May 14, 1968 E. B. WILLIAMS, JR 3,382,938

DRILL COLLAR

Filed Oct. 3, 1966

Fig. 1. Fig. 2. Fig. 3.

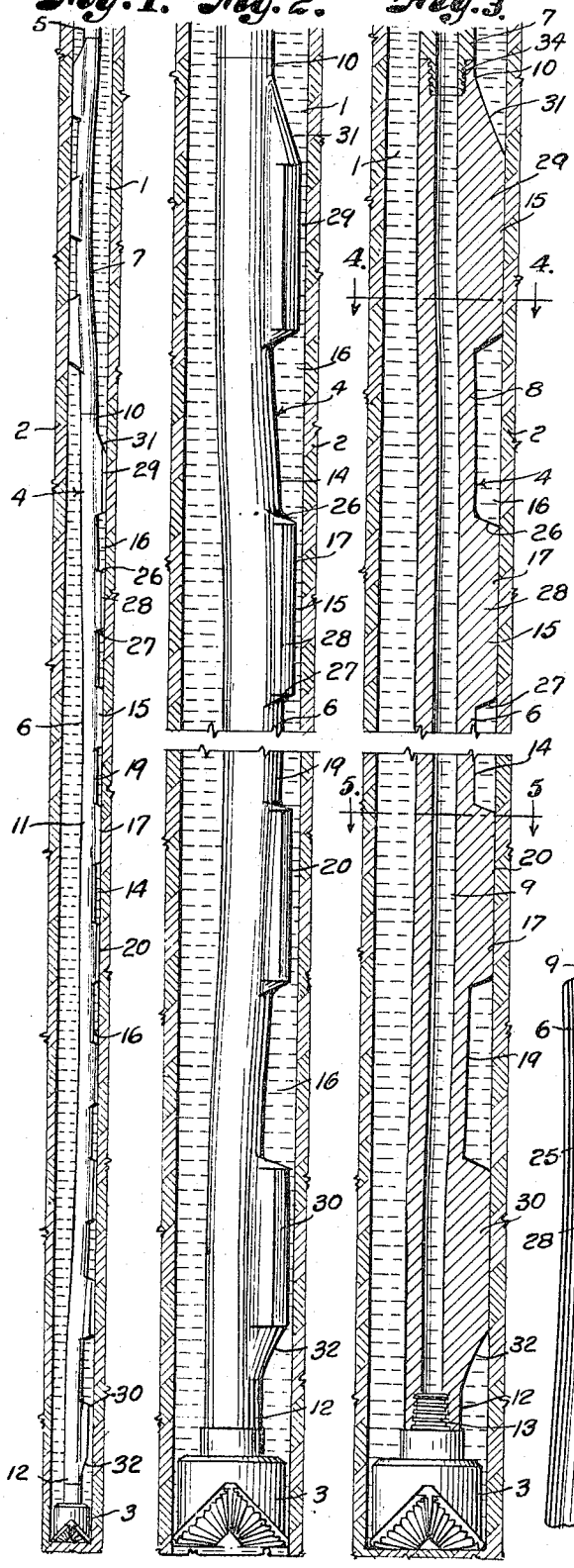


Fig. 4.

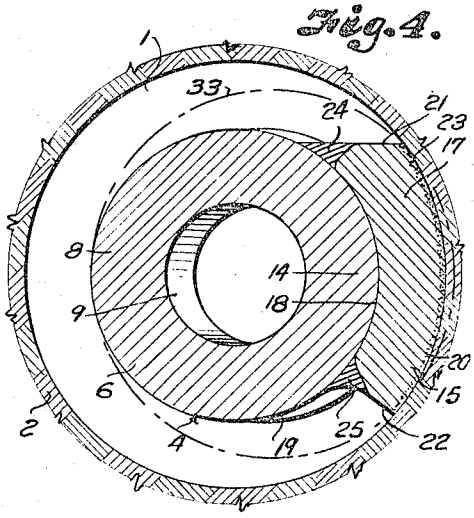


Fig. 5.

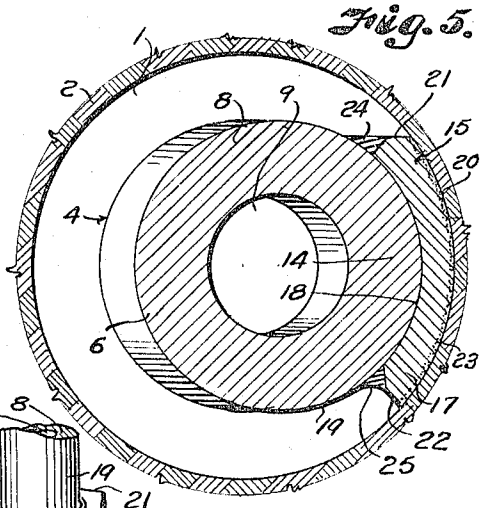
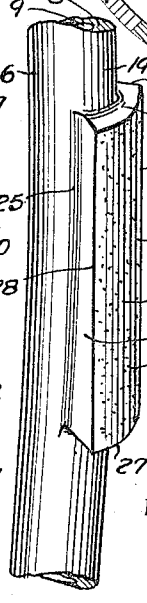


Fig. 6.



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DRILL COLLAR

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10 Claims. (Cl. 175—325)

This invention relates to drill collars used in rotary drilling of a borehole through earth formations to substantial depths, and particularly to an improved drill collar for controlling deviation of the drill bit from its intended course.

Usually drill collars consist of one or more stands of heavy-walled drill pipe that are inserted into the drilling string just above the drill bit in an attempt to maintain a stiff stem for the bit. The drill collars, together with the drill pipe secured thereto, provide an elongated heavy-weight column of metal that pushes the drill bit against the bottom of the borehole as the drill bit is rotated. Due to the length and yieldability of the string of drill pipe, the drill pipe bends under compression of its own weight, and makes contact with the wall of the borehole at various points along the length thereof. It is obvious that as the weight increases toward the bottom of the borehole, the spacing between points of contact becomes less, and in spite of the increased rigidity afforded by the drill collars, there is sufficient bend therein to carry the drill bit toward the wall of the borehole. When the drilling operations are carried out with the drill collar in contact with the wall of the borehole by bending, the axis of rotation remains in the center of the collar as it rotates about its bent axis, thereby aiming the drill bit at an angle to the true axis of the borehole. Consequently, the bit continuously deflects from its intended drilling position, to produce a crooked hole. When the drill bit encounters a dipping formation, this deflection of the borehole is aggravated because the drill bit tries to drill in a direction normal to the plane of the formation.

Many schemes have been devised to correct angularity of the drill bit, such as inserting a relatively short offset coupling between the lower end of the lowermost drill collar and the bit to compensate for deflection of the bit by the drill collar and thereby hold the drill bit on its intended course, however, such couplings are not satisfactory.

Another method is to use a drill collar having a section modulus therein which produces a predominately greater bend in the drill collar at the point of contact with the wall of the borehole and which locks under weight to hold the bit centered in the borehole. Such a drill collar is readily moved into and out of the borehole because the induced bend straightens out when the drill bit is lifted off the bottom of the hole. But the section modulus is provided by reducing the cross section of the drill at the point of the bend, so that the strength of the drill collar is sacrificed. Also, contact with the wall of the borehole is rather abrupt and there is insufficient guiding of the stem.

A still further method is to use a drill collar wherein the major portion is offset on an axis parallel with the axis of the tool joints which couple the drill collars into the drilling string, the offset being in the manner of a crank and in an amount sufficient to maintain bearing contact with the wall of the borehole, and the offset being of sufficient length to hold the drill bit in a straight course. The difficulty here is in producing the bends in a thick-walled drill pipe to attain the crank effect required for the offset. Also, the continuous contact of the offset along the length thereof interferes with flow of the drilling fluid and cuttings carried thereby.

With the above in mind, it is the object of the present invention to provide drill collars of more rigid character and which carry a series of spaced apart pads extending radially from one side of the collar and having faces in wiping contact with the wall of the borehole. The pads thus support the collar along substantially the full length thereof to maintain the drill bit in the desired drilling axis and prevent deviation because of bending of the drill collar or tendency of the drill bit to follow dipping formations.

It is also an object of the invention to provide the drill collar with a permanent curvature or warp on the side thereof having the pads, to assure that if curvature of the drill collar should occur under weight of the column of drill pipe, the curvature develops on the side having the pads, thereby retaining the pads in wiping contact with the wall of the borehole.

Other objects of the invention are to provide a drill collar which more efficiently accomplishes its intended purpose, and to provide a drill collar which is easily produced without weakening the strength of the collar.

In accomplishing these and other objects of the invention as hereinafter pointed out, improved structure is provided as illustrated in the accompanying drawings, wherein:

FIG. 1 is a longitudinal section of a borehole being drilled by a drilling string equipped with drill collars constructed in accordance with the present invention.

FIG. 2 is a similar, but enlarged, view showing the drilling string being lowered through the borehole, with the drill collar being shown in elevation.

FIG. 3 is a similar view after the drill bit has reached the bottom of the borehole and the drilling is started, the drill collar being shown in section to better illustrate contact of the pads with the wall of the borehole.

FIG. 4 is an enlarged cross section through the upper portion of the drill collar, taken on the line 4—4 of FIG. 3.

FIG. 5 is a similar cross section of a mid-point of the drill collar and taken on the line 5—5 of FIG. 3.

FIG. 6 is a fragmentary perspective view of the drill collar, to better illustrate one of the pads and its wiping face.

Referring more in details to the drawings:

1 designates a borehole being drilled through earth formations 2 by means of a rotary drill bit 3 which forms part of a drilling string 4. The drilling string is made up of a series of stands of drill pipe interconnected by customary tool joints whereby the stands of drill pipe are connected and disconnected when running in and pulling of the drilling string as for changing drill bits and the like.

Connected into the driling string 4 between the lowermost drill pipe 5 and the drill bit 3 are one or more drill collars 6 constructed in accordance with the present invention. In the present illustration, a long drill collar 6 is used with an upper shorter drill collar 7 (FIG. 1). The drill collar 6 comprises extra heavy thickwalled pipe of circular cross section to provide a cylindrical wall 8 of uniform thickness and an axial bore 9 for downflow of drilling fluid therethrough. The drill collar may or may not be of larger diameter than the drill pipe 5, the purpose being to provide weight and stiffness at the lower end of the drilling string and to provide a stiff stem for the drill bit 3 when the full weight of the drill pipe 5 is applied to the drill bit for increasing the drilling pressure and increase the drilling rate.

As previously pointed out, drill collars bend under weight of the drill pipe until a portion thereof makes contact with the wall of the borehole. This bending points or aims the drill bit so that it deviates from a linear course, and results in a crooked hole.

Also, deviation of the bit is increased when the bit is drilling through dipping formations, because the stem is not rigid enough to be properly guided for holding the drill bit in a straight linear course. As above described, it is the purpose of the present invention to avoid these difficulties by providing an improved construction of the drill collars, as now to be described.

In accomplishing the invention, curvature in a drill collar is restricted to one radial direction by forming the collar with a warp or curvature in one direction from near the upper tool joint to near the drill bit, as clearly shown in the drawings. The drill collar **6** thus curves radially outwardly from its upper box end **10** to its midpoint **11**, and then inwardly to the box end **12** which screws onto the pin **13** of the drill bit, and which provides the tool joints. Therefore, when the weight of the drill pipe is bearing on the bit, any tendency of the collar to bend under weight will be in the outward radial direction of said curvature.

In order to support the drill collar by the wall of the borehole and provide a straight guide for the drill bit, the convex side **14** is equipped with a longitudinal series of pads **15**, with the pads **15** spaced apart to allow passes **16** for circumferential flow of drilling fluid therebetween when the drill bit is being rotated, as later described.

Each pad **15** preferably consists of an arcuate block **17** having inner arcuate faces **18** (FIGS. 4 and 5) conforming in curvature to the circumferential face **19** of the drill collar. The outer faces **20** of the pads have a radius corresponding to the radius of the borehole being drilled by the drill bit **3**. Each pad **15** has a transverse width in the direction of rotation slightly less than the outside diameter of the drill collar (FIGS. 4 and 5), and the retractive side edegs **21** may approach a tangent to the outer surface **19** of the drill collar, while the forward edges **22** are formed substantially on a radius from the axis of the drill collar (see FIGS. 4 and 5). Since the faces **20** constitute wiping faces operating in contact with the wall of the borehole, the faces thereof are hardened as indicated by the stippling **23** (FIGS. 4 and 5) to resist wear of the pads through contact with the formations being drilled.

As above infered, the pads **15** are positioned on the surface of the drill collar on the convex side of longitudinal curvature and in substantially exact linear alignment with each other for attachment by welds **24** and **25**. The upper and lower ends **26** and **27** of the intermediate pads **28** are formed on relatively slight bevels, but the endmost pads **29** and **30** are formed on angles of about 15° with the drill collar, as indicated at **31** and **32**, to prevent snagging when running in and out of the drill collar and to facilitate engagement of a fishing tool (not shown) when required. The wiping faces **20** of the pads, being formed on the radius of the borehole **1** and in linear alignment with each other along the longitudinal direction of the drill collar, necessitate pads of different thickness so that the faces **20** all make contact with the wall of the borehole, as is clearly apparent in the drawings, to compensate for the permanent curvature of the drill collar.

The drill colar thus described with the pads thereon is easily lowered through the borehole **1** made by the drill bit **3**, and, in fact may be lowered through a much smaller hole diameter, indicated by the dot and dash circle designated **33** in FIG. 4.

In using the drill collars constructed as described, the box **12** of the drill collar is connected with the pin **13** of the drill bit **3** and lowered into the borehole. The pin **34** of the drill collar **7** is threaded into the box **10** of the drill collar **6**, in which position the outward curvatures of the drill collars **6** and **7** are diametricaly opposed with respect to each other, as shown in FIG. 1, and in position to engage diametrically opposite sides of the borehole **1**. After lowering the drill collars into the borehole, the stands **5** of drill pipe are connected with the box of the drill collar **7** and the assembly is lowered in the borehole with the connection of each stand **5** of drill pipe until the drill bit **3** is bearing on the bottom of the hole.

When the drilling string is under tension due to the weight thereof being suspended, there is ample clearance for the wiping faces **20** of the pads **28**, **29** and **30**.

Upon rotation of the drilling string as in conventional practice under weight of the column of drill pipe, the wiping faces of the pads are contacting the wall of the borehole and hold the rotational axis of the drill collar in the axis of the borehole. With the drilling string under rotation, the pads gyrate about the axis of the borehole, with the wear resistant faces of the pads riding in contact with the wall of the borehole, to maintain the stem of the bit which constitutes the drill collars in concentric relation with the borehole, the drilling fluid being circulated downwardly through the bore **9** discharging from the bit to carry the cuttings to the top of the borehole. The upwardly flowing drilling fluid passes freely through the passes **16** between the pads without losing substantial velocity. With the pads supporting the drill collars, the drill collars are sufficiently rigid, and guided by the walls of the borehole, to keep the drill bit from deviating from the vertical. It is obvious that each drill collar is loose in the hole, since it engages only one side wall, so that there is no danger of a collar becoming stuck in the hole.

If more than two drill collars are coupled into the drilling string, the curved portions are positioned circumferentially of the borehole, so that the pads contact the wall in symmetrical relation.

The drill collar **7** has the same construction as the drill collar **6**, but may be of shorter length. The drill collar **7** is arranged in the drilling string so that the outward curve therein is opposed to the outward curve of the drill collar **6** to stabilize the upper end of the collar **6** and prevent crowding thereof out of the axis of the borehole.

What I claim and desire to secure by Letters Patent is:

1. A drill collar for minimizing deviation of a borehole being drilled by a drill bit of a drilling string which includes a column of drill pipe under rotation in the borehole, said drill collar comprising

a drill pipe having ends for connection into the drilling string between the drill bit and the column of drill pipe to provide a stem for the drill bit,

said drill collar having a curvature extending longitudinally thereof to provide a convex side in the direction of a wall of the borehole and assure that any bend of the drill collar under weight of the column of drill pipe takes place in the direction of curvature, and

pads on the convex side of the drill collar and having virtually aligning faces for wiping contact with the wall of the borehole to provide support of the drill collar substantially along the full length thereof under weight of said column of drill pipe and to minimize bending that produces deviation of the drill bit.

2. A drill collar for minimizing deviation of a borehole as described in claim **1**,

wherein the pads are of different thickness to compensate for curvature of the drill collar to align said wiping faces.

3. A drill collar for minimizing deviation of a borehole as described in claim **2**, and

wherein the pads are spaced apart to provide passes therebetween for flow of drilling fluid.

4. A drill collar for minimizing deviation of a borehole as described in claim **1**,

wherein the pads are spaced apart to provide passes therebetween for flow of drilling fluid.

5. A drill collar for minimizing deviation of a borehole as described in claim **1**,

wherein the wiping faces of said pads have a transverse curvature substantially conforming to the radius of the borehole, and

the pads are spaced apart to provide passes therebetween for flow of drilling fluid.

6. A drill collar for minimizing deviation of a borehole as described in claim 1,

wherein the drill collar comprises a uniform thickwalled drill pipe to provide a comparatively stiff stem.

7. A drill collar for minimizing deviation of a borehole as described in claim 1,

wherein the wiping faces of said pads have a transverse width substantially equal to the outside diameter of the drill collar.

8. A drill collar for minimizing deviation of a borehole as described in claim 7,

wherein the pads are spaced apart to provide passes therebetween for flow of drilling fluid.

9. A drilling string, including

a column of drill pipe,

a drill bit rotated by the column of drill pipe for drilling a borehole,

thickwalled drill collars providing a substantially rigid stem connecting the drill bit with the column of drill pipe,

said drill collars having a preformed curvature to provide a convex side, and

pads carried by the convex side of the collars and having wiping faces supporting the drill collars against the wall of the borehole to guide the drill bit,

said collars being positioned relatively to each other for the pads of the respective drill collars to be supported against diametrically opposite walls of the borehole.

10. A drilling string as described in claim 9,

wherein the pads on each drill collar are spaced apart to pass drilling fluid therebetween.

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