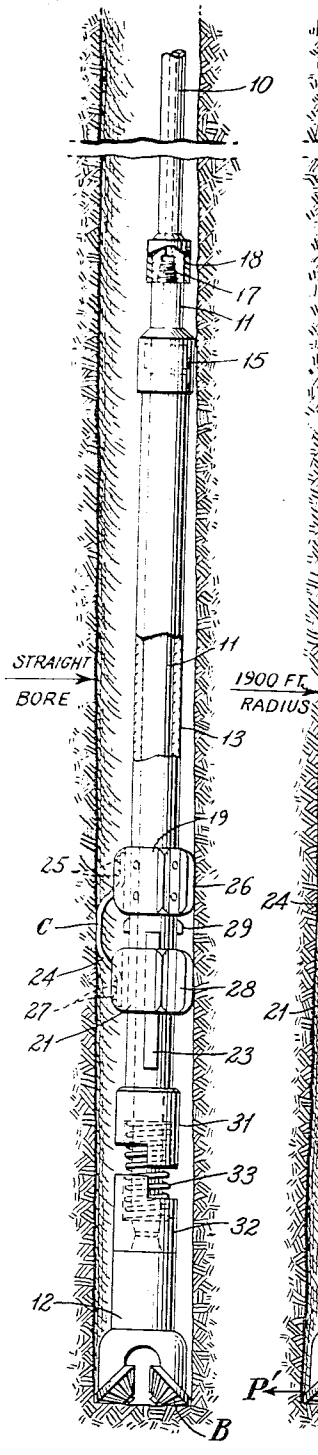


Fig. 2.

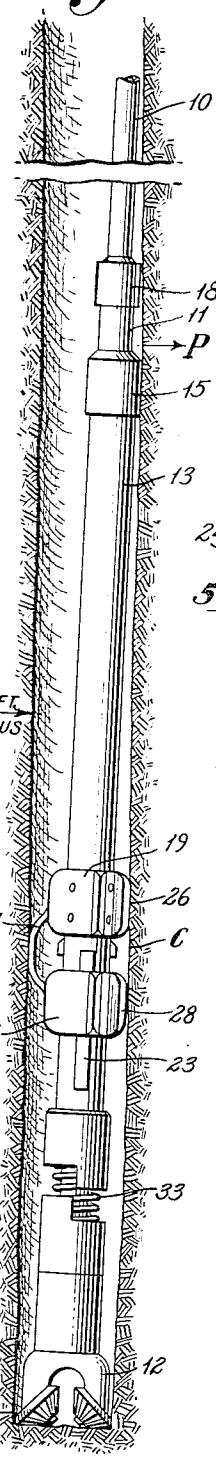
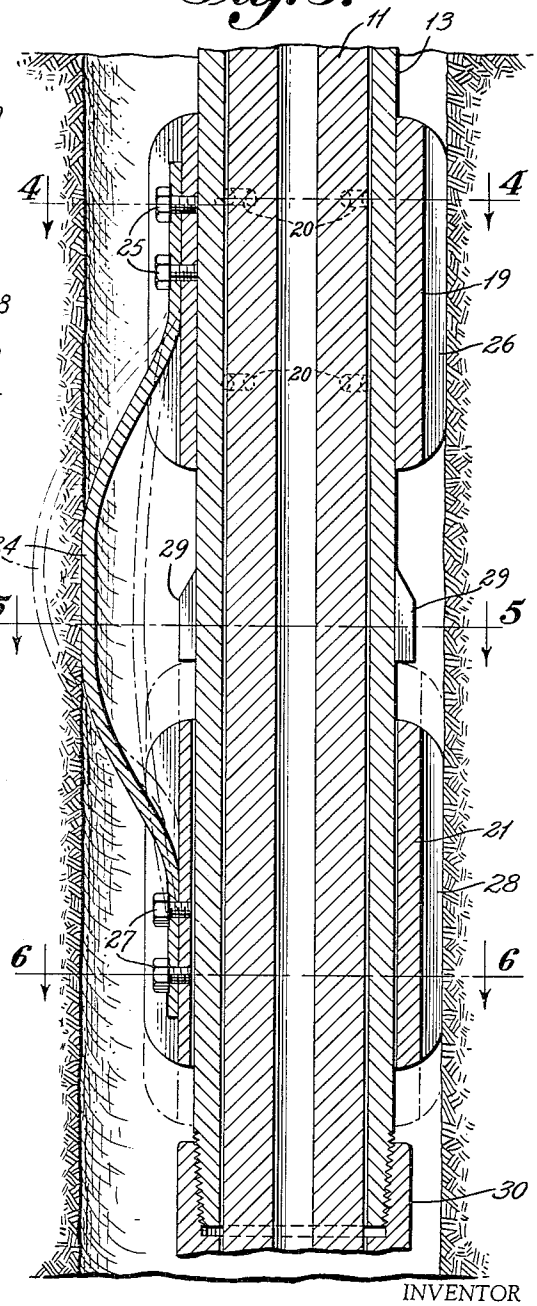


Fig. 3.



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Fig. 4.

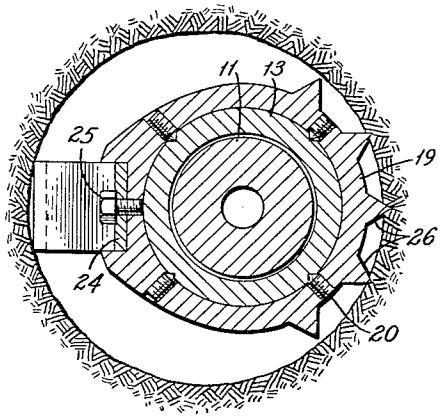


Fig. 5.

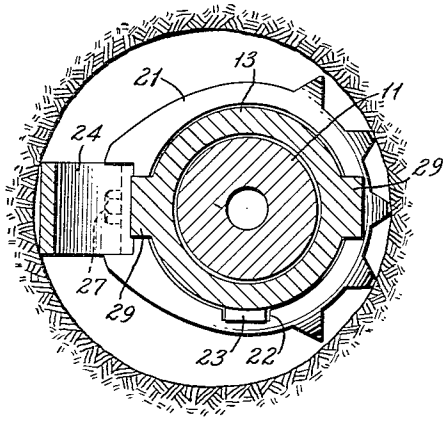


Fig. 6.

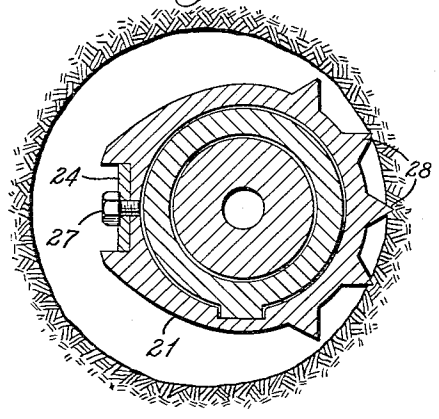


Fig. 7.

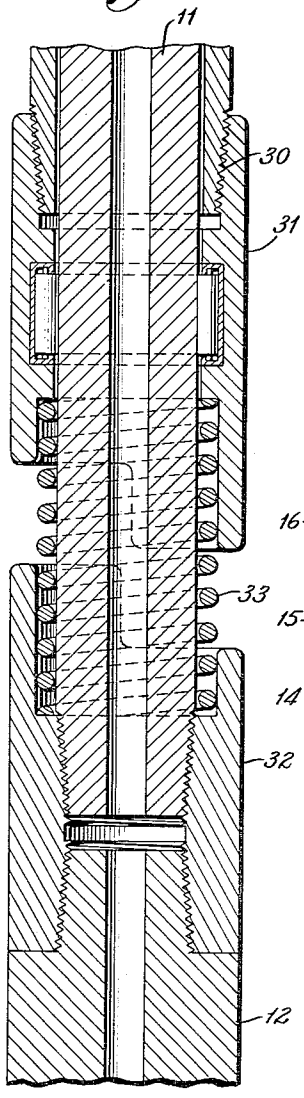
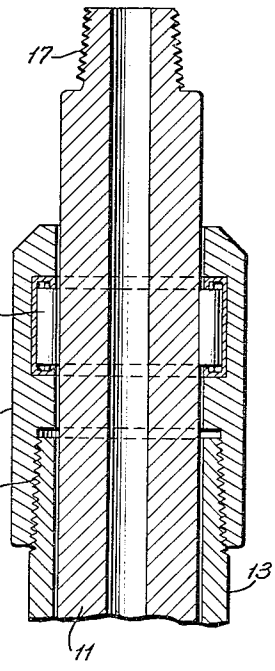


Fig. 8.



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APPARATUS FOR DRILLING WELLS WITH ORIENTED CURVED BORES OF LARGE RADII

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Application December 30, 1952, Serial No. 328,680

5 Claims. (Cl. 255—1.6)

The present invention relates to a method and apparatus for drilling oil wells with oriented curved bores of large radii. It is the purpose and object of the invention to provide a method and apparatus by which oriented curved bores of large radii may be effectively drilled with but one round-trip of the drilling equipment.

The need for the drilling of deflecting bores having as their purpose the recovery of oil from points in a producing formation horizontally spaced a substantial distance from the point of initiation of the vertical well bore, has become increasingly pronounced with attempts to recover oil, for example from under water formations. Indeed there are many instances where real need for the drilling of a deflecting bore in a given azimuth is apparent.

It is the purpose and object of the present invention to provide a method and apparatus by which such a deflecting bore may be produced through conventional rotary drilling technique as a direct continuation of an initiated vertical well bore.

The present invention is not concerned with the production of curved deviating bores of small radii, such as drain holes drilled directly from a vertical well bore laterally into the producing formation, but is rather concerned with the production of a deflecting bore as a continuation of an initially straight well bore, in the original drilling of which the bore is deflected in a curved path of large radius of the order of 1,000 to 2,000 feet.

In the prior art practice of drilling deflecting bores, the expedient of using whipstocks has been largely resorted to. Generally speaking, the tubular drill strings employed in rotary drilling have sufficient inherent flexibility to permit of their deviation from the vertical in an amount approximating about three degrees per hundred feet of length of drilling string. Again speaking generally, whipstocks set in a vertical well bore for the purpose of causing a deflection of the drill bit usually contemplate a deflection from the vertical of from around three degrees to five degrees. In practice it has been found that when drilling a deflecting bore through the medium of a whipstock, the drill string, after it passes the whipstock, tends to follow the path of least resistance and return to a straight line under the influence of gravity. Because of this inherent tendency of the rotary drill string to follow the path of least resistance it has been the prior art practice in the drilling of deflecting bores through the use of whipstocks to drill a limited distance beyond the point of setting of a given whipstock; to then withdraw the drill string and bit from the well bore and set another whipstock at the lower depth to which the deflecting bore has been drilled, this procedure being repeated throughout the drilling of the deflecting bore. Such practice has entailed the necessity for a complete round-trip each time a whipstock is set. Each round trip and each setting of the whipstock entails hazards that, quite apart from the sheer loss of time involved, render the drilling of deflecting bores of large radii very costly.

It is the purpose and object of the present invention to provide a greatly simplified method and apparatus for the drilling of deflecting bores of large radii through the medium of which it is possible to completely eliminate the use of whipstocks and complete the drilling of the deflecting bore on one round-trip of the drilling equipment.

More specifically it is the purpose and object of the invention to provide a method and apparatus for initiating and continuing the drilling of a deflecting bore, at substantially the same fixed radius, sufficiently large to lie within the limits of inherent flexibility of the conventional rotary drill string.

From the apparatus standpoint, the purpose and object of the invention is to provide a unit suspendable from the lower end of a rotary drill string susceptible of manipulation in such a manner as to effect the initiation and continued drilling of a curved deflecting bore of large radius without the use of other elements or instrumentalities than those suspended from and carried by and insertable into the well bore through the medium of a conventional rotary drill string.

By the expression "curved bores of large radii" as employed in this application, it is intended to identify and define degrees of curvature attainable through the inherent flexibility of a normal rotary drill string. Generally speaking, the radii of deflecting bores, in the drilling of which the present invention is addressed, lie within the limits of 1,000 to 3,000 feet. The further purposes and objects of the invention will become apparent as the description proceeds which will be given in connection with the accompanying drawings forming a part hereof, and in which:

Figure 1 is a fragmentary view and side elevation with parts broken away and illustrating the position in a preformed vertical well bore of a drilling unit suitable for practicing the method and exemplifying the apparatus of the present invention.

Figure 2 is a view similar to Figure 1 but illustrating the position of the unit in a deflecting bore that has been produced thereby.

Figure 3 is a detailed cross-sectional view illustrating the manner in which the deflecting force is applied to the drilling unit.

Figure 4 is a detailed cross-sectional view taken on the line 4—4 of Figure 2.

Figure 5 is a detailed cross-sectional view taken on the line 5—5 of Figure 2.

Figure 6 is a detailed cross-sectional view taken on the line 6—6 of Figure 2.

Figure 7 is a detailed cross-sectional view through the clutch mechanism illustrating operational features of the apparatus, and

Figure 8 is a detailed cross-sectional view illustrating the manner in which the drilling unit may be suspended from a conventional rotary drill string.

Referring to Figures 1 and 2, a conventional hollow rotary drill string is indicated at **10** which is adapted to extend to the surface of the well and be rotated by the conventional rotary equipment. Drilling fluid is adapted to be passed down and through the drill string **10** from the lower end of which is suspended a unit assembly embracing an inner tubular rotary drive member **11** which carries the bit **12** at its lower end so that rotation of the rotary drill string **10** and the rotary tubular drive member **11** will effect a positive rotation of the bit **12**. Surrounding the rotary drive member **11** is an elongated sleeve **13**, the upper end of which is threadably engaged at **14** in a collar **15** carrying anti-friction means **16** for facilitating free rotation of the tubular drive member **11** within the sleeve **13** (see Figure 8). The upper end

of the rotatable inner drive member **11** is threaded at **17** for reception in the threaded socket **18** at the lower end of the rotary drill string **10**.

At a point above the bit **12**, there is provided an anchoring collar **19** fixedly held on the outer sleeve **13** by the set screws **20** (see Figure 4). Spaced below anchoring collar **19**, a slidable collar **21** having the keyway **22** for accommodating the key **23**, is mounted for relative vertical movement on the exterior of the sleeve **13** (see Figure 5). A heavy leaf-spring **24** adapted to exert a predetermined lateral force on the drill unit has its upper end secured as indicated at **25** to the fixed collar **19** opposite the gripping teeth **26** carried thereby. The lower end of spring **24** is secured as indicated at **27** to the slidable collar **21** opposite the gripping teeth **28** thereof. Stop members **29** are carried by the sleeve **13** to limit the upper movement of the slidable collar **21** on the sleeve **13**. Secured to the lower end of the sleeve **13** by the threaded connections **30** is the upper member **31** of the two-member clutch, the lower member **32** of which is secured to and carried by the inner rotary drive member **11**. The spring **33** normally urges the clutch members **31** and **32** toward disengaged position. When however an upward pull is exerted on the rotary drill string **10**, the frictional resistance offered by the collar **19**, the spring **24** and attendant mountings carried by the outer sleeve **13**, will hold the sleeve **13**, permitting limited vertical movement of the inner drive member **11** and engagement of the clutch members **31** and **32** to permit concurrent rotation of the inner drive member **11** and the sleeve **13** to facilitate orientation of the sleeve **13** and insure deflection of the bit **12** in a desired azimuth. It will also be appreciated that the weight of the sleeve **13** and parts carried thereby is normally sufficiently in excess of the frictional resistance or drag created by spring **24** and the ribs on collars **19** and **21** engaging with the well bore such that the sleeve will normally move along with the drill collar **11** and drill bit **12**.

Referring to Figure 1, which illustrates the position of the unit in the bottom of a previously formed well bore, it will be observed that the action of the spring **24** at point C is to tilt the unit embracing the non-rotating sleeve **13** against the right hand side of the well bore, as seen in Figure 1. The bit **12** holds the lower end of the unit against lateral displacement so that the top of the unit at the point of its interconnection with the lower end of the rotary drill string **10** is canted over with the result that when weight is placed on the bit and the drill string **10** is rotated, the bit **12** will tend to deflect to the left, as shown in Figure 1.

Now referring to Figure 2, which represents the position of the unit in a deflected bore that has been produced thereby on a radius of curvature of about 1,900 feet, it will be noted that the drill string **10** hugs the side of the well bore of greatest radius. This is caused by the weight on the bit applied through the drill string **10** to the unit embracing the outer sleeve **13** and by spring **24** which tend to urge collars **19** and **21** into firm engagement with the wall of the deflecting well bore. The weight on the bit thus exerts a force in the direction of the arrow P in the upper end of the unit and imposes deflecting force on the bit **12** in the direction of the arrow P'.

After the unit has been operated to produce the initial portion of a deflecting bore, such as exemplified in Figure 2, its relationship to the deflecting bore becomes stabilized and it continues to drill at about the same degree of deflection as that of the initial portions of the deflecting bore. Since the rotary drill string **10** will continue to hug the wall of the deflecting bore of largest radius and since the diameter of the well bore itself is the limiting factor on the extent to which the upper end of the unit may be canted about the fulcrum provided by the collars **19** and **21**, the inclination of the unit from the upper end of sleeve **13** to the bit **12** will remain substantially constant.

The relationship of the unit to a straight bore, as shown in Figure 1, and to a curved bore produced by utilization of the unit, as shown in Figure 2, illustrates the manner in which the weight applied through the drill string tends to force the upper end of sleeve **13** laterally toward engagement with the well bore wall levering sleeve **13** about collars **19** and **21** serving as a fulcrum for sleeve **13**. It will be appreciated from a consideration of Figure 2 on the drawings that, should the drill bit deviate upon continued drilling operation toward a radius of curvature smaller than that shown in Figure 2, rigid sleeve **13**, acting as a lever, will pivot about its upper end which engages with the well bore wall as a fulcrum. Upon the occurrence of this event, the gripping teeth **26** will be moved out of engagement with the well bore. Spring **24**, acting against the well bore wall will tend to force the teeth **26** and **28** back into engagement with the well bore and thus through sleeve **13** acting as a lever fulcrumed about its upper end urge the drill bit to return to a course of drilling a uniformly curved bore as shown in Figure 2.

In some instances it may be advantageous to give some elasticity to the fulcrum to permit it to better adjust itself to variable drilling weight applied through the rotary drill string. This can be accomplished when the unit is actually in the curved deflecting bore by engaging the clutch elements **31** and **32** and turning the sleece **13** 180°. In this position the spring **24** will then constitute the bearing face of the fulcrum since it will then contact the side of the deflecting bore of greatest curvature. When spring **24** is used as the bearing face of the fulcrum, it will be observed that the relation of the axis of the unit in relation to the axis of the bore hole is of a more flexible nature permitting direct response to variations in the magnitude of weight on bit applied at the derrick floor.

It will be appreciated that the clutch elements **31** and **32**, normally held in disengaged position by the spring **33**, may be brought into engagement by a slight upward pull on the drill string **10** sufficient to free the bit from the bottom of the hole and overcome the resistance of the spring **33**. With the clutch elements **31** and **32** engaged, positive force can be applied to turn the sleeve **13** for a fraction of a revolution to facilitate orienting of the unit to obtain deflection in a desired azimuth.

Having thus described my invention, what I claim is:

1. Apparatus for controlling the direction and extent of deviation of a well bore by the rotary drilling method comprising an elongated relatively inflexible tubular section, an elongated drill collar rotatably mounted in said tubular section, a drill bit carried at the lower end of and rotatable with said drill collar, means at the upper end of said drill collar for connecting same to the lower end of a rotary drill string for rotation therewith, said tubular section having a well bore engageable fulcrum means thereon, and well bore engaging deflecting means carried by said tubular section at a point spaced from said well bore engageable fulcrum means acting to urge said inflexible tubular section and said drill bit to pivot about said fulcrum means in a predetermined radial direction.

2. Apparatus as recited in claim 1 wherein said well bore engageable fulcrum means is disposed at the upper end of said tubular section, and said deflecting means is carried by said tubular section at a point spaced below said well bore engageable fulcrum means.

3. Apparatus for controlling the direction and extent of deviation of a well bore by the rotary drilling method comprising an elongated relatively inflexible tubular section, an elongated drill collar rotatably mounted in said tubular section and capable of limited longitudinal movement relative to said tubular section, interengaging clutch elements carried by said tubular section and said drill collar respectively, means normally holding said clutch elements in disengaged position while permitting engage-

ment of said clutch elements upon limited longitudinal movement of said drill collar within said tubular section, a drill bit carried at the lower end of and rotatable with said drill collar, means at the upper end of said drill collar for connecting same to the lower end of a rotary drill string for rotation therewith and whereby said drill collar may be moved longitudinally relative to said tubular section by lifting of the drill string for engagement of said clutch elements, said tubular section having a well bore engageable fulcrum means thereon, and well bore engaging deflecting means carried by said tubular section at a point spaced from said well bore engageable fulcrum means acting to urge said inflexible tubular section and said drill bit to pivot about said fulcrum means in a predetermined radial direction.

4. Apparatus as recited in claim 3 wherein said well bore engageable fulcrum means is disposed at the upper end of said tubular section, and said well bore engaging deflecting means is carried by said tubular section at a point spaced below said well bore engageable fulcrum means.

5. Apparatus for controlling the direction and extent of deviation of a well bore by the rotary drilling method comprising an elongated relatively inflexible tubular section, an elongated drill collar rotatably mounted in said tubular section, a drill bit carried at the lower end of and

rotatable with said drill collar, means at the upper end of said drill collar for connecting same to the lower end of a rotary drill string for rotation therewith, said tubular section having a well bore engageable fulcrum means thereon, a pair of collars mounted on said tubular section adjacent one another and spaced from said fulcrum means with at least one of said collars being capable of longitudinal non-rotatable movement relative to said tubular section, a leaf spring connected at its opposite ends to said collars and protruding outwardly from said tubular section to engage with the well bore wall to urge said inflexible tubular section and said drill bit to pivot about said fulcrum means in a predetermined radial direction and each of said collars having on the side thereof opposite said leaf spring an outwardly protruding tooth.

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