

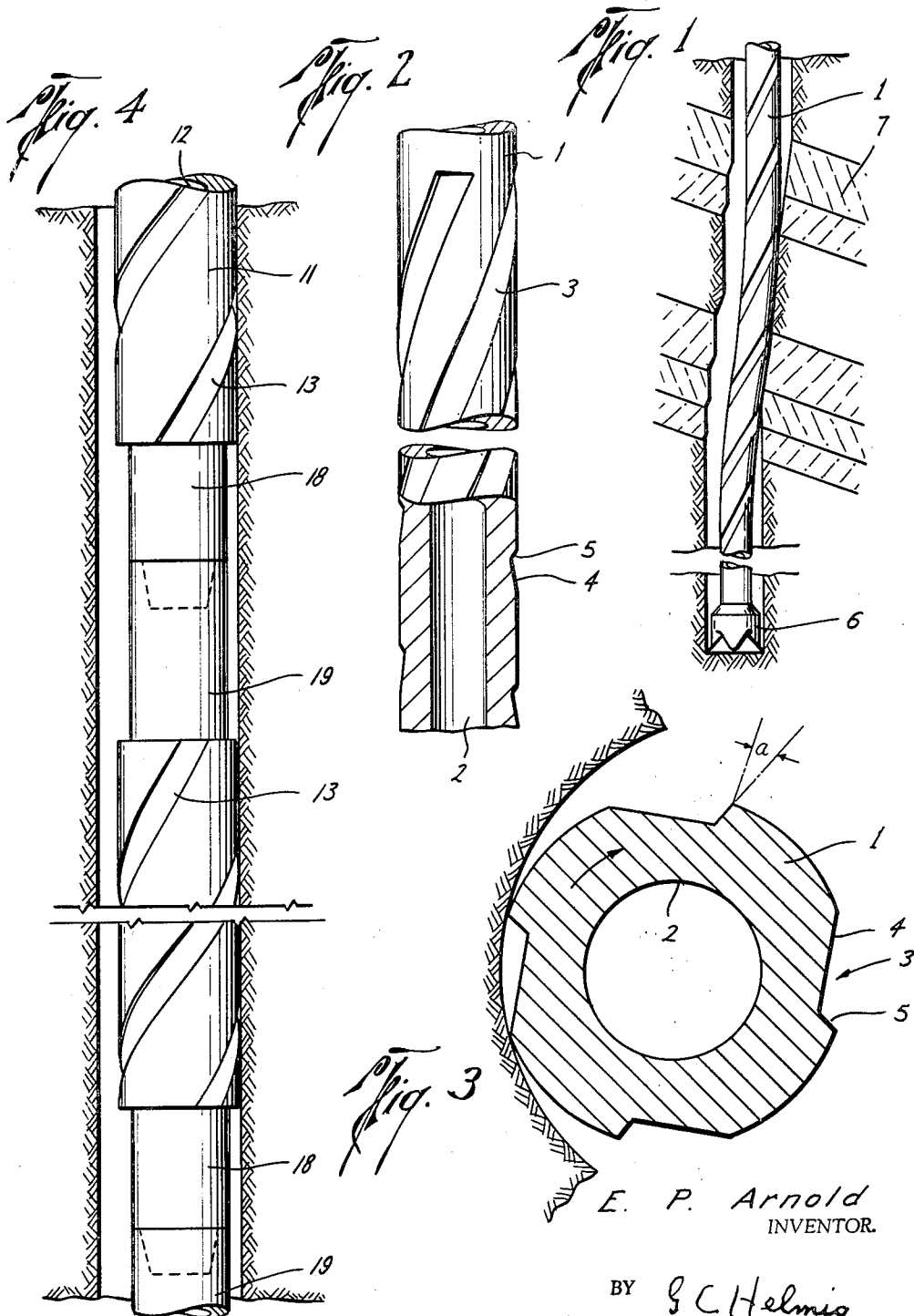
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E. P. ARNOLD

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DRILL COLLAR WITH HELICAL GROOVES

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E. P. Arnold
INVENTOR.

BY *S C Helmig*
ATTORNEY

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DRILL COLLAR WITH HELICAL GROOVES
Edward P. Arnold, % Arnold Pipe Rental Company,
P.O. Box 4014, Corpus Christi, Tex.
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This invention relates to the rotary drilling of deep wells and more particularly to improved drill collars to be coupled in multiple succession at the lower end of a tubular drill string for controlling weight on the bit and for co-operation with the well bore wall in minimizing hole deviation and stuck drill collars and also for facilitating wash-over operations.

An object of the invention is to provide a drill collar whose peripheral surface contains an improved helical groove formation to interrupt longitudinal continuity of the surface and materially reduce collar bearing contact area and to provide an effective cutting edge which can on occasion act as a broach against troublesome bore wall surfaces.

A further object of the invention is to provide a tubular drill string member having one or more peripheral grooves extending throughout the length of an intermediate large diameter portion whose diameter is only slightly smaller than the drill bit and therefore the wellhole so that the surrounding annulus space for drilling fluid approximates the size of the internal bore through the collar and which grooves freely communicate in open ended relation with opposite end reduced diameter portions of the drill string members so that the grooves and the longitudinally spaced apart annular recesses afforded by the reduced diameter portions co-operate in enlarging the annulus flow space and increase the collar surface area which will be spaced from contact with the wall face of the wellhole.

Other objects and advantages will become apparent from the following specification and reference to the accompanying drawing, wherein

FIG. 1 is a vertical section of a small length of drilled earth containing a drill string;

FIG. 2 on a larger scale is a view partly in elevation and section of collar fragments;

FIG. 3 is a transverse section on a still larger scale, and

FIG. 4 is a vertical section of a well bore containing a modified collar configuration.

In conventional rotary drilling operations, a string of pipe sections, each about thirty feet long, suspended from the surface and extended through the wellhole, is driven at the surface normally in a clockwise direction and drives a drilling bit on bottom with drilling fluid being pumped to the bit through the tubing string and returning through the annulus space surrounding the pipe. Usually, in deep wells the upper pipe sections are held in tension to control weight on the bit and the lower sections, just above the bit and often as many as thirty in number, have thicker, stiffer and heavier walls and are known as drill collars whose purposes, among others, are to weight the bit and direct it on a straight course. Downhole characteristics and operational conditions sometimes result in hole deviation, the formation of key seats and a tendency toward the pipe becoming stuck for any one or more of several recognized causes. One cause of pipe sticking has been attributed to drilling fluid pressure acting laterally against the drill collars, which may be in bearing contact with the wall of a formation whose pressure is less than that of drilling fluid pressure. Practices to lessen sticking have been many, including continuous rotation, oil spotting, decreased fluid weight, stabilizers, drilling collar surface configurations,

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which also facilitate wash-over operations during fishing and in some instances provide a broaching or cutting onto the formation for clearing a stuck point or a potentially sticking condition. None affords the complete answer to the problems and loss of equipment in wellholes continues.

A drilling string with improved peripheral surface configuration which not only breaks up continuity of bearing surface also provides a useful cutting action when required to minimize hole deviation, sticking problems, loss of pipe from twist-off and fishing costs, will now be described.

Referring first to FIG. 2, there is illustrated a hollow drill string pipe section or drill collar 1 consisting of an elongate tubular member of circular cross section having a central bore 2 therethrough as well as the conventional screw threaded pin and box formations at opposite ends for end to end coupling in a string of hollow pipe sections as in FIG. 4. For handling convenience, drill collars are usually about thirty feet long and of selected outside diameter of about two thirds of hole diameter. The annulus space surrounding such drill collars will be of a volume capacity or size somewhat in excess of the size of the central bore through the tubing string. A central bore of two and three fourths inches is common for a six-inch drill collar whose wall thickness will be about one and five eighths inches, and thirty feet of such a drill collar will weigh a little more than twenty-four hundred pounds. These figures are mentioned as exemplary.

To conserve weight and stiffness while providing downwardly facing peripheral working edges associated with axially spaced apart and reasonably large longitudinal gaps in bearing surface continuity, it is here proposed to incorporate a special and purposefully designed and effective groove shape in the outside of a drill collar and around its circumference. Preferably, a number such as four grooves 3 are cut to follow helical paths, each with a pitch of forty-two inches as measured longitudinally of the drill collar. Each groove 3 is particularly defined by a V-bottom and, as seen in vertical section in FIG. 2, its angularly related sides constitute a long leg 4 and a short leg 5 which project inwardly from the collar periphery in convergent relation one to another in a manner to resemble an inverted L and with the upper short leg 5 constituting a downwardly facing shoulder, making an acute angle to a horizontal radial plane transversely of the collar and terminating at its outer edge in a sharp corner relationship with the collar peripheral surface. Its long side or leg 4 runs downwardly at an obtuse angle with the short leg 5 of the groove for a distance to insure optimum clearance or gap length. In one preferred embodiment, the distance across each of such helically directed grooves 3 measures four and a half inches longitudinally on a six-inch drill collar and the intervening uncut periphery will be six inches long, yielding a resultant reduction of about forty-three and three tenths percent of the peripheral bearing surface.

To obtain the described groove shape, a rotating cutter on an axis transverse to the collar axis turns across a circumferential zone of the collar periphery and removes metal from a circular wall segment. The design of the revolving cutter forms a V-groove which, as seen in the transverse section of FIG. 3, is about two inches wide and to a depth at the point of leg convergence of about three tenths of an inch and the short leg 5 of the V-groove projects inwardly from the collar periphery at an abrupt angle preferably in the range of eighteen degrees to twenty-two degrees but in any event less than forty degrees from a radial line intersecting the outer end of the short leg. Such angle is indicated at *a* in FIG. 3 by projection

lines. Here, again, the surface of the long leg 4 of the V-groove projects generally circumferentially at an obtuse angle to the short leg and for the required distance to provide the clearance gap previously mentioned. The circumferential direction of the long leg 4 as viewed in FIG. 3, follows a line to merge smoothly into the peripheral surface of the collar without an abrupt bend at their intersection.

Thus the short leg 5, as seen in transverse section, is at the leading end of the groove 3 during normally clockwise rotation of the drill string so that desirably its cutting or broaching action is confined to that which may occur under certain conditions because this leg 5 also is a downwardly facing shoulder at the top of the groove as viewed in vertical section, FIG. 2, and can shear incident to descending travel of the drill string. Such descending travel not only occurs during normal drilling but also on down strokes of drill string reciprocation when greater broaching action is desirable. A broaching and bore face cutting action may be obtained by controlled reverse rotation and without longitudinal travel of the drill string since the sharp angle of the short leg is then the trailing edge of the groove. The reference to broaching action assumes that some portion of the collar has bearing contact with the wall of the wellhole. The length of such contact may vary from a short offset in hole direction up to the over-all length of the number of drill collars employed.

In this connection, mention should be made that desired collar stiffness and controlled weight application for hole straightness is affected by difficult formation characteristics such as those with dips of forty degrees or less, wherein the bit 6 tends to drill up-dip or into the hill. Crooked holes are experienced in tilted laminar shale and sandstone as illustrated at 7 in FIG. 1. Fracture of rock occurs perpendicular to the bedding plane and the bottom portions of upwardly inclined layers on the uphill or the high side during bit penetration, and because of insufficient backing support, tend to crack off and enlarge the hole at the up-dip side, whereupon the bit 6 shifts laterally. Thus it cuts through successive layers, but successively offsets the hole in more or less staggered fashion, somewhat as diagrammed in FIG. 1 and as more thoroughly discussed in World Oil, page 71, March 1963. In such situations, contact with the downhill side of the well wall by the herein disclosed V-grooved drill collars will occur and during descent of the collars, a desired broaching and cutting away of the stepped bore wall will avoid key seat problems and smooth out sharp offsets in hole direction.

In the modification shown in FIG. 4, the drill collar 11 is somewhat oversize throughout the major portion of its length as compared to a conventional collar for use in a given size hole and leaves a smaller than ordinary annulus clearance whose size advantageously approximates the size of the central bore 12 through the collar. Hence the collar will more readily come into bearing contact with the wall of the hole for guiding the direction of drilling and minimizing deviation from an intended straight course. Again, to break up surface continuity and to compensate for reduced annulus clearance and provide flow size around the collar in excess of volumetric capacity of the central bore through the drill string, there are provided a group of helically directed V-grooves 13 shaped as previously described and, in addition, all the grooves open into and communicate at both ends with reduced diameter portions 18 and 19 at opposite pin and box end connecting regions of each drill collar. These end portions are turned down by machining, either before or after the helical grooves are cut, and are of outside diameter that when joined in a string they form an annular recess inwardly below the peripheral surface of the medial portion of the collar and to a depth that the added annular clearance within the recess

is at least equal to the combined flow areas within all the helical grooves.

In addition to increasing annulus flow size, the annular recesses at the ends 18 and 19 co-operate with the grooves in breaking up and materially decreasing the exterior surface bearing area on the drill collar periphery. By making the annular recess at the box end eighteen inches long and the annular recess at the pin end twelve inches long, there would be a total of two and a half feet in length taken out of the bearing area of each collar and in a group of thirty end to end coupled collars, each thirty feet long, these recesses, located at axially spaced intervals, account for a combined seventy-five feet to reduce surface contact with the bore wall. That over-all length plus the total longitudinal footage provided by groove clearances will be substantially equal to the uncut bearing area measured longitudinally and any portion of which might contact with the wall of the well bore. Because of the increased weight and stiffness in such oversize collars, one or more additional annular recesses could properly be cut intermediate and axially spaced from the smaller diameter end portions for a further reduction in bearing area without objectionable loss of necessary weight and stiffness in the drill collar section of the tubular string.

During drilling rotation of the tubing string, return flow of drilling fluid upwardly through the annulus space will react downwardly on the upwardly facing groove surfaces and apply a helpful load on the bit supplemental to drill collar weighting. Because of such additional loading on the bit, it will be feasible in some cases to cut down the number of drill collars required and replace them with less costly drill pipe. Similar cost savings will be realized through the use of oversize drill collars having the improved surface configurations described and without sacrifice of advantages. It will be noted that the weight of metal removed by groove formation will be less in relation to total collar weight in the case of a large diameter oversize collar than in a collar of conventional size heretofore used for a given diameter hole. By comparison, seventeen V-grooved collars whose dimensions are four and three quarters inches outside diameter, two and one quarter inches inside diameter and thirty feet long will approximate the weight of and replace twenty-one conventional collars whose dimensions are four and one eighth inches outside diameter, two inches inside diameter and thirty feet long. Comparison of hydraulics of the same two drill collar strings is also interesting. Assuming no pressure loss attributable to fluid passage through the bit and considering the same drilling mud characteristics, circulation rate and hole sizes, calculations indicate a decrease of forty-three and nine tenths percent in pressure loss with the grooved collar string as against pressure loss with the conventional string based on pressure differentials from the time injected drilling mud enters the inside bore of the uppermost collar of each string until the same fluid rises through the annulus and past the identical spot outside the string. Lower loss in annulus pressure affords surer entrainment and clearing of cuttings and especially the removal of the larger and heavier fragments from bit working interference at the formation face being drilled.

While the foregoing has been specific to detail structure, it is to be understood that such variations and modifications can be made as come within the scope of the appended claims.

What is claimed is:

1. An integral elongate tubular member having means at opposite ends for connection in a rotary drill string and at least one helical groove in its outer peripheral surface, which is of V-shape in section transversely of the member, the leg of the V-shape which is located at the leading edge of the groove during drill string rotation in the normal drilling direction being on the order of about thirteen percent as long as the other leg and pro-

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jecting inwardly of said peripheral surface at an angle of less than forty degrees to a radial line at said leading edge of the groove.

2. An integral elongate tubular member having means at opposite ends for connection in a rotary drill string and at least one helical groove formation in its outer peripheral surface, said groove formation in section transversely of the member being defined by a pair of inwardly converging side surfaces of which one is relatively shorter than the other and projects inwardly from said peripheral surface and from the groove leading edge in relation to the direction of rotary drilling, at an acute angle of about twenty degrees with a radial line intersecting said leading edge, the other of the side surfaces extending at an obtuse angle from the shorter side surface and on a line which merges smoothly without an abrupt cutting edge into said peripheral surface at the trailing end of the groove, said shorter side surface constituting the top of the groove in any section longitudinally of the member and projecting at an acute angle to its inter-

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section with said peripheral surface to provide a downwardly directed cutting edge portion.

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CHARLES E. O'CONNELL, *Primary Examiner.*

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