

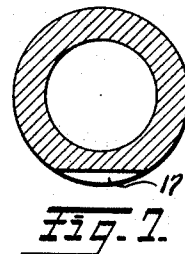
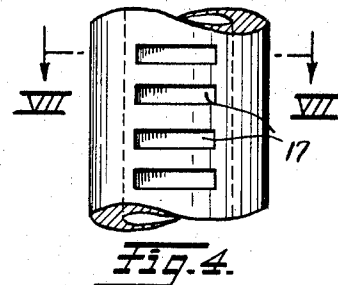
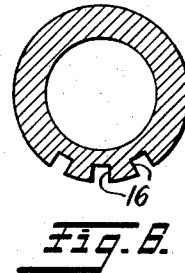
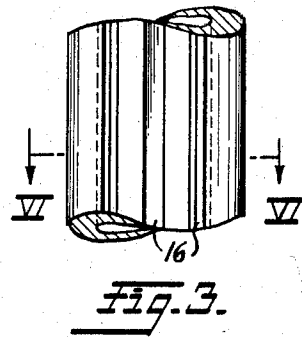
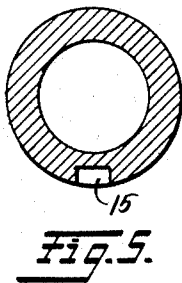
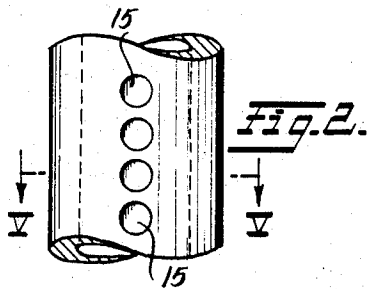
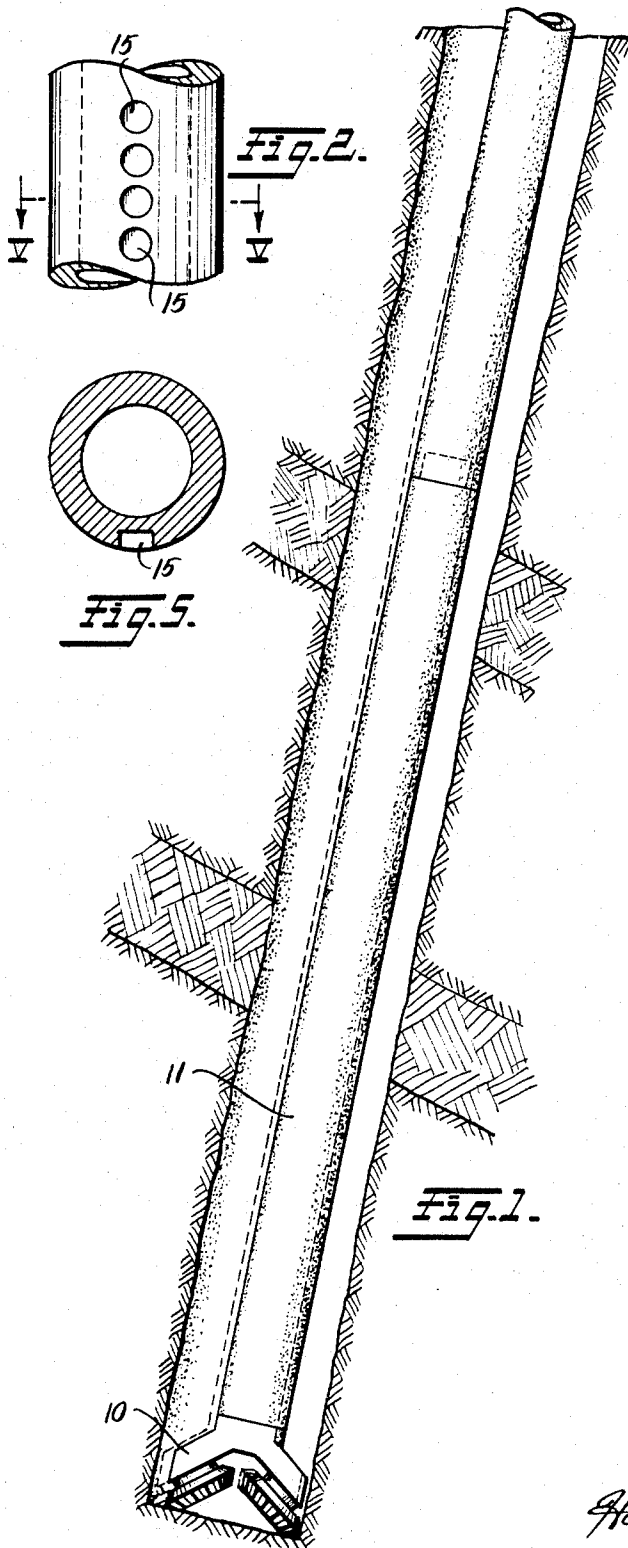
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METHOD AND APPARATUS FOR DRILLING STRAIGHT WELLS

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METHOD AND APPARATUS FOR DRILLING STRAIGHT WELLS

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Continuation-in-part of application Ser. No. 351,068, Mar. 11, 1964. This application June 6, 1966, Ser. No. 555,426

14 Claims. (Cl. 175—61)

ABSTRACT OF THE DISCLOSURE

A well borehole is prevented from deviating from the vertical as it is being drilled by use of a drill collar which is eccentrically weighted with respect to its axis of rotation. Such a drill collar can comprise a straight tubular member weight relieved along one side by, for example, drilling blind holes along the side of the collar. Thus, the eccentric weight is imposed upon the drill bit without providing any protrusions or elbows which are designed to bear on the wall of the borehole.

This application is a continuation-in-part of my prior application, Ser. No. 351,068, filed Mar. 11, 1964, now abandoned.

It is the object of my invention to provide a method and apparatus for preventing a well from deviating from a vertical line as it is being drilled, or for causing it to return to the vertical after it has deviated therefrom.

It is well known that when drilling bits encounter layers of rock or other material which are harder or softer than the layers immediately above and/or below them, and these layers extend at an angle to the horizontal, the drilling bits tend to be diverted from the vertical.

Various methods have been proposed for overcoming this difficulty. The most common procedure is to utilize an "angle mounted" bit. In such bits the cutter head is connected to the shank at a point laterally spaced from the longitudinal axis of the shank and collar, and is tilted at an angle to that axis. Such bits are effective in preventing deviation, but "make hole" slowly, since only a relatively light load may be imposed on them, and are relatively expensive. Consequently it is not practical to use them until adverse conditions are actually encountered, and then it is necessary to pull up the pipe in order to substitute them for the conventional bits previously in use.

It has also been suggested that the bit be kept centered in the hole by using "stabilizers," or even by using collars having off-center elbows which wipe against the walls of the well. Such devices, however, impose an additional resistance to rotation which must be overcome by the driving engine and tend to get stuck in the hole if it is not absolutely straight, may have an abrasive effect on the wall of the well when passing through soft formations, and are themselves abraded.

In accordance with my invention, deviation is inhibited by imposing on the bit a weight which is eccentrically positioned with respect to the axis about which the bit is designed to turn. This may conveniently be done by inserting in the string just above the bit a substantially cylindrical drill collar which is heavier on one side of an axis of symmetry about which it is designed to rotate than on the other. For example, holes may be drilled in one side of an ordinary cylindrical drill collar so as to lighten that side.

Since the top of the drilling string is constrained against horizontal displacement, the effect of the centrifugal force resulting from the eccentric position of the weight,

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when the string is rotated with the hole and string vertical, is to urge the bit to swing in a circular path, instead of rotating about a fixed point, so that the side of the bit on which the eccentric weight is positioned is urged against the side of the hole. This affects all sides of the hole equally, so long as the hole is vertical, since the heavy side of the collar spends an equal portion of the cycle directed toward each side of the hole.

However, when a hole deviates so as to be positioned at an angle to the vertical, the weight of the bit and collar tend to cause them to gravitate to the low side of the hole exerting thereagainst a force dependent on the angle between the hole and the vertical. This is true regardless of whether the collar is eccentrically weighted or not and is a well known phenomenon. Now, when an eccentrically weighted collar is used, whenever the heavy side of the collar is rotated away from the low side of the hole, centrifugal force urges the bit and collar toward the heavy side of the collar, away from the low side of the hole, thus subtracting from the force exerted by the weight of the bit. On the other hand, when the heavy side of the collar approaches the low side of the hole, the centrifugal force resulting from the eccentric weight is added to that resulting from the weight of the bit. The result is an intermittent pounding force which acts preferentially against the low side of the hole only, since the weight of the collar and bit always adds to the pressure against the low side of the hole but is subtracted from that against the high side. It is believed that this pounding tends to abrade away the lower side of, and thus straighten, the hole.

Several embodiments of my invention will now be described, purely by way of illustration, since other embodiments could easily be designed without departing from the basic principles of my invention. Referring now to the drawings:

FIG. 1 is a vertical section showing a bit surmounted by one of my eccentrically weighted drill collars at work in a well, the deviation of which from the vertical has been exaggerated to make it more clearly apparent;

FIGS. 2, 3 and 4 are side views of various types of eccentrically weighted drill collars suitable for use in carrying out my invention; and

FIGS. 5, 6 and 7 are transverse sectional views taken along the lines V—V, VI—VI and VII—VII of FIGS. 2, 3 and 4 respectively.

Like reference characters denote like parts throughout the several views.

Referring now to FIG. 1, it will be seen that a conventional drilling bit 10, e.g., a three-cone rock bit, is mounted at the bottom of a string of pipe. Immediately above the bit is a collar 11. This collar is substantially straight. By this it is meant that, when placed in a stationary position under normal compression, say 10,000 to 50,000 pounds, above the bit, no portion of the collar will project radially beyond the periphery of the bit. The outer surface of the collar is preferably, but not necessarily, concentric with or symmetrical with respect to its longitudinal axis. One side of the collar is, however, heavier than the other so that as the drill string rotates the collar will tend to revolve or gyrate about the longitudinal axis of the string. It is, however, neither necessary nor desirable for the collar itself to swing far enough out of line to brush against the wall of the well.

As the collar revolves about its longitudinal axis the bit swings from its solid line position against the low side of the hole to its dotted line position toward the high side once in every revolution. (This distance has likewise been exaggerated in the figure so that it may be clearly seen.) As hereinbefore pointed out, every time the heavy side of the collar approaches the low side of the hole, a

force representing a component of the total weight of the collar and bit is added to the centrifugal force due to the extra weight on the heavy side of the collar to produce an abrasive pounding of the low side of the hole, but the effect of this component of the total weight is subtracted from that of centrifugal force as the heavy side of the collar approaches its dotted line position, so that there is much less force exerted against the high side of the hole.

It will be appreciated that any desired number of my collars can be mounted in series above a bit, with their heavy sides in alignment, thus multiplying the force exerted on the bit.

However, experience has shown that one eccentrically weighted collar is sufficient, and this should be mounted immediately above the bit.

The difference in weight between the heavy and light sides of the collar must be substantial, ordinarily from $\frac{1}{2}\%$ to 6% of the total weight of the collar, certainly no less than $\frac{1}{10}\%$ and no more than 10%. In the case of a collar weighing 4300 pounds from 1% to $1\frac{1}{2}\%$ has proven quite satisfactory.

It will of course be appreciated that if the weight differential is produced by removing material from one side of the bit, the removal of material located at a maximum distance from the longitudinal axis of the collar will be more effective than such removal from a point nearer that axis.

Under certain circumstances it is desirable to concentrate the weight differential in the lower part of the collar, so as to get it as near the bit as possible.

The use of my invention permits the imposition of weights on bits used in sloping formations which are substantially in excess of those which may be imposed on angle-mounted bits in the same formations, thus materially increasing the speed at which the hole is drilled and producing substantial savings, since drilling costs are to a considerable extent dependent on the length of time a drilling rig must be employed and its crew paid. It should be borne in mind, however, that it is still necessary to take into account all the factors which commonly affect the choice of weight in drilling a well. The use of my invention simply reduces the extent to which the weight must be reduced due to sloping formations. For example, in drilling one well using my invention in a formation which permitted weights of no more than 5-10 thousand pounds if serious deviation were to be avoided, I was able to use weights of from 10 to 50 thousand pounds, thereby cutting the normal drilling time for even reasonably straight holes in that formation in half. When, however, weights of 75-100 thousand pounds were imposed, deviation resulted.

It should be noted that my eccentrically positioned weight is concentrated within a radius no greater than that of the bit. If the weight were in the form of an eccentric projection or an elbow in the collar extending beyond the circumference of the bit, the projection or elbow would itself strike the low side of the hole at a point too high to alter its direction, and would prevent hammering against the bottom of the low side of the hole by the bit itself. It should additionally be borne in mind that when drilling for oil the space between the collar and the wall of the well is normally full of a rather viscous "mud." The rotation of a projection or elbow through such "mud" would waste a considerable quantity of power. My weight is so positioned as to avoid such waste.

It will be appreciated that there are many possible ways of constructing collars which have one side heavier than the other, despite being substantially straight, and even though having an outer surface free from projection or elbows.

Several possibilities are illustrated in FIGS. 2-7 inclusive. FIGS. 2 and 5 show a collar in which a series of radial blind holes 15 have been drilled in the outer surface along a line parallel to its longitudinal axis.

FIGS. 3 and 6 show a collar in which longitudinal

grooves 16 have been cut on one side only of its outer surface.

FIGS. 4 and 7 show a collar in which transverse slots 17 have been cut in its outer surface.

It will of course be understood that these holes may be of any shape, and could be filled with a heavier metal, such as lead, instead of being left open, and my collars may be used with any conventional non-directional bits.

What is claimed is:

1. An eccentrically weighted collar for connection in a drill string above a drill bit in a borehole comprising a straight member having parallel axes of symmetry and rotation which member is eccentrically weighted with respect to a plane passing through said axis of rotation, said member being radially contained within the circle described by rotation of said drill bit in drilling said borehole and having no portion which preferentially bears upon the wall of the borehole during use.

2. The drill collar of claim 1 wherein said axis of symmetry is coincident with said axis of rotation.

3. The drill collar of claim 1 wherein said straight member is free of projections and elbows.

4. The drill collar of claim 1 wherein said weight differential between the heavier and lighter sides of the collar is from one-half percent to ten percent of the overall weight of the collar.

5. An eccentrically weighted drill collar for interconnection in a drill string above a rotary drill bit in a borehole and having means at the end thereof for connection to said bit to provide a common axis of rotation of said collar and said bit, said collar having an axis of symmetry parallel to said axis of rotation, being eccentrically weighted with respect to a plane passing through said axis of rotation, and having a rigidity and radial dimensions such that it is contained during operation within the circle described by rotation of the periphery of said drill bit in drilling said borehole so that no portion of said collar preferentially bears on the wall of the borehole.

6. An eccentrically weighted drill collar for interconnection in a drill string above a drill bit in a borehole comprising:

a straight member having means at the end thereof for connection to a rotary drill bit to provide a common axis of rotation of said collar and said bit;

said collar being eccentrically weighted with respect to a plane passing through said axis of rotation to impose an eccentric weight on said bit sufficient to urge said bit to a vertical drilling position;

said collar being radially contained within the circle described by rotation of said drill bit in drilling said borehole and having no portion which preferentially bears on the wall of the borehole during use.

7. The drill collar of claim 6 wherein said eccentric weight imposed on the bit corresponds to one-half percent to ten percent of the weight of the collar.

8. An eccentrically weighted drill collar for interconnection in a drill string above a drill bit comprising:

a straight tubular member having means at the end thereof for connection to a rotary drill bit to provide a common axis of rotation of said member and said bit;

said member being weight-relieved along one side of a plane passing through the axis of rotation of said member to produce an eccentric weighting on opposite sides of said plane corresponding to one-half percent to ten percent of the overall weight of said collar.

9. The drill collar of claim 8 wherein said tubular member has a generally cylindrical outer configuration.

10. The drill collar of claim 8 wherein said material removal is from the radially outermost portion of the collar.

11. The drill collar of claim 8 having blind holes in

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the outer surface of said member longitudinally along said weight relieved side.

12. The drill collar of claim 8 having at least one longitudinal groove in the outer surface of said member along said weight relieved side.

13. The drill collar of claim 8 having slots in the outer surface of said member along said weight relieved side.

14. A method of inhibiting deviation from vertical in drilling a borehole with a rotating bit on a drilling string which comprises:

placing in said drilling string immediately above the bit an eccentrically weighted drill collar to impose on said bit, within the cylindrical space defined above the circle described by rotation of said bit in drilling said borehole, a weight corresponding to one-half percent to ten percent of the overall weight of the collar, which weight is eccentrically positioned with respect to the axis of rotation of said bit; and

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rotating said bit while avoiding preferential bearing of any portion of the drill string against the wall of the borehole in the region of said eccentric weight.

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