Sept. 12, 1961 F. K. FOX 2,999,552

TUBULAR DRILL STRING MEMBER

Filed March 4, 1959

Fig. 3

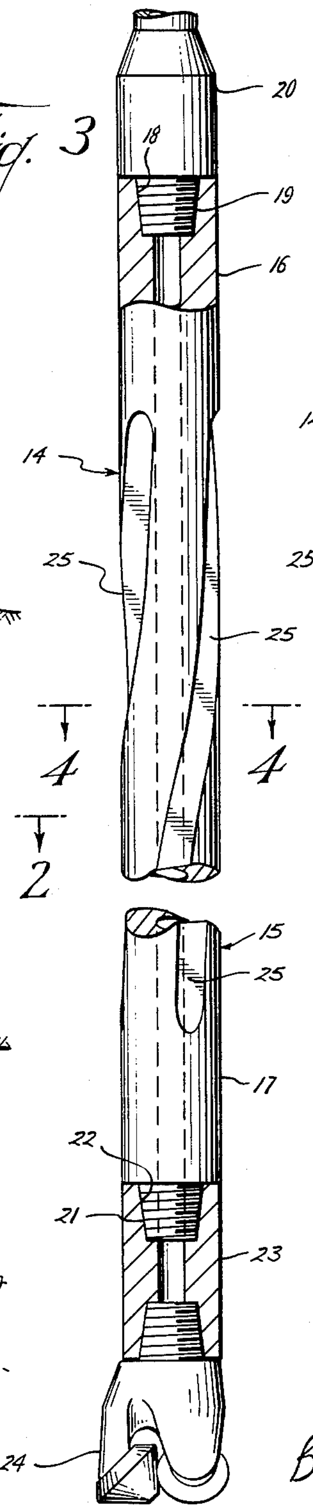


Fig. 4

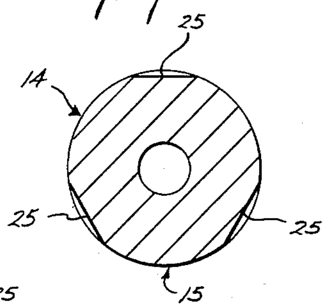


Fig. 1

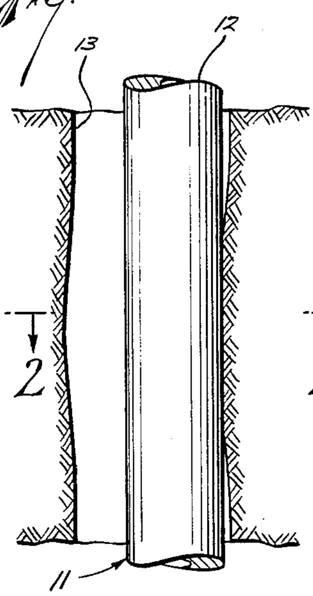


Fig. 5

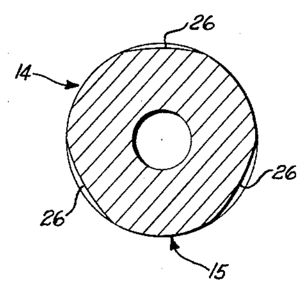
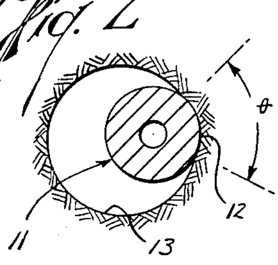


Fig. 2



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TUBULAR DRILL STRING MEMBER

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This invention relates to an improved tubular drill string members such as a drill collar for use in the rotary drilling of wells.

The purpose of a drill collar is to concentrate the weight load on a bit at the lower end of a rotary drill string. It comprises a long and heavy tubular member connectable in the string above the bit for conducting drilling fluid to the bit. Two or more collars may be used in series with one another depending on the desired weight to be applied to the bit.

The outer diameter of such collars is less than that of the bit so as to permit the drilling fluid to be returned up through an annulus between the well bore and collar. Nevertheless, they frequently become stuck in the well bore. It is a relatively modern theory that, in the drilling of oil and gas wells, such sticking can be caused by a force acting on the collar when it engages a side of the bore. That is, the hydrostatic pressure of the drilling fluid or "mud" conventionally employed in this type of drilling is greater than that of the formation at this location in the bore, such that the collar will be held against the bore with a force dependent upon the area of contact and the pressure differential.

The considerable length of these collars raises the problem of bending and, for this purpose, it has been proposed to dispose annular sleeves known as "stabilizers" about them. While they may hold a certain portion of the collar out of engagement with the bore, these stabilizers actually constitute protrusions which may cause the collar to stick. Also, of course, there is nothing to prevent the portions of the collar intermediate the stabilizers from engaging the well bore.

It is an object of this invention to provide a drill collar so constructed as to at least lessen the likelihood of its sticking despite engagement with the well bore at substantially any location along its length.

Another object is to provide such a collar which is of uniform strength throughout substantially its entire length.

Still another object is to provide such a collar which facilitates the passage of fluid therepast in drilling and wash-over operations.

A further object is to provide such a collar which may be used in increase the effective weight on the bit.

These and other objects are accomplished, in accordance with the present invention, by a drill collar having one or more grooves about its outer peripheral surface to decrease the effective pressure area between the collar and the well bore with which said peripheral surface may engage, thereby proportionately decreasing the force to be overcome in releasing it.

The radius of this portion of the unrelieved outer peripheral surface of the drill collar is constant and no greater than the radius of the outer peripheral surface of such collar on opposite ends of the outermost grooved areas. Thus, this construction is distinguishable also from drill collars having outwardly projecting fins or ribs for reaming or other purposes.

For reasons mentioned below, it is preferred that such grooved areas be along at least one helical path. These grooves are of such depth and extend about a percentage of the over-all circumference of the collar so designed as to reduce the aforementioned area of contact a desired amount while, at the same time, maintaining the weight of the collar above a desired minimum.

One reason that the helical groove is preferred is that it distributes the reduced thickness of the collar uniformly

throughout the intermediate portions thereof so that there is no concentration of stresses sufficient to twist off the collar. Furthermore, the helical groove or reliefs increase the area of the vertical fluid course between the collar and a wash pipe during a wash-over operation. Also, when the drill string is rotated in the direction of the helix, the grooves cause the peripheral surface between them to have a propeller action in the heavy drilling mud or against the well bore so as to convert a portion of the frictional force on the collar due to its rotary movement into a longitudinal force effective to load the bit. Thus, the portions of the collars between the grooves act like propeller blades in that they create a force on the collar equal and opposite to the force with which they engage the fluid or semi-fluid in which the collar is rotated. Rotation of the helical grooves also reduces the chances of stciking by constantly changing the points of the well bore which are contacted by the peripheral surface of the drill collar intermediate the grooves.

It is further preferred that the helical grooves be formed by flat or convex surfaces so that the mud lining on the well bore is not removed by rotation of the collar.

In the drawings, wherein like reference characters are used throughout to designate like parts:

FIG. 1 is a longitudinal view of part of a conventional type of drill collar extending through a well bore and having a portion engaged with a side of the bore;

FIG. 2 is a cross-sectional view of the drill collar and bore, taken substantially along broken line 2—2 of FIG. 1;

FIG. 3 is a longitudinal view, partly in section, of one embodiment of a preferred from of drill collar constructed in accordance with the present invention, and with an intermediate portion thereof broken away;

FIG. 4 is a cross-sectional view of the drill collar of FIG. 3, as seen along broken line 4—4 of FIG. 3; and

FIG. 5 is a cross-sectional view of another embodiment of a preferred form of drill collar constructed in accordance with this invention.

Turning now to a detailed description of the above-described drawings, FIGS. 1 and 2 thereof are illustrative of the problem with which the present invention is concerned. More particularly, these figures show a conventional type of drill collar **11** having a portion **12** of its outer peripheral surface engaged with a side of a well bore **13**. As previously mentioned, the space within the bore and about the drill collar is filled with a drilling mud which has a high specific gravity such that it will normally be at a hydrostatic pressure greater than the pressure of the formation adjacent thereto.

As is apparent from FIGS. 1 and 2, the differential in pressure between the drilling mud and that of the formation is effective over an area determined not only by the length of the portion **12** of the collar, but also by the peripheral arcuate portion thereof of the portion **12** of the collar transcribed by the angle theta. If this area is large, as it well may be, and the pressure differential is also of considerable magnitude, it is quite possible that there would not be sufficient power available at the well-head to produce an axial lifting force sufficient to overcome this radial force such that the pipe will remain stuck.

For example, assuming that the drill collar were 6 inches in diameter and that it engaged with the well bore (which would normally be approximately 8¾ inches in diameter) for a length of 10 feet and about 60 degrees of its circumference, the total area of contact between the collar and bore would be 376.9 square inches. Assuming further that the formation pressure was 8,000 p.s.i. and that of the drilling mud were 10,000 p.s.i., the total force holding the collar against the well bore would be 753,840 lbs.

Referring now to FIGS. 3 and 4, one embodiment of the preferred form of drill collar **14** will be seen to comprise an elongate tubular member **15** connected in a drill string at its upper and lower ends **16** and **17**. More particularly, the upper end is provided with a threaded box **18** for connection with a threaded pin **19** on the lower end of a drill pipe **20**, and the lower end is provided with a threaded pin **21** for connection with the threaded box **22** of a bit sub **23** which connects the collar with any suitable rotary type bit **24**.

As can be seen from the drawings, the radius of the ungrooved outer peripheral surface of the member **15** is uniform from one end to the other thereof. It will also be seen that the maximum diameter of the collar is less than that of the bit **24** so that an annulus is formed between the well bore and collar during the drilling operation.

Three helical grooves **25** are formed in the peripheral surface of the intermediate portion of the tubular member **15** and extend longitudinally thereof in substantially equally spaced apart relation. In effect then, each groove surrounds the member **15** over a longitudinal portion thereof dependent on the pitch of the groove. As can be seen from FIG. 4, the peripheral contact area of any section through the intermediate portion of the drill collar will be reduced by the width of the three grooves **25**.

For example, in a drill collar having a 6½ inch O.D., a flat groove ¼ inch deep would have a peripheral length of 2.55 inches. Thus, three such grooves would cover approximately 38.3 percent of the total periphery of the collar. It will be understood that, in the average case, this would reduce the force holding the collar against the well bore a corresponding percentage.

Normally, a drill collar having a 6½ inch O.D. would have a 2⅞ inch I.D., such that it would still be 1$^{13}/_{16}$ inches thick at its thinnest point. Also, the weight of such a collar per lineal foot would be reduced only from approximately 91 lbs. to approximately 86½ lbs.

As shown and as previously discussed, these grooves are preferably formed by flat surfaces which may be machined on a conventional drill collar as it is turned on a mandrel. Normally, bevels would be formed at each end of the grooves as shown in FIGS. 3 and 4. This eliminates any sharp corners which might otherwise mill out the mud lining in the well bore. If desired, however, the grooves may be slightly convex, as shown at **26** in FIG. 5, without the danger of any substantial damage to the well bore.

In either case, the groove has a base which forms, in any section transversely of the axis of the collar (as shown in FIGS. 4 and 5), a smooth continuous line which intersects the peripheral surface of the collar at circumferentially spaced-apart points, all points on such line being spaced from the axis of the collar a radial distance at least as great as the radial distance from said axis of a chord connecting the intersecting points.

Instead of the three grooves illustrated, there may be only one or two or there may be more than three grooves, if desired. Of course, the advantage of having two or more grooves is that it increases the grooved area of the portion of the collar engageable with the well bore, without a substantial decrease in the thickness of the collar.

It is contemplated that the total peripheral lengths of the grooves **25** may equal from 15 percent to 60 percent of the outer circumference of the collar. It is also contemplated that the maximum depth of the grooves may be from 10 percent to 50 percent of the wall thickness of the drill collar. In both cases, the upper limits will be determined by the permissible reduction in weight and thickness of the collar.

As previously mentioned, if the collar is rotated in the direction of the helix of the grooves, the peripheral surfaces of the collar intermediate the grooves will have a propeller effect on the heavy drilling mud or the well bore so as to increase the effective load on the bit. In this respect, it is contemplated that the pitch of the helix will be not less than that necessary to encircle the collar over a length equal to three times the outer diameter of the collar and not more than that necessary to encircle same over a length twenty-five times such diameter. The vertical component of the speed of any point on the helix must be greater than the vertical speed of the drilling mud. This may be accomplished by adjusting both or either the pitch of the helix and/or the r.p.m. of the collar.

From the foregoing it will be seen that this invention is one well adapted to attain all of the ends and objects hereinabove set forth, together with other advantages which are obvious and which are inherent to the apparatus.

It will be understood that certain features and subcombinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of the claims.

As many possible embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matter herein set forth or shown in the accompanying drawing is to be interpreted as illustrative and not in a limiting sense.

The invention having been described, what is claimed is:

1. An integral, elongate tubular member connectable at its opposite ends in a drill string and having at least one helical groove in its outer peripheral surface which has a base forming, in any section transversely of the axis of said member, a smooth continuous line which intersects said peripheral surface at circumferentially spaced-apart points, all points on said line being spaced from the axis of said tubular member a radial distance at least as great as the radial distance of a chord connecting the intersecting points.

2. An integral, elongate tubular member having means at its opposite ends for connection in a drill string and at least one helical groove in its outer peripheral surface, which has a base forming, in any section transversely of said member, a line which is at least substantially flat and intersects at its opposite ends with said peripheral surface.

3. A tubular member of the character defined in claim 2, wherein said line is convex with respect to the axis of said tubular member.

4. A tubular member of the character defined in claim 2, having a plurality of said grooves in substantially equally spaced-apart relation about its outer peripheral surface.

5. A tubular member of the character defined in claim 2 which is a drill collar.

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