

June 28, 1966

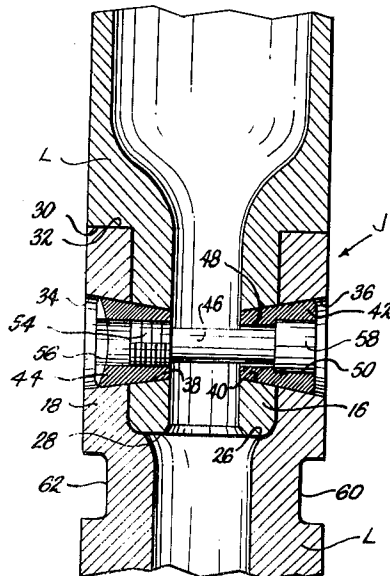
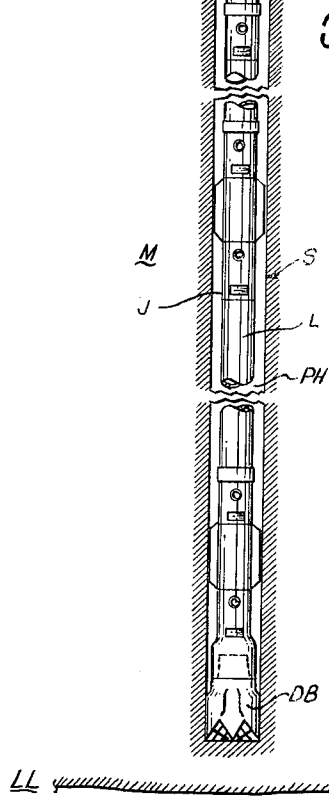
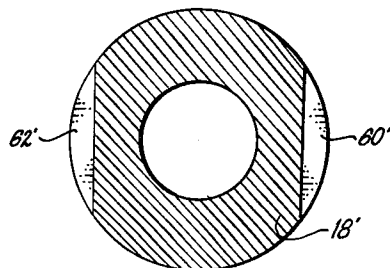
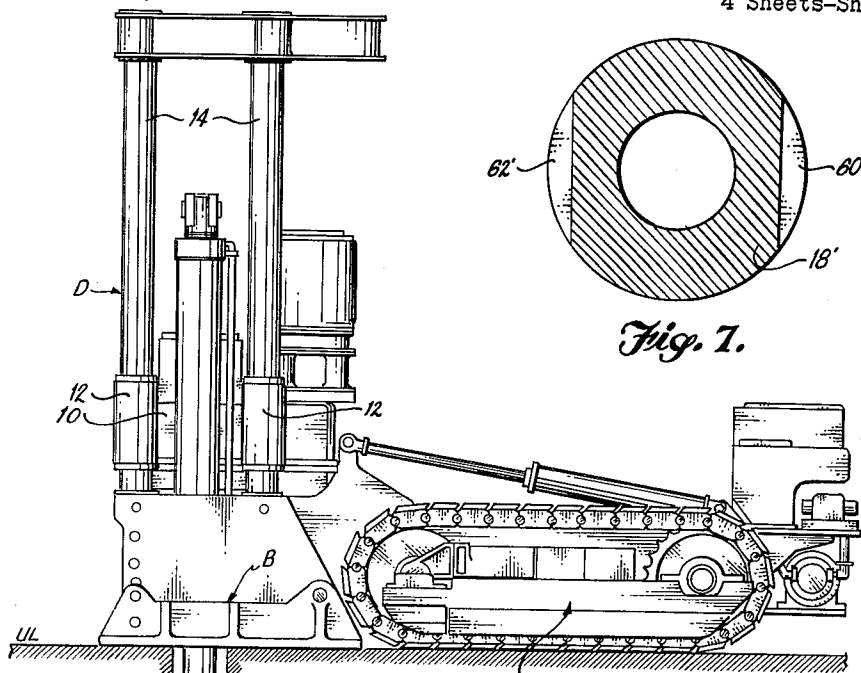
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3,258,283

DRILLING SHAFT COUPLING HAVING PIN SECURING MEANS

Filed Oct. 7, 1963

4 Sheets-Sheet 1



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4 Sheets-Sheet 2

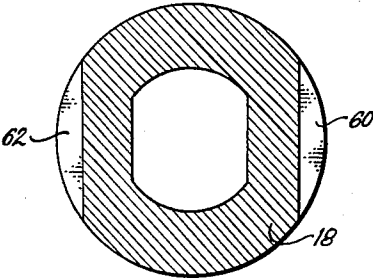


Fig. 6.

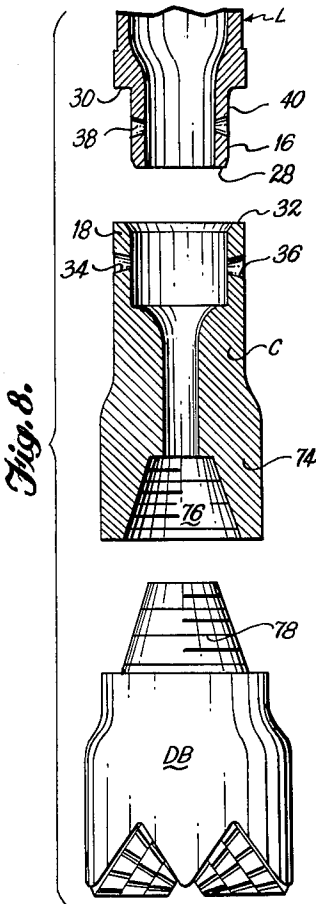


Fig. 8.

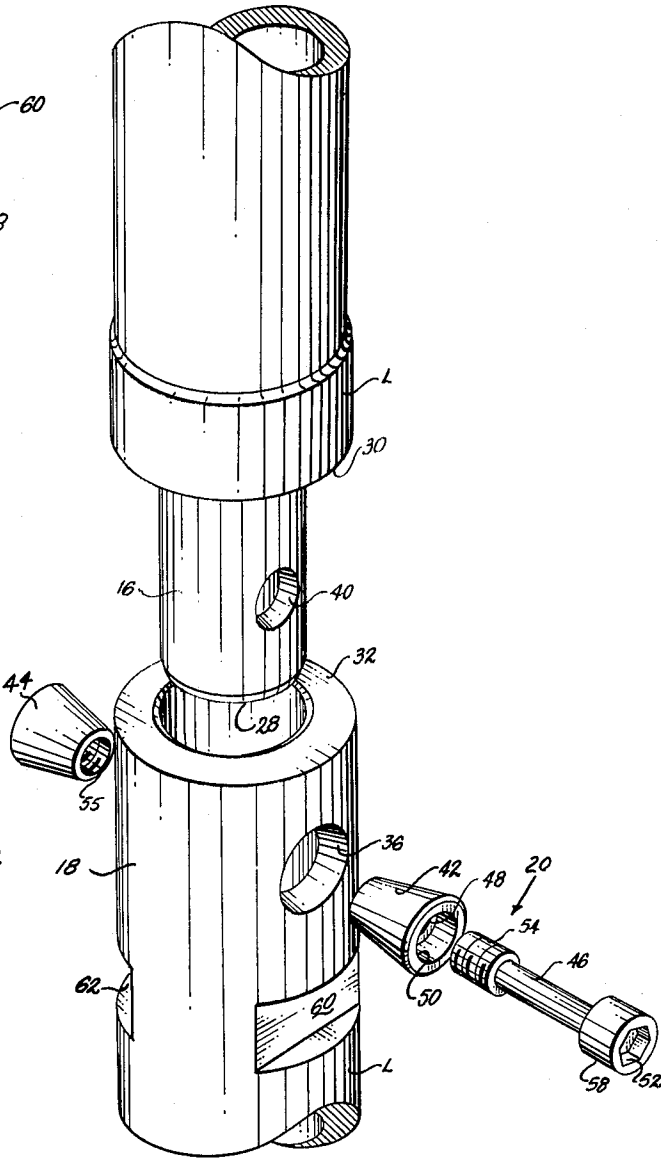


Fig. 3.

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4 Sheets-Sheet 3

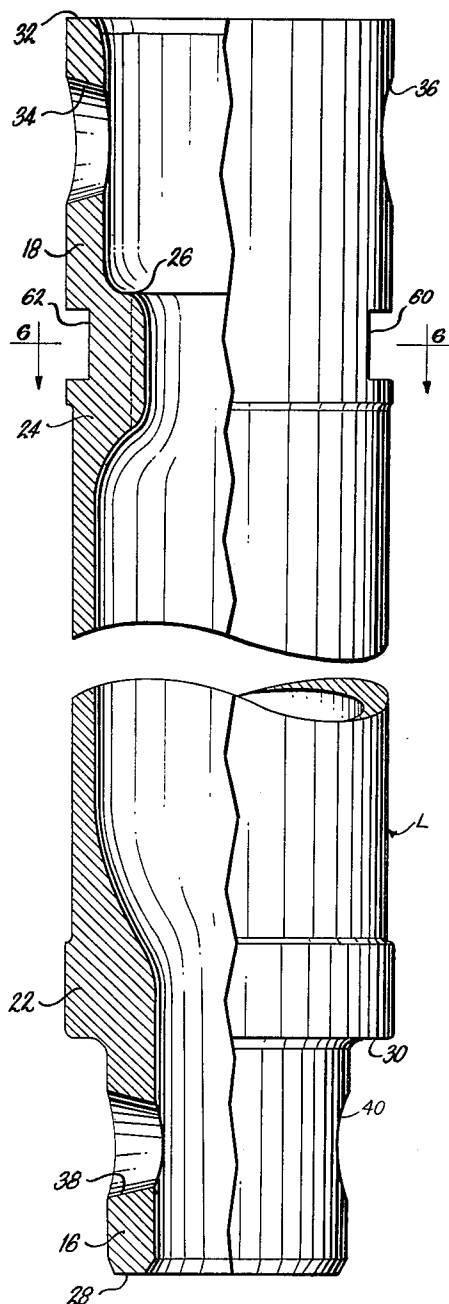


Fig. 4.

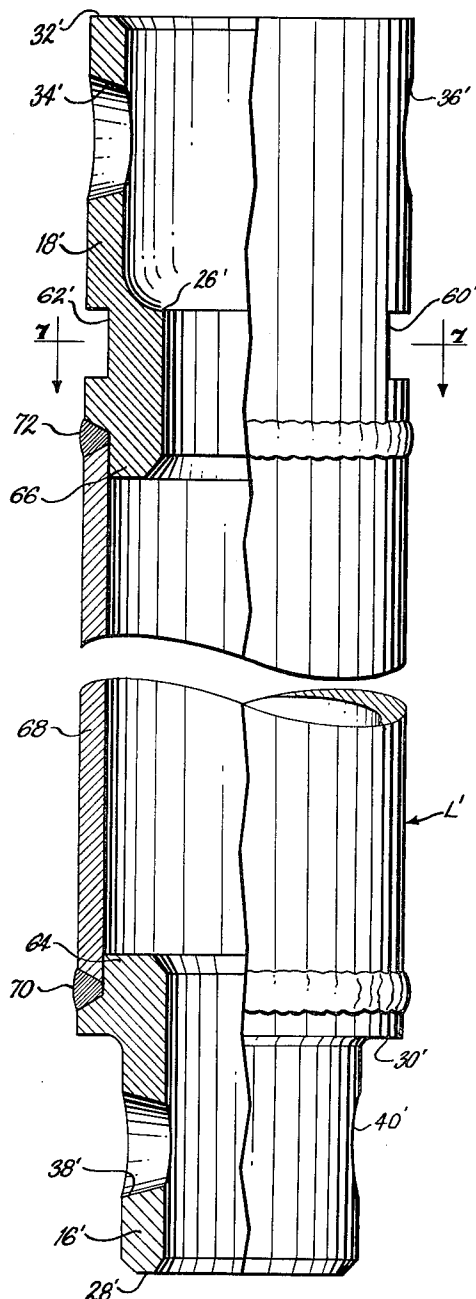


Fig. 5.

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4 Sheets-Sheet 4

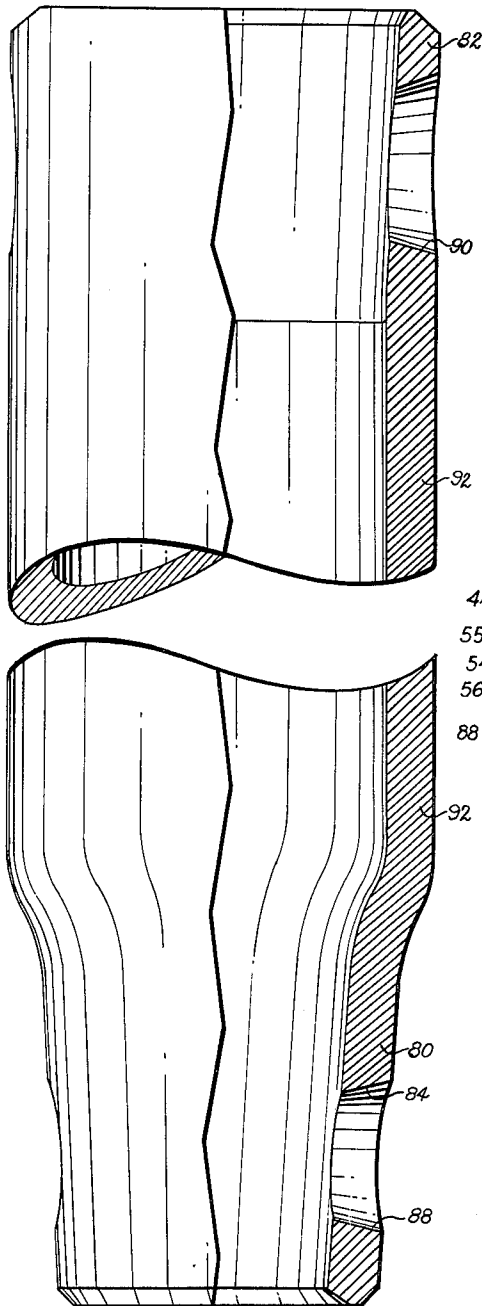


Fig. 9.

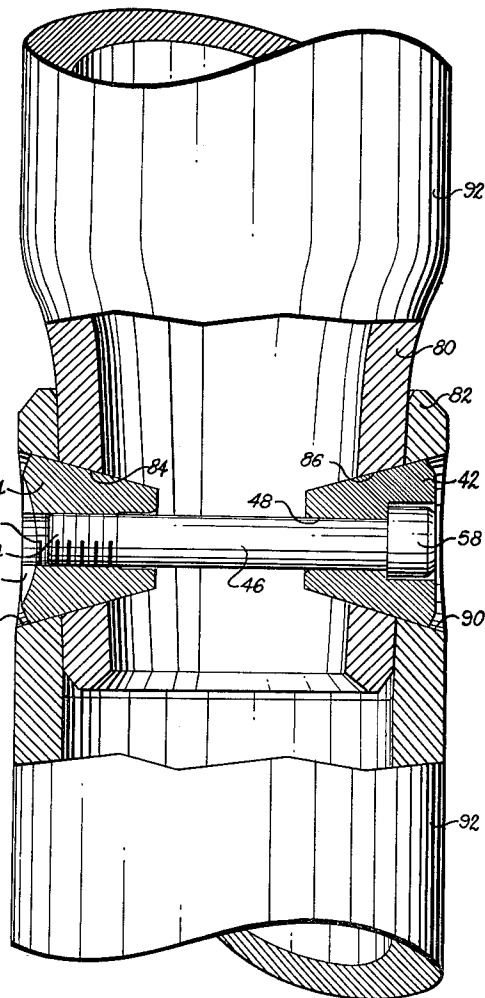


Fig. 10.

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1

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DRILLING SHAFT COUPLING HAVING PIN SECURING MEANS

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3 Claims. (Cl. 287-119)

The present invention relates to improvements in drilling shafts or stems, and more particularly to the provision of a high torque drilling shaft of sectional construction and characterized in part by a novel non-threaded tool joint construction.

In earth boring operations according to the rotary drilling method, the work is accomplished through the use of an elongated drilling shaft, at the lower extremity of which is placed the "cutting tool." Through the intermediary of the drilling shaft the cutting tool is rotated and either pushed or pulled (e.g. as in a raise drilling operation) against the work face of the material being drilled. Basically, the drilling shaft consists of the cutting tool, "drill collars," "lengths" of "drill pipe" successively interconnected by "tool joints," and the "kelly" or "grief stem" by which the shaft is attached to a drive mechanism.

Known conventional tool joints are merely threaded connections consisting of an internally threaded "box" constituting an end of a first member or component of the drilling shaft (e.g. a length of drill pipe) and an externally threaded "pin" constituting an end of a second member or component of said shaft. The said first and second members or components are joined or coupled together by merely screwing the said pin into the said box. This type of joint construction proved to be unsatisfactory for use in high torque operations, such as in raise drilling operations, for example, because the high torque to which the drilling shaft is subjected in such operations tends to "tie" the threads together, making it extremely difficult, and in some cases practically impossible, to unthread the joints for removal of lengths of drill pipe from the upper end of the drilling shaft. In raise drilling operations, tensile forces also account for thread distortion or "tying." This is because the drilling shaft is in tension and the tensile forces are carried by or transmitted through the joints solely by the threads.

A further disadvantage of threaded tool joints is that when such are employed each length of drill pipe being added to or removed from the drilling shaft must be both rotated and moved endwise an amount equal to the pitch of the threads per each three hundred and sixty degrees (360°) of rotation. Since in most installations the lengths of drill pipe are too large and too heavy to be handled by hand, the drilling rig must be equipped with a mechanism for causing synchronous rotary and rectilinear movement of the drill pipe. Known mechanisms of this sort are highly complicated, are subject to breakdowns that stop the work, and in general are quite costly, both to acquire and to maintain.

A principal object of the present invention is to provide an improved tool joint construction that is characterized by the absence of threads and the afore mentioned disadvantages that accompany the use of threaded tool joints. The unique tool joint construction provided by the invention is in the nature of "slip joint," and completely obviates the problem of thread "tying" or "distortion," and further obviates the need of a mechanism for effecting synchronous rotary and rectilinear movements of the lengths of drill pipe being added to or removed from the drilling shaft.

Characteristically, the tool joint of the present inven-

2

tion comprises an elongated non-threaded pin interfittingly engageable within the elongated non-threaded opening of a box, and a coupling assembly consisting of a pair of frusto-conical members, herein termed "cones," insertable into diametrically opposed frusto-conical bores extending laterally through said pin and box and formed by two pairs of complementary inwardly tapering openings, and a coupling bolt insertable through an axial bore in one of the cones and threadably engageable into an axial bore of the other.

In one form of tool joint according to the invention, wherein the pin and box opening are cylindrical, compressive stresses are essentially transferred from one length of drill pipe to the next by way of surface-to-surface contact between shoulder and terminal portions of said pin and box. In another form of tool joint according to the invention the pin and box opening are tapered, and the compressive stresses are transferred by way of surface-to-surface contact between the respective side walls of the pin and the box opening. Of course, the tensile and torsional stresses are transmitted from one length of drill pipe through the joint to the next length of drill pipe by the coupling assembly.

In the joint form involving a cylindrical pin and a cylindrical box opening the tolerances at the joint between the several surfaces of said pin and box opening are relatively close, in the order of a thousandth $\frac{1}{1000}$ of an inch, for example. In the joint form involving a tapered pin and matching tapered box opening the pin is preferably driven into tight contact with the inside wall of the box opening. Owing to either the close tolerance or tight fit, during bending the joint behaves essentially the same as an intermediate straight section of the drill pipe, i.e. during bending the curvature of the drilling shaft is substantially uniform, with essentially no irregular angular deviation occurring at the joints between the center line axes of adjacent lengths of drill pipe.

Obviously, the novel "slip joint" construction of the present invention is not limited in use to the interconnection of adjacent lengths of drill pipe, but rather may be used for connecting together any two adjacent elements or components of the drilling shaft, such as the drill bit or cutterhead to the drill collar, the drill collar to the drill pipe, and the drill pipe to the kelly, for example. Also, such "slip joint" construction may have utility in other installations completely foreign to earth boring but requiring the interconnection of tubular, or even solid, members.

Another principal object of the invention is to provide, as a new article of commerce, an improved form or type of drill pipe, such form being characterized by a generally straight tubular body or intermediate portion, a right cylindrical or frusto-conical pin at one end, and a box at the other end having a right cylindrical or frusto-conical box opening, with diametrically opposed, inwardly tapering openings extending laterally through both the pin and the box, and with the openings in the pin corresponding in taper to the openings in the box. According to one form of this aspect of the invention the drill pipe is either internally or externally upset at the ends and the joint components, i.e., the pin and the box, are fashioned from the upset end portions. According to another form of this aspect of the invention the pin and box are swaged onto the ends of a cylindrical section of pipe. According to still another form of this aspect of the invention, the pin and the box are constructed as separate fittings and are then welded or otherwise suitably fastened to the ends of a length of drill pipe.

In comparison to conventional threaded tool joints, additional advantages gained by using the non-threaded, "slip joint" of the present invention include:

(a) A drilling shaft constructed according to the invention and employing the "slip joint" of the invention, is

more readily assembled and disassembled, both in terms of the handling required and speed.

(b) The coupling assembly is wear compensating, i.e., wear on both the cones and the frustro-conical bores is taken up by merely threading the coupling bolt an additional amount into the interiorly threaded cone, so as to locate the cones closer together and put them once again in tight abutting engagement with the side surfaces of the frustro-conical bores; and

(c) The several elements of the coupling assembly are relatively inexpensive to manufacture and hence are inexpensive to replace when they wear out or are lost.

These and other objects, features, advantages and characteristics of the drilling shafts, drill pipe and non-threaded tool joints of the present invention will be apparent from the following description of typical and therefore non-limitative embodiments thereof, taken together with the accompanying illustrations wherein like letters and numerals refer to like parts, and wherein:

FIG. 1 is a small scale view of a raise drilling machine in operation and forming a pilot hole on a downward pass, the separation between the upper level and the lower level shaft between which the raise is to run being fragmented for simplicity of illustration, and the drilling shaft embodying features of the present invention;

FIG. 2 is an enlarged scale detail view of a tool joint construction typifying the invention, with the coupling bolt shown in side elevation in such view, and with the remaining elements shown in section;

FIG. 3 is an exploded perspective view of the tool joint of FIG. 2;

FIG. 4 is a view partly in medial longitudinal section, and partly in elevation, of a length of drill pipe, shown in the form of a one piece casting;

FIG. 5 is a view similar to FIG. 4, showing a modified form of construction of the length of drill pipe, namely, a composite form;

FIG. 6 is a cross-sectional view of the length of drill pipe shown in FIG. 4, such view being taken substantially along the line 6—6 of FIG. 4;

FIG. 7 is a cross-sectional view of the length of drill pipe shown in FIG. 5, such view being taken substantially along line 7—7 of FIG. 5;

FIG. 8 is an exploded elevational view of a fragmented lower portion of the drill stem such view illustrating a drill collar especially constructed for coupling a conventional drill bit to the lowermost length of drill pipe; and

FIGS. 9 and 10 are views like FIGS. 4 and 2, respectively, of a modified form of drill pipe and a modified form of joint construction involving same.

Referring to the several figures of the drawing more specifically, the raise drilling mechanism illustrated in FIG. 1 in general comprises a crawler or tractor C, a base member or footing B, and a rotary drilling rig D. The rotary drilling rig D includes a gear reducer 10 mounted on guide sleeves 12 for rectilinear movement along mast-like guide columns 14. A kelly or grief stem (not shown) is attached to the output shaft (not shown) of the gear reducer 10. A sectional drilling shaft S is rotated and carried by the said kelly. Such drilling shaft includes an internal fluid passageway extending from end to end through which a suitable drilling fluid is delivered to the cutting tool and the work face of the hole being drilled.

The drilling operation involves first boring a small pilot hole from the upper level UL where the drilling mechanism is situated down to a lower level LL. The pilot hole drill bit DB is of suitable size to leave the pilot hole PH just slightly larger than the drill stem S. Drilling of the pilot hole PH is commenced with the gear reducer 10 in its raised position. Then the drilling shaft S is rotated while the gear reducer 10 is hydraulically or otherwise suitably urged downwardly. When the drilling has proceeded to the point where the guide sleeves 12 and the gear reducer 10 have reached about their lowermost extent of travel on guide columns 14, the downward move-

ment thereof is ceased, the portion of the drilling shaft S then in the ground is uncoupled from the kelly, and the gear reducer 10 is returned to its raised position. A length of drill pipe L is then coupled between the kelly and the portion of the drilling shaft S that is in the ground, and then the drilling is resumed. The pilot hole drilling operation thus progresses with successively introduced lengths L of drill pipe and downward work strokes until the pilot hole is formed through the mineral formation M between the upper lever UL and the lower lever shaft LL.

With the pilot hole PH formed, the pilot hole drill bit DB is removed from the drill stem S and a raise cutterhead (not shown) is connected to the lower end of the drill stem S. The raise hole drilling operation is then commenced. This involves simultaneously rotating and hydraulically lifting of the drilling shaft S and the raise cutterhead. The raise hole boring operation proceeds with cyclic performance of a working lift of the drilling shaft S and raise cutterhead, and uncoupling and removal of the upper lengths of drill pipe, a lowering of the gear reducer 10, a recoupling of the drilling shaft S to the gear reducer 10, and a further raising of the drill stem S and cutterhead and so on until the raise hole is formed between the lower level shaft LL and the upper level UL.

For a more extensive and comprehensive discussion and disclosure of the raise drilling technique and the mechanism employed, reference is made to the copending application of Cannon et al., Serial No. 224,756, filed September 19, 1962, and entitled Raise Drilling Method and Mechanism, now Patent No. 3,220,494. To the extent that it may be necessary for a clearer understanding of the present invention, the disclosure of such application is expressly incorporated herein by reference.

Turning now to the features of the present invention, FIG. 4 shows a length L of drill pipe typifying one aspect of the invention, and FIG. 2 illustrates a tool joint J typifying another aspect of the invention.

FIGS. 2-8 are drawn to scale and depict rather accurately the relative proportions of the several parts of the drill pipe lengths L and of the various coupling elements typifying the invention.

According to the invention, the lower end of a length L of drill pipe is in the form of a right cylindrical pin 16 and the upper end of such length L is in the form of a box 18. Unlike known conventional pins and boxes, pin 16 and box 18 are not threaded. Rather, they form male and female parts, respectively, of what may be termed a non-threaded, "slip joint" J, retained by a cross pin coupling assembly 20, hereinafter to be described.

As illustrated, the length L of drill pipe includes an internal upset at each end, designated 22, 24, respectively. However, it is to be understood that in certain installations, e.g., in installations requiring greater fluid volumes and reduced pump pressures, the upsets may be external so as to make possible a larger internal diameter. Of course, the purpose of the upsets 22, 24 are to give additional wall thickness and strength to the ends of the lengths L of drill pipe.

Referring now to FIG. 2 in particular, the pin 16 of an upper length L of drill pipe is shown fully accommodated within a right cylindrical opening provided in the box 18, of the lower adjacent length L. An interior shoulder 26, formed at the bottom of box 18, abuts the generally squared off terminal 28 of the pin 16. In similar fashion, the generally squared off terminal 32 of the box 18 abuts against an external shoulder 34 formed at the base of pin 16. A relatively close tolerance is required at joint J between the inside wall of box 18 and the outside wall of pin 16, between internal shoulder 26 and terminal 28, and between terminal 32 and external shoulder 34. This tight fit of the pin 16 within the box 18 makes joint J behave during bending of the drill stem S, such as during the pilot hole boring operation wherein the

5

drill stem S is in compression, essentially the same as if the drill stem S were not broken at such joint J. The close tolerance between the outer cylindrical surface of pin 16 and the inner cylindrical surface of box 18 prevents the pin 16 from "rocking" within the box 18. Also, the close tolerances between the respective pairs of abutting surfaces of the terminals 28, 32 and the shoulders 26, 34 enhances the resistance of the joint J to "rocking" since each prevents the displacement of the surface against which it abuts, and such displacement is necessary in order for relative angular movement, i.e. rocking between adjacent lengths of drill pipe, to occur.

As shown in FIG. 2, for example, inwardly tapered openings 34, 36 extend through the cylindrical wall of box 18 at diametrically opposed locations and are paired with inwardly tapered openings 38, 40 extending at diametrically opposed locations through the cylindrical wall of pin 16 so as to form a pair of diametrically opposed, frustro-conical bores at the joint J. The coupling assembly 20 includes a first frustro-conical member or cone 42 which is insertable into one pair of inwardly tapering openings, say openings 36, 40, for example, a second frustro-conical member or cone 44, insertable into the other pair of aligned tapered openings (i.e., openings 34, 38), and a coupling bolt 46. As shown, cone 42 includes a bore 48 sized to accommodate the shank of coupling bolt 46, and a countersink 50 sized to receive and accommodate the head 52 of such bolt 46. Cone 44 is shown to be internally threaded at 55 (FIG. 3) and in effect is a nut into which the threaded end 54 of bolt 46 is screwed. Owing to their tapered construction, cones 42, 44 are easily inserted into the frustro-conical bores formed by paired openings 34, 38 and 36, 40, respectively. The coupling bolt 56 is then easily inserted through cone 42 and screwed into cone 44. Cone 44 is prevented from turning by the insertion of an appropriate tool (not shown), similar to a screwdriver, into a slot 56, or the like, provided in the outboard end thereof, as the coupling bolt 46 is being turned by another appropriate tool, the end of which is inserted into the socket opening 58 (shown as being of hexagonal shape merely by way of typical and therefore non-limitative example). The threading of bolt 46 into cone 44 draws the cones 42, 44 together and wedges them tightly in the openings 34, 38 and 36, 40.

As an added advantage, owing to the tapered nature of cones 42, 44 and the bores composed of openings 34, 38 and 36, 40, the coupling assembly automatically compensates for its own wear and the wear of openings 34, 38 and 36, 40. As the cones 42, 44 and/or the pairs of openings 34, 38 and 36, 40 wear, the bolt 46 is merely threaded a little bit further into cone 44 in order to take up the wear and place the frustro-conical surfaces of the cones 42, 44 into tight engagement with the frustro-conical surfaces of the pairs of openings 34, 38 and 36, 40, respectively. Also, owing to the symmetrical construction of the coupling assembly about the center line axis of the drilling shaft, the forces carried by said coupling assembly are balanced relative to said center line.

Each length L of drill pipe is provided with wrench receiving slots, such as indicated in FIG. 6 at 60, 62. During the raised hole drilling operation a holding wrench (not shown) is used to engage the drilling shaft at such slots 60, 62 and prevent it from dropping downwardly into the hole when the upper length of drill pipe is being removed therefrom. Since there are no threads at the joints, there is no rotation of the uppermost length of drill pipe relative to the remaining portion of the drill stem, and hence the wrench is not needed to hold the drilling shaft S against rotation while lengths L are being added. During pilot drilling the drilling shafts need not be held against endwise movement because it is fully supported at its lower end by the contact of the drill bit DB with the bottom of the pilot hole PH.

6

The composite form of drill pipe, designated L' in FIG. 5, has substantially the same overall configuration as the one piece offset form heretofore described. However, according to this form of the invention the pin 16' and the box 18' are originally formed as separate elements having inboard end portions 64, 66, respectively, of reduced diameter and adapted to tightly interfit within the cylindrical body portion 68. The pin 16' is welded to one end of a generally straight body portion 68 at 70, and the box 18' is welded to the other end of the body portion 68 at 72.

As shown in FIG. 8, a double box collar C, one box 74 being internally threaded at 76 and the other box 18 being constructed according to the invention, may be used for interconnecting the pin 16 of the lower length L of drill pipe with a conventional drill bit DB having a threaded pin 78. No particular harm is done by the threads of this threaded connection at 76, 78 becoming tied together, as collar C and drill bit DB are both relatively short in length and light in weight and once assembled can later be handled as a unit, i.e. once assembled they need never be taken apart. Of course, the drill bit DB could be constructed to include a non-threaded pin, like pin 16 of length L, and the collar constructed to include two non-threaded box ends 18.

Further modified forms of collars according to the invention included a collar having a threaded pin and non-threaded box for engagement with a non-threaded pin, and a collar having a non-threaded pin and a threaded box for connection to a threaded pin.

Referring now to FIG. 9, this figure shows another modified form of drill pipe involving a modified form of pin and box construction, designated 80 and 82, respectively. Pin 80 is provided with a pair of diametrically opposed, inwardly tapering openings 84, 86 that register with complementary openings 80, 90 extending through the side wall of box 82. Pin 80 and the box opening possess the same degree of taper and preferably the outside dimension of pin 80 is such that the pin 80 must be driven slightly into the box opening in order to align openings 84, 86 with openings 80, 90, respectively, in the axial direction. This assures an extremely tight fit between the outer surface of pin 80 and the inner surface of the box opening, and makes possible the elimination of the shoulders employed with the cylindrical pin and box construction shown in FIGS. 1-8, for example. The coupling assembly 20, comprising cones 42, 44 and pin 46 is employed in a joint involving pin 80 and box 82 in the same manner as described above in connection with FIG. 2.

According to the invention, the length of drill pipe 92, shown in FIG. 9, is formed by swage forming the pin 80 out of one end portion of an initially cylindrical piece of drill pipe, and swage forming the box 82 out of the other end portion thereof. While possessing the same advantages of the drill pipe shown in FIGS. 4 and 5 as to simplicity and ease in joint assembly and disassembly, this form of the invention further possesses the advantages of involving no welded parts nor shoulders.

Although the drill pipe and drill pipe joint construction presented by the invention has a particular advantageous application in connection with raised joint operations, wherein the high torque condition at the joints of the drill stem practically prohibits the use of threaded joint, such joint construction constitutes an improvement in drilling shafts in general and the principles herein disclosed have application in all types of drilling or boring operations.

From the foregoing, further variations, modifications, adaptations and usages of drill pipe and drill pipe joints will be apparent within the scope of the following claims.

What is claimed is:

1. A sectional, high torque, rotatable drilling shaft, comprising separable, first and second tubular drilling shaft elements, each formed to include a central drilling

fluid passageway, and a slipjoint connection between said elements subjected to a high degree of torque during drilling, said joint comprising:

- (a) a tubular box at an end of the first drilling element, said box including side wall means forming an axially extending box opening, constituting an end portion of the drilling fluid passageway in said first drilling shaft element, with at least one pair of opposed, inwardly tapering openings extending laterally through said side wall means; 5
- (b) a tubular pin at an end of the second drilling shaft element, snugly insertable into said box opening, said pin including side wall means of at least about the same thickness as the wall means forming said box, and forming a passageway in the pin that constitutes a reduced diameter end portion of the drilling fluid passageway in said second drilling shaft element, with at least one pair of opposed, inwardly tapering openings extending laterally through said side wall means and being registerable with the said inwardly tapering openings of said box, when the pin is in the box opening, to form a pair of opposed, inwardly tapering bores; and 10
- (c) a coupling assembly comprising a pair of plug elements insertable into said inwardly tapering bores, and each being of one-piece continuous form and including tapered side surfaces of like taper as its bore, and each sized to snugly fit within one of said bores, and bolt means detachably connectable to said plug elements for pulling them together and their tapered side surfaces into tight engagement with the side surfaces of such bores, with the combined length of said bolt means and said pair of plug elements when in the assembled position being not more than about the outer diameter of said tubular box. 15 20 25 30 35

2. The combination of claim 1, wherein the pin and the box opening are both frusto-conical in form, each is an integral part of its drilling shaft element, the box constitutes a swage formed enlargement on an end of its drilling shaft element, and the pin constitutes a swage formed reduction on an end of its drilling shaft element. 40

3. A torque transmitting slip-joint between first and second tubular, drilling shaft components, each formed to include a central drilling fluid passageway, said joint comprising: 45

- (a) a tubular box at an end of the first tubular drilling shaft component, said box including annular side wall means forming an axially elongated box opening constituting an end portion of the drilling fluid passageway in said first drilling shaft component, 50

with at least one pair of diametrically opposed, inwardly tapering openings extending laterally through said side wall means;

- (b) a tubular pin at an end of a second tubular drilling shaft component, insertable into and snugly engageable by said box opening, said pin including annular side wall means forming a central passageway in the pin constituting the end portion of the drilling fluid passageway in said second drilling shaft component, with at least one pair of diametrically opposed, inwardly tapering openings extending laterally through said side wall means, and being registerable with the said inwardly tapering openings of the box when the pin is in the box, so as to form a pair of diametrically opposed, inwardly tapering bores; and
- (c) a coupling assembly comprising a pair of plug elements, each being of one-piece continuous form and having side surfaces of like taper as said bores, and each sized to snugly fit within one of said bores, and a bolt having an enlarged head at one end and a threaded portion at the other end, with one of said plug elements having an elongated opening extending axially therethrough to accommodate the shank of said bolt, and the other having an internally threaded, elongated opening therein for receiving the threaded portion of said bolt, said bolt serving when tightened to draw the plug elements together and the tapered side surfaces thereof into tight engagement with the side surfaces of the bores, with the combined length of said bolt and said pair of plug elements when in the assembled position being not more than about the outer diameter of said tubular box.

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