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T. F. MOORE ET AL
HOLE STRAIGHTENING DEVICE

3,154,156

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3 Sheets-Sheet 1

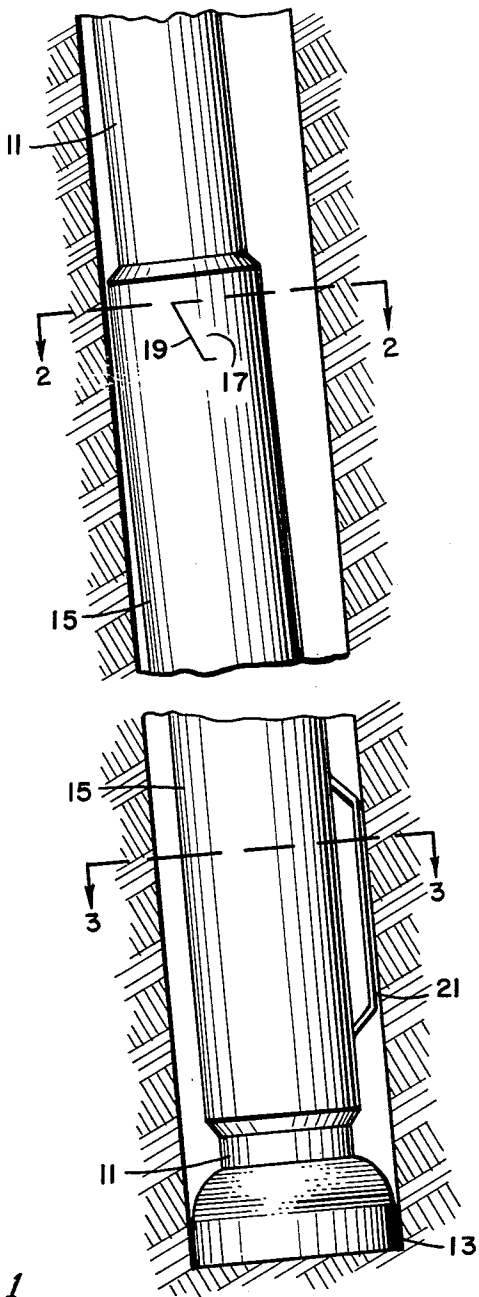


Fig. 1

ATTEST
Charles A. Steininger

INVENTORS
Thomas F. Moore,
James M. Cleary
BY *Frederick E. Birch*
Attorney

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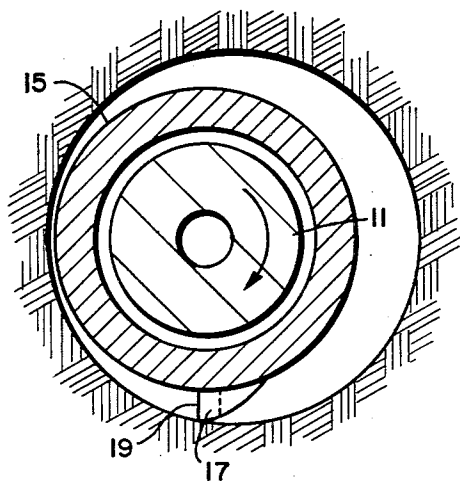


Fig. 2

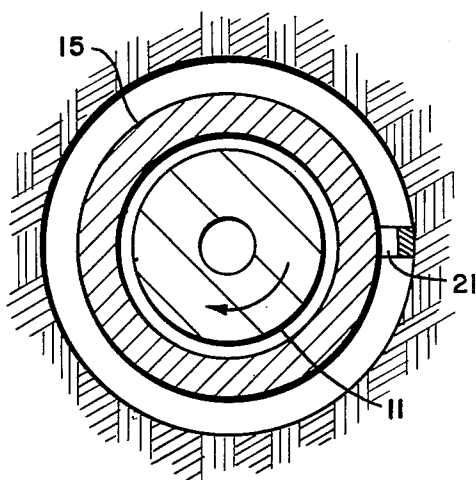


Fig. 3

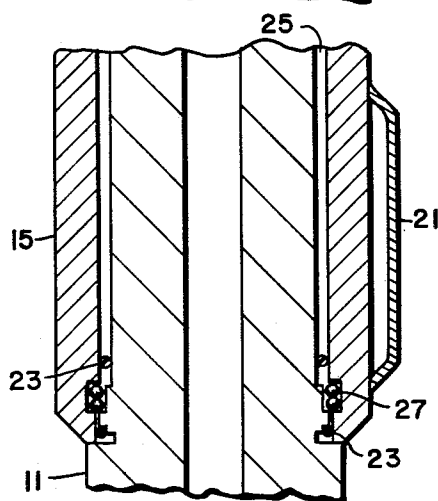
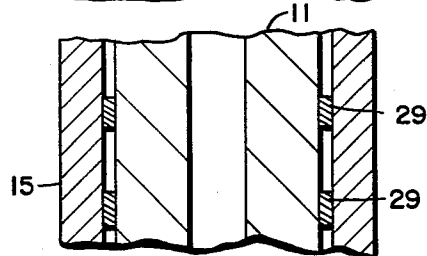
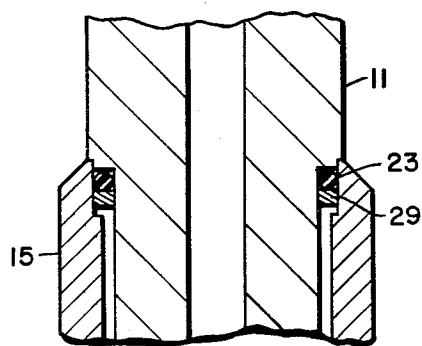


Fig. 4

ATTEST
Charles F. Steininger

INVENTORS
Thomas F. Moore,
James M. Cleary
BY *Robert E. Birch*
Attorney

Oct. 27, 1964

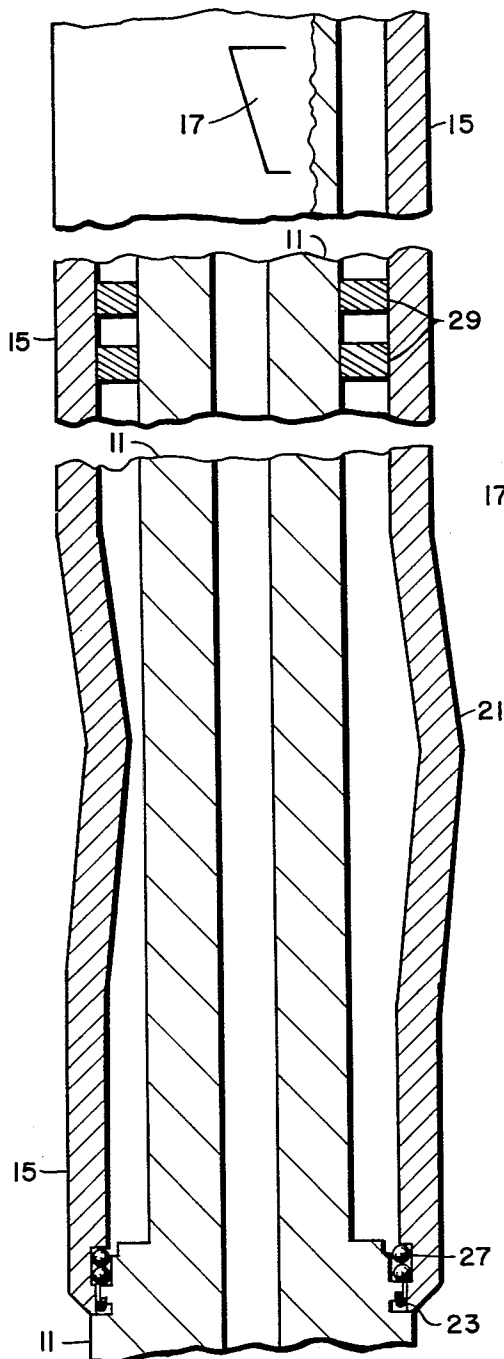
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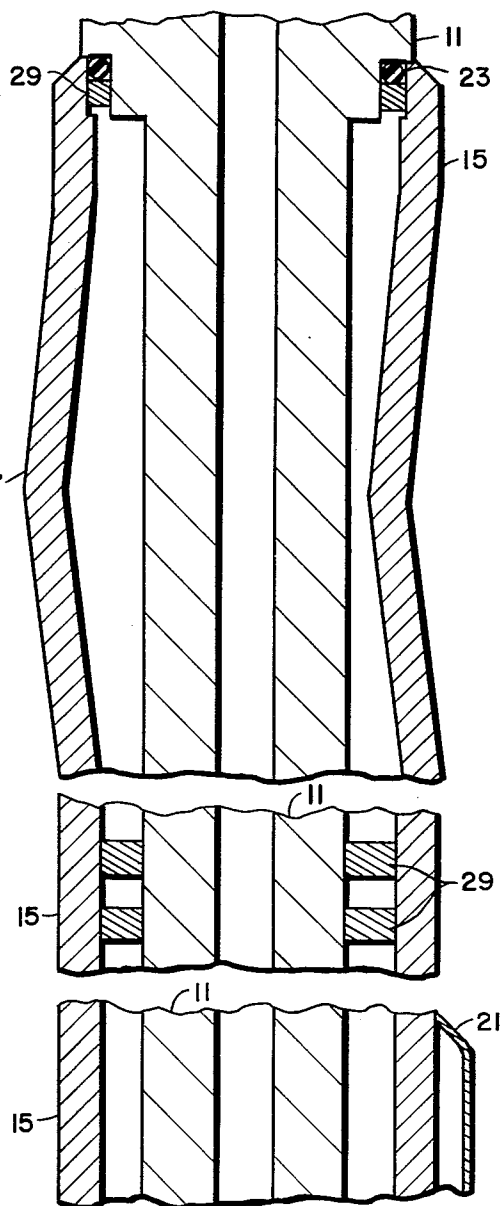
HOLE STRAIGHTENING DEVICE

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3 Sheets-Sheet 3



ATTEST
Charles A. Steininger



INVENTORS

Thomas F. Moore,
James M. Cleary

BY *Robert E. Birch*
Attorney

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HOLE STRAIGHTENING DEVICE

Thomas F. Moore and James M. Cleary, Dallas, Tex.,
assignors to The Atlantic Refining Company, Philadel-
phia, Pa., a corporation of Pennsylvania

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6 Claims. (Cl. 175—76)

This invention pertains to a means and method of rotary drilling that produces a borehole approaching gravitational vertical. More specifically, the present invention relates to an elongated, automatically self-orienting, rotatable sleeve which urges a drilling means to follow a gravitational vertical path.

It is well known that earth drilling bits tend to drift thereby drilling crooked holes. This drifting creates many problems in earth drilling, among which are drill-stem fatigue, pinching and freezing of the bit, increased collar wear and key slotting, decreased drilling rates, non-uniform drill bit wear and dry holes.

Prior attempts to alleviate these problems of crooked holes have been many and varied, but, in general, unsatisfactory. One group of devices were developed to straighten boreholes already deviated from vertical. These latter devices are usually called directional drilling devices and consist of means for controlled deflection of a bit. Normally, these directional devices are manually oriented to force the bit in one set compass direction. Once these devices are put in operation, the direction of deflection cannot be altered without deactivating, re-orienting and reactivating the device. This seriously limits their use in routine drilling of vertical boreholes and they are, in general, uneconomical and unsuitable for this purpose.

Other attempts at eliminating crooked holes have been concerned primarily with means for stabilizing the bit and drilling straight boreholes instead of vertical boreholes. These stabilizers tend to resist any deflection of the drill bit. But they do not prevent a gradual change in direction; therefore, if the bit gradually drifts from vertical but maintains a substantially straight borehole, these stabilizers will not cause the bit to return to vertical. Where these stabilizers were described as drilling vertical boreholes, the devices relied on the "plumb-bob" or "pendulum" effect. This effect exists when the deviation from vertical exceeds an angle at which the pull of gravity on the bit and drill collars prevents the forces tending to deflect the bit from causing added deviation. Occasionally, however, the causes of these deflecting forces abruptly change and the pull of gravity causes too rapid a change in direction. The "plumb-bob" effect, therefore, is not a reliable cure for "crooked holes."

Other devices allegedly designed to drill vertical boreholes actually increase non-uniform bit wear, drill collar wear, bending stresses and key slotting in the vicinity of the bit because they tend to cock or wobble the bit and drill collars.

Presently available equipment, therefore, is either ineffective for drilling a vertical borehole or has undesirable characteristics. It is an object of this invention to provide an economical and practical device and method for drilling vertical boreholes without increasing drill collar wear, bending stresses and non-uniform bit wear.

It is a further object of this invention to provide an automatically, self-orienting, lateral force applying means to deflect the drill bit back to vertical even if the borehole is straight.

Another object is to provide a means which may perform as a controlled unstabilizer urging the drill bit to follow a substantially vertical path.

Yet another object is to provide means for automatically orienting a lateral force in relation to the earth's center of gravity.

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A further object is to provide a relatively simple device which can be readily utilized in conjunction with devices controlling the rate of deviation of a borehole.

Still another object is to provide a borehole straightener whose principles of operation can be adapted to many forms and whose operation can be made intermittent.

Further advantages and objects will become apparent after reading this specification and examining the accompanying drawings showing simplified embodiments of this invention.

In the drawings,

FIGURE 1 is a fragmented, elevational view of a borehole straightening device in the position that it will assume when the borehole deviates from vertical.

FIGURES 2 and 3 are transverse, cross-sectional views taken as indicated by 2—2 and 3—3 on FIGURE 1. FIGURE 2 shows a stop means which orients a force means whose position relative to the "stop" means is shown in FIGURE 3.

FIGURE 4 is a fragmented, elevational, cross-sectional view showing the internal construction of the borehole straightening device of FIGURE 1.

FIGURE 5 is a fragmented, elevational, partial, cross-sectional view showing an alternative means for applying a straightening force to the device of FIGURES 1 and 4.

FIGURE 6 is a fragmented, elevational, cross-sectional view showing an alternative means for orienting the force means of the device shown in FIGURES 1 and 4.

In rotary earth drilling, when the borehole deviates from vertical, the drill collars immediately above the bit will buckle to the low side of the borehole. The distance from the bit to the point of tangency of this buckle and borehole wall varies with the degree of borehole deviation and shifts downward toward the bit as the degree of deviation increases. This invention utilizes this buckling phenomenon to control a lateral force which urges the bit to return to a vertical path. Generally, this invention comprises an elongated, frictionally mounted, rotatable sleeve of sufficient length to be measurably influenced by the lowest naturally occurring buckle in the drill collar string. The sleeve is mounted on the drill collars immediately above the bit. Near the lower end of the sleeve in the vicinity of the bit is a lateral force applying means whose direction of application is controlled by the sleeve. On the sleeve above the force means is a stop means which in relation to the direction of rotation leads the force means by circumferential spacing of not more than 180°. The stop means and force means are circumferentially oriented in relation to each other so that the force means is directed to the high side of the borehole whenever the stop means prevents rotation of the sleeve. Briefly, in operation, the sleeve is normally rotated by rotation of the drill collars and advancement of the drill bit. As the borehole deviates from vertical, the collars buckle to the low side of the borehole deflecting the sleeve in the same direction and causing the stop means to contact the wall of the borehole thereby preventing further rotation of the sleeve. This orients the force means toward the high side of the borehole so that its lateral force urges the bit toward vertical.

For more detail, referring now to the drawings and in particular to FIGURE 1, there is indicated a borehole which for illustrative purposes has been deviated from vertical to an exaggerated degree. Drill collars 11 are shown as adapted to this invention. Removably attached to the lower end of these drill collars is conventional drilling means 13 that represents any form of drilling means that can be rotated by a drill string. Frictionally and rotatably mounted about a portion of drill collars 11 is elongated sleeve 15 of sufficient length to utilize the influence of the first naturally occurring buckle in drill

collars 11 above drilling means 13. The length of sleeve 15 is, therefore, dependent on the flexibility of the drill collars, the weight of and on the drill collars and the degree of borehole deviation. Since, in normal drilling operations, drill collars 11 are substantially inflexible, the length of sleeve 15 will exceed twenty-five feet and usually be nearer fifty feet. Because of this length, the sleeve will frequently extend over several drill collars and may be formed of several sections threaded together.

Normally, sleeve 15 tends to rotate with drill collars 11 because of the friction between sleeve 15 and drill collars 11.

As shown in FIGURE 1, near the upper end of sleeve 15 is stop 17 which strikes the wall of the borehole when the upper end of sleeve 15 is buckled toward the low side of the borehole by drill collars 11. In this position, stop 17 prevents further rotation of sleeve 15 thereby holding it stationary while drill collars 11 are freely rotated therein. FIGURES 1 and 2 show stop 17 as a rigidly mounted, single, protruding, longitudinal rib whose leading face surface 19 is a flat, smooth, surface and whose upper end in relation to the direction of rotation circumferentially leads the lower end thereby inclining leading face surface 19. This inclination in the leading face surface acts to prevent stop 17 from digging into and wedging into the formation because as drilling means 13 is advanced into the borehole, inclined leading face surface 19 presses against the formation and tends to rotate the stop in a direction opposite to the direction in which the drilling means is rotated. The trailing surface of stop 17 is shown in FIGURE 2 as rounded and gradually tapering to the surface of sleeve 15. It should be noted that stop 17 can be in any form that does not prevent rotation of the drill collars inside the sleeve. For example, stop 17 could be spring biased instead of rigidly mounted, and could be retractable to facilitate fishing or jarring operations if the drilling means or sleeve should become wedged or pinched in the borehole. Moreover, the stop could be made of frangible materials or hardened rubber for similar reasons. In addition, the stop could be utilized in drilling operations where the drilling means is rotated both clockwise and counterclockwise as viewed from the surface. In such cases, the stop could be movably fitted to the sleeve so that changing the direction of rotation would slide the stop to a new position dependent on the design of that particular sleeve and the stop would have faces similar to leading face surface 19 in both directions. The stop could also be designed to open and close valve ports to control the application of a hydraulically operated force means as described later.

The distance that stop 17 protrudes from sleeve 15 is determined by the relative diameters of the sleeve and borehole and by the length of the sleeve and the factors controlling this length as mentioned previously.

Near the lower end of sleeve 15 is lateral force applying means 21 which in FIGURE 1 is shown as a bow spring exerting a substantially continuous, predetermined, lateral force on drill collars 11 and drilling means 13. As shown, force means 21 is circumferentially spaced 90° from stop 17 and trails the stop in the direction of rotation. It should, however, be recognized that the circumferential spacing of force means 21 and stop 17 may be varied from 90° so long as force means 21 trails stop 17 with relation to the direction of rotation of drill collars 11 and the circumferential spacing is not more than 180°. As shown by FIGURES 1, 2 and 3, force applying means 21 is oriented in relation to stop 17 so that its force is applied against the high side of the borehole when stop 17 prevents rotation of the sleeve. Force means 21 thereby deflects drilling means 13 away from the high side of the borehole or, in other words, toward gravitational vertical.

Force applying means 21 can be any suitable device for applying a lateral force to the bit, e.g., a mud jet, an expansible and retractable hydraulically operated plate or

rod, a spring loaded rod or plate, or a permanent bow in the lower end of the sleeve. Moreover, lateral force applying means 21 could be made to operate intermittently or continuously. For example, the force means could be a hydraulically activated, retractable plate whose force would only be applied when stop 17 pushes against the wall of the borehole and opens ports communicating with the high pressure drilling fluids used in rotary drilling. In another example, both the stop and force plate could be normally retracted and be connected by suitable ports to the high pressure drilling fluid. The stop and force plate would be activated only upon closing a flow channel thereby restricting the flow of drilling fluid through the bit and raising the pressure in the drilling fluid high enough to expand the stop and force means or the mud pump pressure could be increased to expand the stop and force means. Moreover, the sleeve or drilling means could incorporate devices to control the rate of deviation of the drilling means to prevent force means 21 from causing too rapid a change in direction.

Referring now to FIGURE 4, the mounting of sleeve 15 to drill collars 11 is shown. The sleeve shown in FIGURE 4 is sealed at both ends by seal rings 23 and annulus 25 between drill collars 11 and sleeve 15 is filled with lubricant. The lower end of sleeve 15 is mounted to the drill collars on ball bearings 27 for rotation of the collars inside the sleeve. The rest of sleeve 15 is mounted in friction bearings 29. There is enough friction between sleeve 15 and drill collars 11 that sleeve 15 tends to rotate with the drill collars until stop 17 prevents further rotation of the sleeve. Force means 21 will, therefore, tend to change direction until stop means 17 prevents further rotation of the sleeve.

FIGURE 4 shows but one embodiment for mounting the sleeve. The sleeve could be mounted to the collars in a clamp around fashion to permit easy removal thereof. Moreover, the sleeve could be mud lubricated by permitting mud to flow continuously through the sleeve-collar annulus 25.

The operation of the hole straightening device is best understood by reference to FIGURES 1 and 4. During drilling, drill collars 11 are continuously rotated as drilling means 13 advances. As drill collars 11 are rotated, sleeve 15 rotates. As sleeve 15 rotates, force means 21 continuously applies a lateral force to drilling means 13 tending to unstabilize the drilling means and cause it to drift, but since force means 21 is continuously changing in direction the amount of drift is slight. This could cause drilling means 13 to follow a slightly spiralling path. This continuously changing force tends to prevent uneven wear of the drilling means and to decrease the natural tendency of the drilling means to seek a gradually drifting path. When drilling means 13 drift from vertical as shown in FIGURE 1, drill collars 11 will buckle to the low side of the borehole and in turn buckle sleeve 15 toward the low side. When this occurs, stop 17 starts to impede rotation of the sleeve until the buckle is sufficient for stop 17 to press against the borehole wall with sufficient force to prevent further rotation of sleeve 15. Force means 21 being oriented in relation to stop 17 is then placed toward the high side of the borehole and continuously applies its force in one direction thereby deflecting drilling means 13 from the high side until the borehole returns to a vertical path and stop 17 no longer prevents the sleeve from rotating. The sleeve, therefore, automatically orients a straightening force to urge the drilling means to follow a substantially vertical path regardless of the straightness of the borehole.

In FIGURE 5, there is shown an alternative means for applying a force to deflect the bit back to vertical. The sleeve 15 has a permanent bow in its lower portion. This permanent bow is oriented with relation to stop 17 so that the bow is placed toward the high side of the borehole when stop 17 prevents further rotation of the sleeve. In operation, as the borehole deviates from vertical, stop

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17 prevents rotation of sleeve 15 and places the permanent bow in sleeve 15 toward the high side of the borehole. Upon further deviation, drill collars 11 tend to buckle inside sleeve 15 to conform to the permanent bow and this places the first buckle in the drill collars above drilling means 13 on the high side of the borehole causing the drilling means to be deflected toward the low side and return to vertical.

In FIGURE 6, there is shown an alternative stop means. The sleeve 15 has a permanent bow in its upper portion. This permanent bow is oriented at 180° from force means 21 so that force means 21 is placed toward the high side of the borehole when the permanent bow prevents rotation of the sleeve. In operation, as the borehole deviates from vertical, drill collars 11 buckle to the low side of the borehole and when the buckle is sufficiently large, the permanent bow in sleeve 15 will align with the buckle in the drill collars and sleeve 15 will no longer rotate with the drill collars. At this point, force means 21 is placed on the high side of the borehole and deflects drilling means 13 back to vertical.

The above description of this invention details three simplified embodiments capable of performing all the objects set forth herein; but this invention is not limited to these specific details. We reserve the right to variations or modifications that are apparant to those skilled in the art and that are within the scope of the following claims.

We claim:

1. In a borehole drilling apparatus having a drilling means rotated by a drill collar string, an improved borehole straightener comprising a substantially inflexible, elongated, cylindrical sleeve rotatably and frictionally mounted about said drill collar string adjacent said drilling means, force applying means formed on the lower end of said sleeve, stop means located on said sleeve above said

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force applying means and leading said force applying means with relation to the direction of rotation of said drill collar string by a predetermined angle of not more than 180 degrees, said stop means being adapted to engage the wall of said borehole and prevent rotation of said sleeve with said drill collar string at such times as the borehole deviates from vertical by a predetermined amount, and said force applying means being adapted to apply a lateral force to the lower end of said sleeve to urge said drilling means toward vertical at such times as said stop means prevents rotation of said sleeve with rotation of said drill collar string.

2. A borehole straightener in accordance with claim 1 wherein the force applying means is a bow spring.

3. A borehole straightener in accordance with claim 1 wherein the force applying means is a permanent bow in the lower end of the sleeve.

4. A borehole straightener in accordance with claim 1 wherein the stop means is a single protruding rib.

5. A borehole straightener in accordance with claim 1 wherein the stop means is a permanent bow in the upper end of the sleeve.

6. A borehole straightener in accordance with claim 1 wherein the length of the sleeve is at least twenty-five feet.

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