Jan. 25, 1966 D. F. WINBERG 3,231,029

ARTICULATED DRILLING SHAFTS FOR RAISE DRILLING

Filed Oct. 28, 1963 3 Sheets-Sheet 1

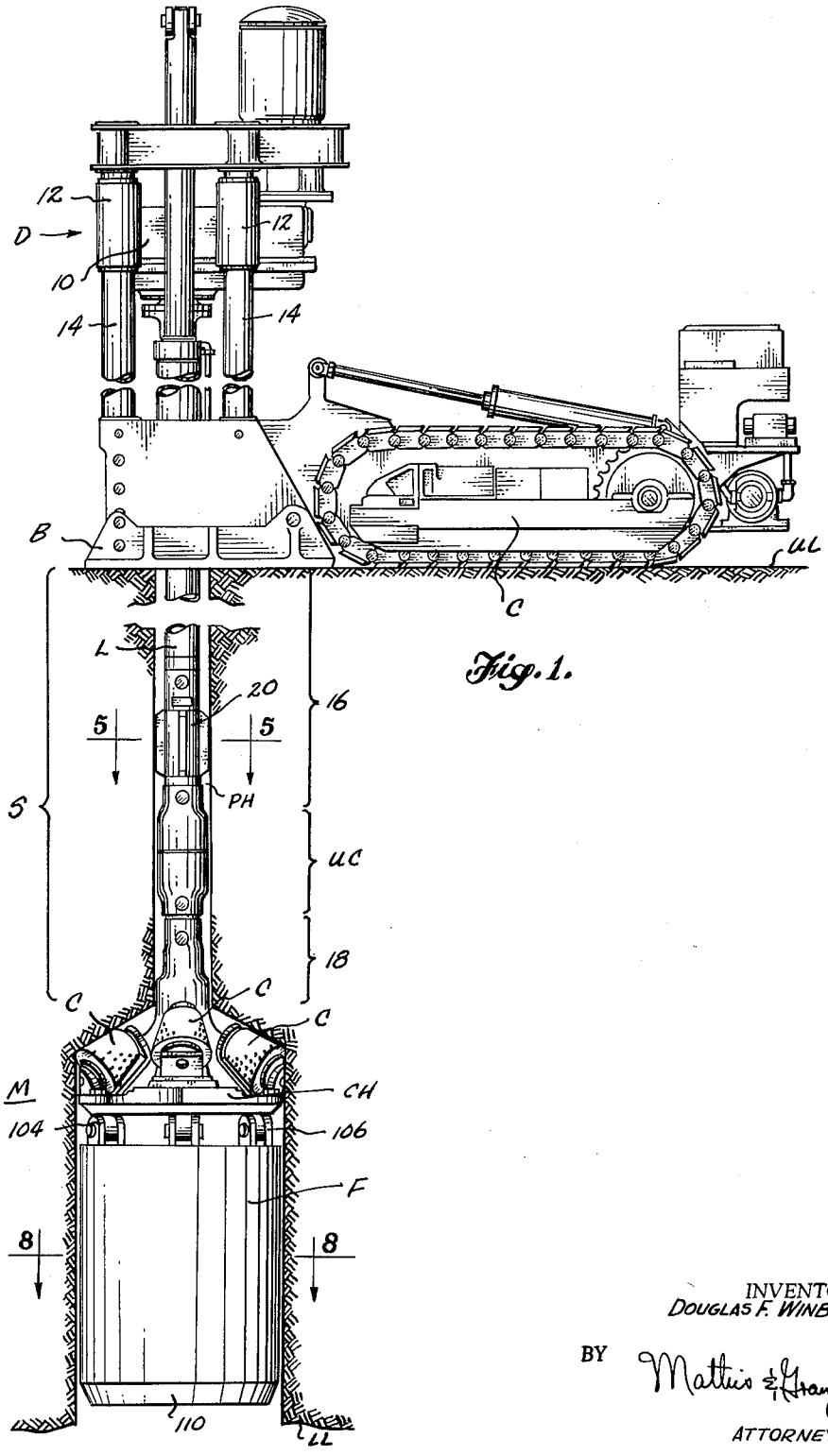


Fig. 1.

INVENTOR.
DOUGLAS F. WINBERG

BY Mattis & Grayseal

ATTORNEYS

Jan. 25, 1966 D. F. WINBERG 3,231,029

ARTICULATED DRILLING SHAFTS FOR RAISE DRILLING

Filed Oct. 28, 1963 3 Sheets-Sheet 2

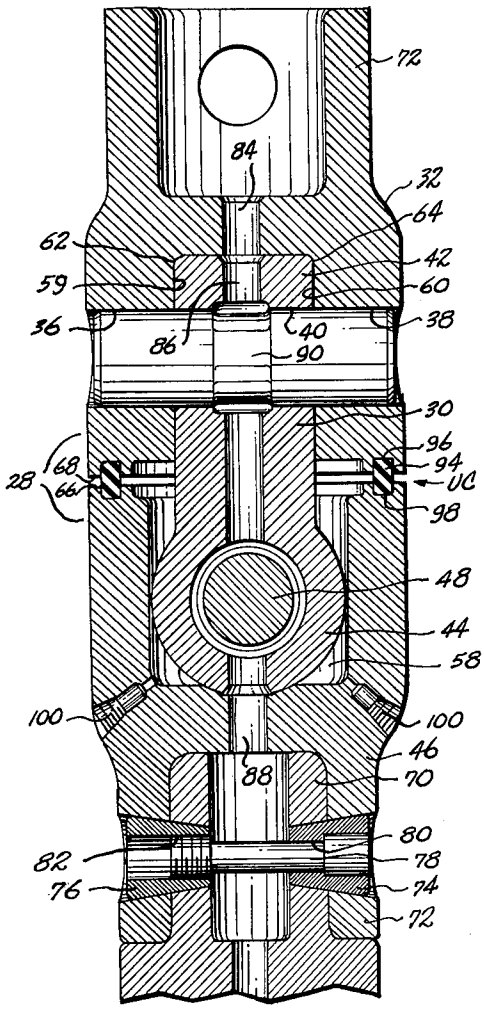


Fig. 2.

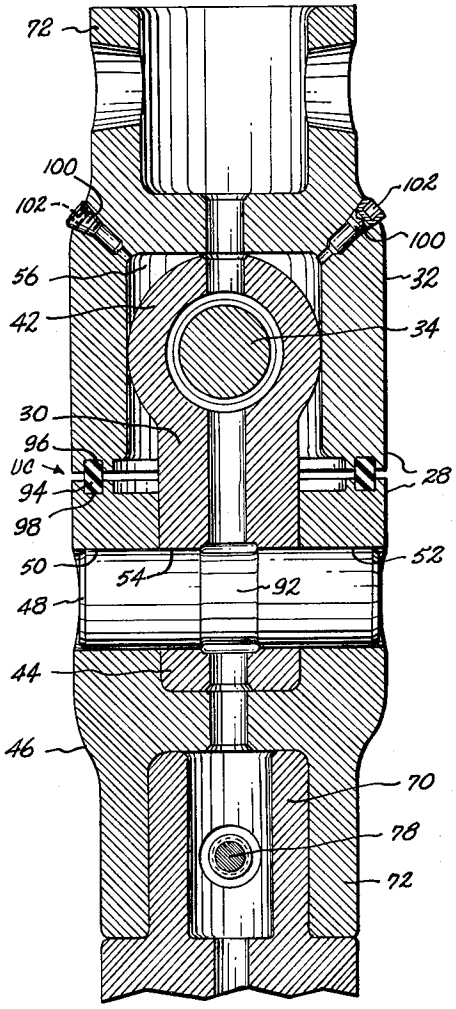


Fig. 3.

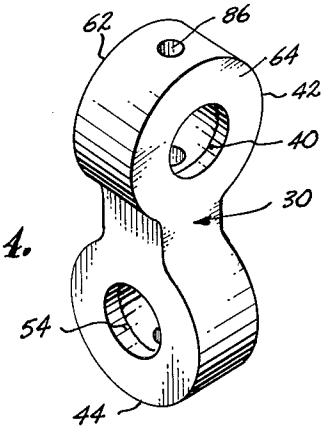


Fig. 4.

INVENTOR.
DOUGLAS F. WINBERG

BY Mathis & Grayseal

ATTORNEYS

Jan. 25, 1966 D. F. WINBERG 3,231,029

ARTICULATED DRILLING SHAFTS FOR RAISE DRILLING

Filed Oct. 28, 1963 3 Sheets-Sheet 3

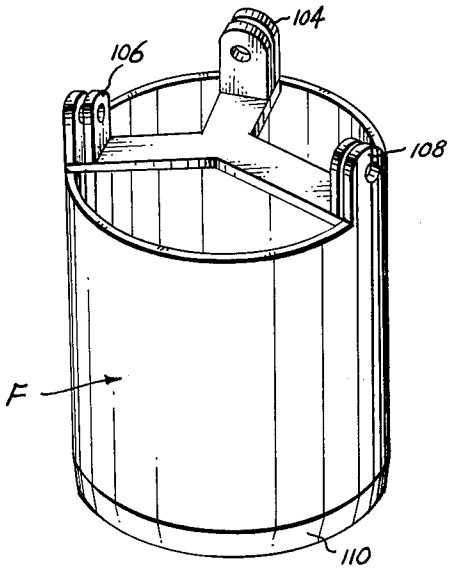


Fig. 6.

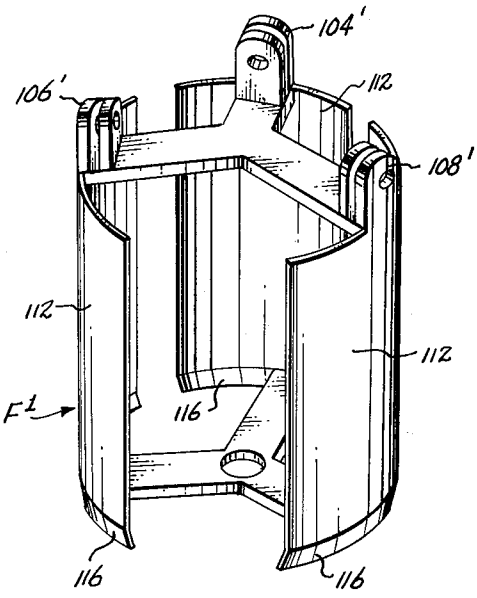


Fig. 7.

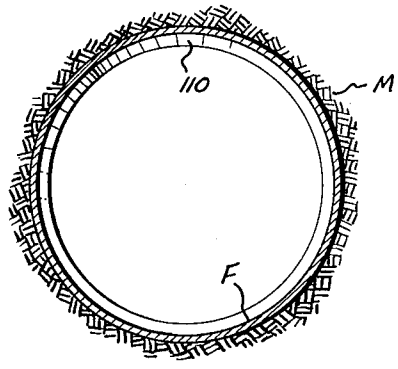


Fig. 8.

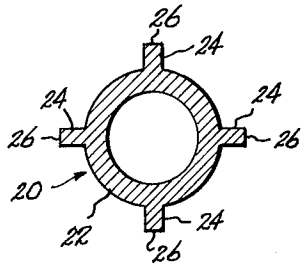


Fig. 5.

INVENTOR.
DOUGLAS F. WINBERG

BY Mattis & Crawford

ATTORNEYS

United States Patent Office 3,231,029 Patented Jan. 25, 1966

3,231,029

ARTICULATED DRILLING SHAFTS FOR RAISE DRILLING

Douglas F. Winberg, Bellevue, Wash., assignor to James S. Robbins and Associates, Inc., Seattle, Wash., a corporation of Washington

Filed Oct. 28, 1963, Ser. No. 319,200
20 Claims. (Cl. 175—53)

The present invention relates to earth boring, and more particularly to drilling shafts or strings especially adapted for use in raise drilling operations wherein a raise hole is drilled upwardly from a lower level to an upper level along the path of a previously drilled pilot hole.

In general, raise drilling involves the proposition of boring a small pilot hole by a downward pass, then enlarging the hole on an upward pass. A rotary drilling rig is anchored to the floor of an upper level and the pilot hole is formed from the upper level to a lower level in a downward pass by means of a small cutterhead mounted at the end of a sectional drill stem rotated and moved progressively downwardly by the drilling rig. At the lower level the small cutterhead is removed from the sectional drill stem and replaced by a cutterhead that is substantially larger in diameter than the pilot hole. The drill stem and cutterhead are then rotated and hydraulically lifted to form the raise hole, with the upper sections of the drill stem being successively removed from such drill stem at the upper level.

Herein the terms "drilling shaft" and "drilling string," or more simply "string," are used to designate an assembly comprising the drill stem (i.e., that portion of the drilling equipment that interconnects the drilling rig and the cutterhead or cutting tool), the cutterhead or cutting tool, and all appurtenances of the drill stem and cutting tool, such as drill stem "stabilizers," for example.

In the Cannon et al. patent application Serial No. 244,756, filed September 19, 1962, and entitled, Raise Drilling Method and Mechanism, there is disclosed a drilling shaft comprising an elongated drill stem of sectional but rigid construction, a raise cutterhead rigidly attached to the lower end of said drill stem, and, depending on the length of the drill stem, one or more stabilizers interposed between the cutterhead and a drilling rig and forming sections of the drill stem. The stabilizers are sized to snugly rotate within a previously drilled pilot hole, for centering the cutterhead with respect to said pilot hole. The cutterhead is both rotated and pulled upwardly by the drilling rig through the intermediacy of the drill stem. The cutterhead is pulled in a straight line essentially due to the rigid nature of the lower portion of the drill stem that interconnects between the cutterhead and the lowermost stabilizer. During a raise drilling operation, when the cutterhead is rotated in a relatively hard material on one side of the raise hole, such as rock, for example, and in a relatively soft material, or in a void, at the other side of the raise hole, the cutterhead is unevenly loaded and is urged by the harder material towards the softer material or void. This subjects the drill stem to a lateral component of force (a bending force) in addition to the torsional forces involved. Experience has shown that when so stressed the stabilizers provide side support for, and essentially prevent bending of that portion of the drill stem that extends upwardly from the lowermost stabilizer. However, the lower portion of the drill stem, located below the lowermost stabilizer, between it and the cutterhead, is not supported against bending at its lower end. Generally speaking, this lower portion of the drill stem behaves during bending as if it were cantilevered from the

lowermost stabilizer. Experience has proven that much too often the rigid lower portion of the drill stem will break when subjected to the combined twisting and bending stresses that it experiences during the raise drilling operation while the cutterhead is turning in both hard and soft materials, as previously described.

According to the invention, a swivel or universal joint, incapable of carrying a moment, but constructed to transmit torque, is interposed in the drill stem slightly above the cutterhead and below the lowermost stabilizer. Owing to this arrangement, the portion of the drill stem located below the lowermost stabilizer is no longer rigid and when loaded by unequal lateral forces acting on the cutterhead, it tends to pivot at the swivel or universal joint rather than bending. Of course, the use of the pivot or universal joint to take away the rigidity of the lower portion of the drill stem for the purpose of eliminating the destructive bending moments also removes the ability of the drill stem to pull the cutterhead in a straight line. Unless it is prevented from doing such, the cutterhead, when being rotated in both hard and soft material as previously described, will swing sideways towards the softer material since the pivot or universal joint is not constructed to prevent the same from happening. Therefore, as an additional feature of the invention, the cutterhead is provided with a "follower," preferably in the form of a cylindrical "skirt," depending therefrom and sized to snugly rotate within the raise hole and stabilize the cutterhead from below. Such follower functions (in place of drill stem rigidity) to maintain the cutterhead in a relatively straight path of travel as it is pulled upwardly. The follower is also especially adapted to prevent the cutterhead from askewing and becoming stuck in the raise hole if and when the drill stem breaks at some intermediate location above the cutterhead. The follower maintains the cutterhead assembly centered in the raise hole and in that manner causes such assembly to fall straight downwardly to the lower level where it can easily be recovered. Preferably, the lower end of the follower is provided with an inwardly sloping lip so as to substantially make it impossible for the lower rim or edge of the follower to catch onto the side wall of the raise hole.

These and other objects, features, advantages and characteristics of the invention will be apparent from the following description of typical and therefore non-limitive 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 drilling machine in operation and forming a raise hole on an upward 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, such view showing a drilling shaft or string typifying various aspects of the invention;

FIG. 2 is a view in medial longitudinal section, of a universal collar, typifying an aspect of the invention;

FIG. 3 is another view in medial longitudinal section, taken substantially at ninety degrees (90°) to the view of FIG. 2;

FIG. 4 is a perspective view of the connector or link portion of the universal collar of FIGS. 2 and 3;

FIG. 5 is a sectional view taken laterally through the drill stem, slightly above a stabilizer, looking downwardly, such view being taken substantially along line 5—5 of FIG. 1;

FIG. 6 is an enlarged scale perspective view of one form of follower, according to the invention;

FIG. 7 is a perspective view of a modified form of follower, according to the invention; and

FIG. 8 is a sectional view taken laterally through the follower of FIG. 1, such view looking downwardly and taken substantially along line 8—8 of FIG. 1.

Referring to the drawings 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 drill stem S is rotated and carried by the said grief stem. As will hereinafter be discussed in greater detail, the drill stem S is generally of tubular construction throughout so that a suitable drilling fluid may be delivered therethrough to the cutterhead and the face of the hole being drilled.

A raise drilling operation involves first boring a small pilot hole PH from the upper level UL where the drilling mechanism is situated down to a lower level LL. The pilot hole drill bit (not shown) is of a 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 their lowermost etxent of travel on guide columns 14, the downward movement thereof is ceased, the portion of the drill stem S then in the ground is uncoupled from the grief stem, and the gear reducer 10 is returned to its raised position. A length L of drill pipe is then coupled between the grief stem and the portion of the drill stem S that is in the ground, and then the drilling is resumed. The pilot hole drilling operation thus progresses in this manner with additional lengths L of drill pipe being successively added to the drill stem S until the pilot hole is formed through the mineral formation M between the upper level UL and the lower level shaft LL.

With the pilot hole PH formed, the pilot hole drill bit is removed from the drill stem S and a raise cutterhead CH, having a plurality of cutters C arranged at the upper end thereof, 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 or otherwise lifting of the drill stem S and the raise cutterhead CH. The raise hole boring operation proceeds with cyclic performance of a working lift of the drill stem S and raise cutterhead, and uncoupling and removal of the upper lengths L of the drill pipe forming the drill stem S, a lowering of the gear reducer 10, a recoupling of the drill stem S to the gear reducer 10, and a further raising of the drill stem S and cutterhead CH, while simultaneously rotating the same, 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 mechanism employed, reference is made to the aforementioned copending application Serial No. 224,756 of Cannon et al. To the extent that it may be necessary for a clearer understanding of the present invention, the disclosure of application Serial No. 224,756 is expressly incorporated herein by reference.

Drill stem S is of sectional construction and is divided by the universal joint into relatively rigid or inflexible upper and lower portions 16, 18, respectively. The universal joint is incorporated into one of the sections of the drill stem E, as will hereinafter be explained in more detail. Certain of the sections of the upper portion 16 of the drill stem S are stabilizer sections and are designated 20 in the drawings. By way of typical and therefore non-limitive example, the said stabilizer sections 20 are illustrated as comprising a cylindrical body 22 and a plurality of radially extending fins 24 circumferentially spaced around said body. Each stabilizer section 20 possesses an effective diameter with rotating that is slightly smaller than the diameter of the pilot hole PH and tends to center the drill stem S (which is smaller in diameter than the pilot hole PH) in the pilot hole PH. As herein used the term "effective diameter," as applied to stabilizers 20, means the diameter of the circular path of travel of the outboard edge surfaces 26 of the fins 24.

As illustrated in FIG. 1, the universal joint may take the form of a box ended universal coupler UC. The lower portion 18 of the drill stem S may be relatively short and an integral part or shank portion of the cutterhead CH. By way of typical and therefore non-limitive example, the universal coupler UC, as shown in FIGS. 2–4, may comprise a two-part tubular casing 28 in which is housed a connecting element or link 30. Connecting element 30 is pivotally connected to the driving half of the casing 28, hereinafter termed the driving hub and designated 32 in the drawing, by means of a pivot pin 34 extending through aligned openings 36, 38 formed in hub 32 and opening 40 formed in the upper end portion 42 of connecting element 30. The lower end portion 44 of connecting element 30 is similarly pivotally connected to the driven half of casing 28, hereinafter termed the driven hub and designated 46 in the drawing, by means of a second pivot pin 48, extending at right angles to pivot pin 34 and through aligned openings 50, 52 formed in hub 48 and opening 54 formed in the lower portion 44 of the connecting element 30.

The hubs 32, 46 are preferably identical in form and each include an inner cavity, such cavities being designated 56, 58, respectively, in the drawing. Cavities 56, 58 are sized to snugly accommodate and prevent lateral movement of end portions 42, 44 of the connecting element axially along the pivot pins 34, 48. However, such cavities 56, 58 are constructed to allow some pivotal movement of the connecting element 30 about the pivot pins 34, 48. Referring to FIG. 2, for example, the generally flat and parallel side surfaces 59, 60 of cavity 56 abuttingly engage the contiguous flat and generally parallel side surfaces 62, 64 of the end portion 42, of connecting element 30, and substantially restrain said end of portion 42 against movement axially along its pivot pin 34 when the cutterhead CH is subjected to a lateral turning force acting in a plane at right angles to the axis of pivot pin 48. In this situation, driven hub 42, which is integrally attached to cutterhead CH by stem portion 18, will pivot about pivot pin 48 until its pivotal movement is arrested by the abutting engagement of the inboard end 66 of hub 46 with the inboard end 68 of hub 32. Preferably, the construction of hubs 32, 46 and connecting element 30 are such that the maximum permissible angular deviation of the center line axis of hub 46 relative to hub 32 is in the order of about one to four degrees (1°–4°). However, these values may change depending upon the particular universal joint employed, it being remembered that coupler UC is presented by way of a typical and therefore non-limitive example. It should also be noted that the universal joint is not employed for the purposes of permitting an appreciable amount of angular deviation to occur between the axes of stem portions 16, 18, but rather to remove the moment carrying capabilities of the drill stem S at the location of the universal joint.

FIG. 3, a view taken substantialy at right angles to the view of FIG. 2, shows that when a turning force acts on hub 46 in a plane at right angles to the axis of pivot pin 34, pivotal movement of such hub 46 occurs about pivot pin 34. In both of the above presented situations, sideways movement of hub 32 is prevented by stem portion 16, owing to its relatively inflexible character (it offers a large resistance to bending). Of course, stem portion 16 is prevented from moving sideways by means of the stabilizers 20.

Preferably, hubs 32, 46 are provided with non-threaded box joint components constructed in accordance with the invention forming the subject matter of the Winberg et al. application, Serial No. 314,142, filed October 7, 1963, and entitled, Sectional Drilling Shafts. Quite briefly, the preferred tool joint construction illustrated in FIGS. 2 and 3 and covered in detail in said application Serial No. 314,142, comprises an elongated, non-threaded, tubular pin 70 interfittingly engageable within an elongated, non-threaded opening of a tubular box 72, and a coupling assembly consisting of a pair of frustro-conical members 74, 76, insertable into diametrically opposed frustro-conical bores (formed by matched pairs of complementary openings in pin 70 and box 72) extending laterally through said pin and box when the same are concentrically related, and a coupling bolt 78 insertable through an axial bore 80 in member 74 and threadably engageable into an axial bore 82 of member 76. The coupling bolt 78 serves as a tension means for interconnecting the frustro-conical members 74, 76 and drawing the same together and in tight engagement with the side walls of the bores.

Drill stem S is tubular in form, providing a central passageway through which a suitable drilling fluid may be delivered from the drilling rig D to the cutterhead CH. FIGS. 2 and 3 show the portion of said drilling fluid passageway that extends through the universal coupler UC, and also shows that the coupling bolts 78 of the non-threaded tool joints are small enough that the drilling fluid can flow around them on its way to the cutterhead CH. More specifically, as shown in FIGS. 2 and 3, a fluid passageway 84 extends lengthwise through hub 32 and communicates at its lower end with the upper end of a passageway 86 extending lengthwise through the connecting element 30. At its lower end, the said passageway 86 communicates with the upper end of passageway 88 extending lengthwise through the driven hub 46. In the region of pivot pins 34, 48, the passageway 86 assumes a generally annular shape and extends in surrounding relationship to reduced diameter portions 90, 92 of the pivot pins 34, 48, respectively. The upper and lower ends of passageway 86 are enlarged so that such passageway 86 is always in fluid-receiving communication with passageway 84 and in fluid discharging communication with passageway 88, regardless of the relative positioning of such passageways 84, 86, 88, due to movement of the several components of the universal joint, i.e. the pivotal movement of hub 46 about one of the pivot pins 34, 48.

An annular sealing ring 94, conventional per se, may be interposed between the spaced inboard ends of hubs 32, 46. The sealing ring 94 may be seated in a pair circumferentially extending grooves 96, 98, one of which (96) is formed in the inboard end 66 of hub 32 and the other of which (98) is formed in the inboard end 68 of hub 46. The sealing ring 94 should be resilient enough to readily compress so as to allow the inboard end 68 of hub 46 to abuttingly engage the inboard end 66 of hub 32, in the previously described manner, and then to recover its original shape when the hubs 32, 46 are again in or near axial alignment.

As previously stated, hubs 32, 46 are preferably identical in form or construction. Such hubs 32, 46 are each provided with at least one opening (preferably two as shown) 100 extending through the side wall portions thereof that define the cavities 56, 58, respectively. The opening or openings 100 in the hub that is chosen to be the driving hub (hub 32 in the illustrated assembly) are plugged and perform no function. As illustrated, the openings 100 are interiorly threaded and are plugged by merely threading an exteriorly threaded plug member 102 therein. The openings 100 in the driven hub (hub 46 in the illustrated assembly) slope downwardly from the floor of cavity 58 and serve as drain openings for the interior of the universal coupler, allowing the drilling fluid and/or ground water leaking into the cavities 56, 58 to flow by gravity out through such drain openings 100.

In FIG. 1, a cutterhead follower F is shown depending downwardly from the cutterhead CH. The follower F of FIG. 1 is in the form of an interiorly open cylindrical skirt and is suitably attached to the cutter head CH as by the pin and ear connections 104, 106, 108, for example. Skirt F has a diameter that is only slightly smaller than the effective or fly diameter of the cutterhead CH, and together with the stabilizers 22, tends to keep the cutterhead CH aligned with the centerline of the pilot hole PH, causing such cutterhead to move in essentially a straight path, so as to make a raise hole RH that is essentially concentrically related to the pilot hole PH. Preferably, skirt F is provided with an inwardly sloping lip 110 at the lower end thereof. In case of a break in drill stem S at a location intermediate the length of the drill stem, the skirt F tends to keep the cutterhead and any portion of the drill stem attached thereto from askewing in the raise hole and becoming stuck in the mineral formation M between the upper and lower levels, and prevents the necessity of a "fishing" operation for their removal. The skirt F keeps the cutterhead and stem assembly aligned in the raise hole RH and causes such assembly to drop straight down through the raise hole RH to the lower level LL, where it can easily be recovered. The inwardly sloping lip 110 minimizes, and perhaps eliminates, the chance of the lower end of said skirt F catching on the side of the raise hole RH.

As previously mentioned, and as clearly shown in FIG. 8, the skirt F is interiorly open so as to allow the essentially uninterrupted fall therethrough of the material cuttings produced by the cutterhead CH.

FIG. 7 illustrates a modified form of cutterhead follower. This form, designated F^1, consists of a plurality of circumferentially arranged cylindrical segments 112, three being shown by way of typical example, interconnected by a suitable frame means 114. When rotating, follower F^1 has an effective or fly diameter slightly smaller than that of the cutterhead CH, and performs the same function as skirt F, i.e. functions as a stabilizer behind the cutterhead. Inwardly sloping lips 116 are provided at the lower ends of such members 112 for lessening or eliminating snagging of the lower ends of members 112 on the side walls of the raise hole RH.

Although the drilling apparatus of the invention has been specifically described in connection with a raise drilling operation wherein the pilot hole is drilled generally vertically downwardly and the raise hole is then drilled upwardly along the path of the pilot hole, such drilling apparatus is not limited to this use alone. For example, the drilling apparatus may be used for slant tunneling from a first gallery to a second, with the drilling rig situated at either the upper or the lower gallery. Also, the drilling apparatus may be used for horizontal tunneling between two galleries at approximately the same elevation, but separated by a mineral formation. In such an operation the larger hole, formed by "pulling" the cutterhead with the drilling rig from the gallery distal the drilling rig toward said drilling rig while simultaneously rotating same, may be termed a "return" hole. Of course, in some horizontal drilling situations, such as drilling through a road fill below the road surface, for example, the drilling apparatus may be considerably smaller in size than is shown in FIG. 1, for example, and the drilling rig may be mounted on a non-wheeled portable base. All of these modifications are within the scope of the present invention.

From the foregoing, various further adaptations, component arrangements and modes of utilization of the raise drilling mechanism characteristic of the invention will be apparent to those skilled in the art to which the invention is addressed, within the scope of the following claims.

What is claimed is:

1. A drilling shaft for use in a raise drilling operation wherein a raise hole is drilled upwardly from a lower level to an upper level along the path of previously drilled pilot hole, said drilling shaft comprising: a drill stem situated in a pilot hole and having a relatively rigid upper portion, a relatively rigid lower portion, a universal joint interconnecting said upper portion with said lower portion, and stabilizer means on said upper portion, said stabilizer means having an effective diameter when rotating that is substantially equal to the diameter of the pilot hole and a cutterhead connected to the lower end of the lower portion of the drill stem, said cutterhead including upwardly directed cutter means having an effective diameter of cut that is larger than the pilot hole.

2. A drilling shaft according to claim 1, wherein a cutterhead follower is attached at its upper end to the cutterhead and depends downwardly from said cutterhead, said follower having an effective diameter when rotating that is substantially equal to the effective diameter of the cutterhead and the raise hole drilled by the cutterhead.

3. A drilling shaft according to claim 2, wherein the lower end portion of the cutterhead follower slopes inwardly so as to place the lower edge of said cutterhead follower radially inboard of the side wall of the raise hole.

4. A drilling shaft according to claim 3, wherein the follower consists of a generally cylindrical member.

5. A drilling shaft according to claim 3, wherein the follower consists of a plurality of circumferentially spaced, generally cylindrical segments, interconnected by frame means.

6. A drilling shaft according to claim 3, wherein the cutterhead follower consists of a relatively thin walled annular member, interiorly open to allow the free fall therethrough of the cuttings, produced by the cutterhead.

7. A drilling shaft according to claim 3, wherein the follower comprises a plurality of circumferentially spaced, generally cylindrical segments, interconnected by frame means, said frame means being substantially interiorly open so as to allow the free fall therethrough of the cuttings, produced by the cutterhead.

8. A drilling shaft for use in a raise drilling operation wherein a raise hole is drilled upwardly from a lower level to an upper level along the path of a previously drilled pilot hole, said drilling shaft comprising: a sectional drill stem situated in a pilot hole and having a relatively rigid upper portion, a relatively rigid lower portion, a collar interconnecting said upper and lower portions, said collar including a universal joint, and a plurality of stabilizers in said upper portion, said stabilizers each having an effective diameter when rotating that is substantially equal to the diameter of the pilot hole; and a cutterhead rigidly connected to the lower end of the lower portion of the drill stem, said cutterhead comprising upwardly directed cutter means, and said cutterhead having an effective diameter while rotating that is substantially larger than the diameter of the pilot hole.

9. A drilling shaft according to claim 8, wherein the said collar comprises a driving hub connected to the lower end of the upper portion of the drill stem, a driven hub connected to the upper end of the lower portion of the drill stem, a connecting element extending generally axially of the drill stem between said driving and driven hubs and having upper and lower end portions, a first pivot pin means extending transversely through the driving hub and the upper end portion of the connecting element for pivotally connecting said connecting element to said driving hub, and a second pivot pin, extending at right angles to the said first pin and transversely through the driven hub and through the lower end portion of the connecting element for pivotally connecting said connecting element to said driven hub.

10. A drilling shaft according to claim 9, wherein the said driving and driven hubs each includes interior wall means extending contiguous to an end surface of the connecting element, and a drilling fluid passageway extends generally axially through each hub and through its wall means; and wherein a drilling fluid passageway extends through said connecting element and communicates at its ends with the drilling fluid passageways in the hubs.

11. In a drilling operation, wherein a return hole is drilled through a mineral formation from a first location distal the drilling rig to a second location proximal the drilling rig, along the path of a previously drilled pilot hole, drilling mechanism comprising: a rotary drilling rig situated at the second location including means for simultaneously rotating and pulling a drill stem; a drill stem situated in a previously drilled pilot hole extending between the first and second locations, said drill stem having a relatively rigid first portion attached to said drilling rig, a relatively rigid second portion, universal joint means interconnecting said first and second portions, and stabilizer means on said first portion, said stabilizer means having an effective diameter, when rotating, that is slightly smaller than the diameter of the pilot hole; and a cutterhead connected to the end of said second portion of the drill stem that is distal the drilling rig, said cutterhead comprising cutter means facing the drilling rig, and said cutterhead having an effective diameter of cut when rotating that is larger than the pilot hole.

12. Raise drilling mechanism according to claim 11, wherein such mechanism further includes a cutterhead follower connected at one of its ends to the cutterhead and extending a substantial distance behind said cutterhead, said follower having an effective diameter when rotating that is slightly smaller than the diameter of the return hole that is being drilled by the cutterhead.

13. Raise drilling mechanism according to claim 12, wherein the said follower is generally cylindrical in form and is generally interiorly open so as to allow the free flow therethrough of the cuttings produced by the rotating cutterhead.

14. In a raise drilling operation, wherein a raise hole is drilled upwardly from a lower level to an upper level along the path of a previously drilled pilot hole, a raise drilling mechanism comprising: a rotary drilling rig situated at the upper level and including means for simultaneously rotating and raising a drill stem; a drill stem situated in a previously drilled pilot hole extending between the upper and lower levels, said drill stem having a relatively rigid upper portion attached to said rotary drilling rig, a relatively rigid lower portion, universal joint means interconnecting the lower end of said upper portion with the upper end of said lower portion, and stabilizer means on said upper portion, said stabilizer means having an effective diameter, when rotating, that is slightly smaller than the diameter of the pilot hole; and a cutterhead connected to the lower end of the lower portion of the drill stem, said cutterhead comprising upwardly directed cutter means, and said cutterhead having an effective diameter when rotating that is substantially larger than the pilot hole.

15. Raise drilling mechanism according to claim 14, wherein such mechanism further includes a cutterhead follower connected and depending a substantial distance below said cutterhead, said follower having an effective diameter when rotating that is substantially equal to the diameter of the raise hole that is being drilled by the cutterhead.

16. Raise drilling mechanism according to claim 15, wherein the lower end portion of the said follower slopes inwardly, placing the lower edge thereof radially inboard of the side wall of the raise hole.

17. Raise drilling mechanism according to claim 16, wherein the said follower is generally cylindrical in form and is generally interiorly open so as to allow the free fall therethrough of the cuttings produced by the rotating cutterhead.

18. For use in an articulated, sectional drilling shaft, a universal coupler comprising: a tubular driving hub having an inboard portion with a hollow interior, and a hollow outboard end portion constituting a component of a tool joint; a tubular driven hub having an inboard portion with a hollow interior, and a hollow outboard end portion constituting a component of a tool joint; a connecting element having a first end prtion housed within the hollow interior of the inboard portion of said driving hub, and a second end portion housed within the hollow interior of the inboard portion of said driven hub; first pivot pin means extending transversely through both said driving hub and said first end portion of the connecting element, for pivotally interconnecting the same; and a second pivot pin means extending at right angles to said first pivot pin means, through both the driven hub and the second end portion of the connecting element, for pivotally interconnecting the same; said driving and driven hubs each also including interior wall means extending contiguous an end surface of the connecting element, and separating the hollow interiors of said inboard and outboard portions, each such wall means being formed to include a drilling fluid passageway, and said connecting element being formed to include a drilling fluid passageway communicating at its ends with the said drilling fluid passageways in the said interior wall means of the hubs, said drilling fluid passageway in the connecting element extending generally axially through said connecting element except in the region of the pivot pin means wherein it assumes an annular form and surrounds said pins.

19. For use in an articulated, sectional drilling shaft, a universal coupler comprising: a tubular driving hub having an inboard portion with a hollow interior and a hollow outboard end portion constituting a component of a tool joint; a tubular driven hub having an inboard portion with a hollow interior, and a hollow outboard end portion constituting a component of a tool joint; a connecting element having a first end portion housed within the hollow interior of the inboard portion of said driving hub, and a second end portion housed within the hollow

interior of the inboard end of said driven hub; first pivot pin means extending transversely through both said driving hub and said first end of the connecting element, for pivotally interconnecting the same; and a second pivot pin means extending at right angles to said first pivot pin means, through both the driven hub and the second end portion of the connecting element, for pivotally interconnecting the same; said driving and driven hubs each also including interior wall means extending contiguous an end surface of the connecting elements, separating the hollow interiors of said inboard and outboard portions, and formed to include a drilling fluid passageway, and said connecting element being formed to include a drilling fluid passageway communicating at its ends with the drilling fluid passageways in the said interior wall means of said hubs; and said driving and driven hubs each further including terminal surfaces at their inboard ends, spaced apart to form a gap, each said terminal surface having a circumferentially extending groove formed therein; and a resilient, annular sealing ring bridging said gap and being anchored in said grooves.

20. The combination of claim 19, wherein a drainage opening extends from the interior of said driven hub out through a side wall of such hub.

References Cited by the Examiner

UNITED STATES PATENTS

636,758	11/1899	Casaday	64—2.6
855,106	5/1907	Hensel	64—2.6
2,694,549	11/1954	James	175—73 X
2,823,900	2/1958	Kandle	175—325
2,930,586	3/1960	Long	175—325 X

FOREIGN PATENTS

215,712	6/1958	Australia.
342,997	7/1904	France.
1,150,035	6/1963	Germany.
939,653	10/1963	Great Britain.

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