(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
9 February 2006 (09.02.2006)

PCT

(10) International Publication Number
WO 2006/014417 A2

(51) International Patent Classification:
E02D 29/00 (2006.01)

(21) International Application Number: PCT/US2005/023783

(22) International Filing Date: 6 July 2005 (06.07.2005)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/585,956 6 July 2004 (06.07.2004) US

(71) Applicant (*for all designated States except US*): **THE CHARLES MACHINE WORKS, INC.** [US/US]; 1959 West Fir Avenue, P.O. Box 66, Perry, OK 73077-0066 (US).

(71) Applicants and
(72) Inventors: **SHARP, Richard, F.** [US/US]; 24276 Country Road 110, Perry, OK 73077 (US). **SELF, Kelvin, P.** [US/US]; 319 Wildwood Acres Drive, Stillwater, OK 74075 (US). **MULLINS, H., Stanley** [US/US]; 11301 Frontier, Perry, OK 73077 (US).

(74) Agent: **O'CONNELL, Sean, V.**; McKinney & String, P.C., 101 North Robinson, Suite 1300, Oklahoma City, OK 73102 (US).

(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *without international search report and to be republished upon receipt of that report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

WO 2006/014417 A2

(54) **Title:** COILED TUBING WITH DUAL MEMBER DRILL STRING

(57) **Abstract:** A system and method for drilling horizontal directional boreholes with a continuous dual member drill string. A horizontal directional drilling machine is comprised of a flexible dual member drill string having a tubular outer member and an inner member rotatably disposed within the outer member. A downhole tool assembly and drill bit is connected to the downhole end of the inner member. The flexible drill string is stored in a coil on a reel or in a drum. At the uphole end of the drill string, a traction drive system provides thrust forces to advance and retract the drill string, and a rotary drive system rotates the inner member. The downhole tool assembly is steered by advancing the drill string with the traction drive and rotating the drill bit with the rotary drive.

COILED TUBING WITH DUAL MEMBER DRILL STRING

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of U.S. Provisional Application Number 60/585,956 filed July 6, 2004, the contents of which are incorporated fully herein by reference.

FIELD OF THE INVENTION

[0002] The present invention relates to creating substantially horizontal near-surface boreholes useful for such purposes as the installation of underground utility services (pipes and/or cables). More particularly, the present invention relates to using a flexible, coiled dual-member drill string suitable for boring a horizontal borehole.

SUMMARY OF THE INVENTION

[0003] The present invention is directed to a horizontal directional drilling machine comprising a frame, a flexible drill string supported by the frame, a downhole tool assembly, a traction drive system, and a rotary drive system. The drill string comprises a tubular outer member and an inner member disposed within the outer member. The tubular outer member has an uphole end and a downhole end, wherein the uphole end is connected to the frame. The inner member is rotatable independent of the outer member and comprises an uphole end and a downhole end. The downhole tool assembly is operatively connected to the downhole end of the inner member. The traction drive system is supported on the frame and adapted to advance and retract the drill string. The rotary drive system is operatively connected to the uphole end of the inner member and adapted to rotate the inner member.

[0004] In another embodiment, the present invention is directed to a method for drilling a horizontal borehole using a continuous dual member drill string comprising a tubular outer member and an inner member rotatably disposed within the outer member. The method comprises the steps of storing the drill string in a coil on a staging unit, rotating the inner member of the drill string, and advancing the drill string by applying frictional forces to the outer member of the drill string.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] Figure 1 is a perspective view depicting a coiled tubing drilling system built in accordance with the present invention.

[0006] Figure 2 is a traction drive for use with the coiled tubing drilling system of the present invention.

[0007] Figure 3 is a partially sectional side view of the top drive assembly and downhole tool assembly of the drilling system of Figure 1.

[0008] Figure 4 is a perspective view of an alternative embodiment for a drill string storage structure built in accordance with the present invention.

[0009] Figure 5 is a perspective view of yet another embodiment of the coiled tubing drilling system built in accordance with the present invention.

DESCRIPTION

[0010] Directional drilling of horizontal boreholes is commonly used for installation of underground utilities. To drill a horizontal borehole, a horizontal direction drilling ("HDD") machine is generally used to advance a drill string and drill bit through the earth. The HDD machine may steer the drilling bit through the earth along an intended path by rotating and thrusting the drill string into the earth. The drill string of the present invention comprises a continuous dual member drill string, having a tubular outer member and an inner member. Directional drilling is accomplished by drilling (boring) with the inner member while controlling direction (steering) with the outer member of the dual-member drill string. The system of the present invention offers several advantages and benefits, which include: (1) a system compactness suitable for use in congested areas, (2) the positive delivery of rotational torque downhole, (3) increased reliability by elimination of connecting tool joints, (4) not having tool joints to make and break increases the production rate, (5) no loss of drilling fluid, as no drill pipe segments are being added or removed, and

(6) continuous drill string offers the opportunity to incorporate therein a communications link and delivery of power and/or control circuitry downhole. These and additional benefits of the present invention will become clear in the description which follows.

[0011] With reference now to the drawings in general and to FIG. 1 in particular, there is shown therein a near-surface HDD system 10 for creating the subsurface borehole 12. The typical path of borehole 12 begins from the ground surface as an inclined segment that is gradually leveled off as the desired product installation depth is neared. This near horizontal path may be maintained for the specified length of the product installation. Alternately, a starting pit (not shown) may be excavated to the desired product installation depth (or shallower) to allow initiating the borehole 12 below ground surface. The desired end point (not shown) of borehole 12 may terminate in a target pit (a.k.a. exit pit) or the borehole may be directed upward to exit the ground surface in a drilling segment of similar or steeper incline to that of the entry segment. The location and orientation of the borehole as it progresses along the intended borepath may be determined by one of several methods commonly known in the HDD industry. A conventional walk-over tracking receiver (not shown) may be utilized in conjunction with downhole electronics, or the positional information may be transmitted up a drill string. One such tracking system is disclosed in U.S. Patent Application S/N 10/724,572, incorporated herein by its reference.

[0012] With continued reference to FIG. 1, the HDD system 10 preferably comprises a frame 14, a drill string 16 supported on the frame, and a downhole tool assembly 18. The drill string 16 of the present invention comprises a flexible continuous dual member drill string having an uphole end 20 and a downhole end 22. As represented in FIG. 2, the dual member drill string 16 is comprised of a tubular outer member 24 and an inner member 26 disposed within the outer member. The inner member 26 is rotatable independent of the outer member 24 and an annulus 28 is formed between the inner member and the outer member. The annular clearance 28 between the inner member 26 and the outer member 24 provides a passageway for conveying drilling fluid downhole as needed.

[0013] The tubular outer member 24 is preferably comprised of a composite construction wherein one or more wire-braided layers are imbedded in the wall or bonded to a surface of the tubular material. More preferably, the tubular member 24 may be made of a material such as polyethylene. Alternately, its composite construction may be much like that of a multi-braided hydraulic hose. The materials and construction utilized must be capable of conveying high pressure (up to 3500 psi) drilling fluids to the directional downhole tool assembly 18. The outer member 24 must also be resistant to internal abrasion from the rotating inner member 26 and external abrasion from the borehole 12 environment.

[0014] The inner member 26 may be comprised of conventional flexible drive shaft construction. This construction may, for instance, comprise overlaid spring steel coil windings around a central core. The inner member 26 transfers the rotational torque produced by a yet to be described drive system to the downhole tool assembly 18, and ultimately to an as yet to be described drill bit used to create the borehole 12.

[0015] Use of the flexible dual member drill string 16 as described provides advantages for the boring operation. For example, the tubular out member 24 may be internally pressurized to reduce its flexibility, enhancing its rigidity, and thereby improving the ability to deliver thrust downhole to a drill bit (yet to be described). Additionally, the annulus 28 in the drill string 16 permits drilling fluids to be pumped down the drill string to facilitate the drilling process as is known in the art.

[0016] Referring again to FIG. 1, the downhole tool assembly 18 is connected to the downhole end 22 of the drill string 16. The downhole tool assembly 18 preferably comprises a housing 30 and a drill bit 32. More preferably, the drill bit 32 will comprise a directional drill bit to permit steering of the borehole 12. Steerable (directional) drill bits, including those described in U.S. Pat. No. 5,799,740, issued to Stephenson, et al., may be utilized to "directionalize" the downhole tool assembly 18.

Alternatively, other known methods of steering may be used, such as non-directional drill bits used with a continuous or deployable steering bias incorporated into the downhole tool assembly or with high-pressure angular discharge of drilling fluid at the drill bit. An example of continuous steering bias in a downhole assembly is described in U.S. Pat. 5,490,569, issued to Brotherton, et al. Examples of fluid assisted drilling bits may be found in U.S. Pat. No. 4,674,579. The contents of the above patents are incorporated herein by their reference.

[0017] The HDD system 10 further comprises a traction drive system 34 supported on the frame 14. The traction drive system 34 is adapted to advance and retract the drill string 16. The traction drive system 34 comprises a plurality of friction wheels 36, at least one motor 38 to rotate the friction wheels, and an alignment tube 40.

[0018] With reference now to FIG. 2, shown therein is a more detailed view of the traction drive 34 for use with the present invention. A pair of opposing plates 42 form a frame for the traction drive 34. The plates 42 provide support for the friction wheels 36. Preferably, the wheels 36 are positioned and shaped for arcuate engagement with an outer circumferential surface of the flexible drill string 16. More preferably, six wheels (as shown in FIG. 1) may be used to provide adequate contact with the drill string 16. The friction wheels 36 may be spring-loaded (not shown) or otherwise biased against the drill string 16 to minimize slippage. The friction wheels 36 apply thrust to the drill string 16, which thrust is relayed downhole to engage the drill bit 32 against the end of the borehole 12. For flexible drill strings that comprise a steel tubular outer member, a conventionally known tubing straightener may serve as the traction drive.

[0019] The motor 38 is operatively connected to the friction wheels 36 and may be connected to the plates 42 for support. The motor 38 is preferably adapted to rotate the wheels 36 in a first direction to advance the drill string 16 into the borehole 12 and in an opposite direction to retract the drill string from the borehole. The motor 38 may be a hydraulic motor or may be otherwise powered.

[0020] The alignment tube 40 is provided to guide the flexible drill string 16 from a staging unit at a storage position (yet to be described) to the traction drive 34. The alignment tube 40 will preferably comprise a tube 44 with a first end 46 and a second end 48 and having an inner diameter greater than the outer diameter of the drill string 16. The tube 44 is connected to the plates 42 such that the first end 46 is proximate the friction wheels 36. The second end 48 of the tube 44 is proximate the storage position for the drill string 16. The alignment tube 40 then is arranged to receive the drill string 16 and position the drill string to engage the friction wheels 36.

[0021] As shown in FIG. 2, the traction drive 34 may also comprise a guide tube 50 to direct the drill string 16 from the traction drive onto the desired starting alignment for the borehole 12. The guide tube 50 preferably comprises a tube 52 having an inner diameter that closely approximates the outer diameter of the drill string 16. One skilled in the art will appreciate that selection of the tube 52 diameter in this manner allows the guide tube 50 to react (support) the thrust being delivered from the traction drive 34 downhole to the drill bit 32. A close diameter borehole 12 (i.e., a narrow annulus between it and the flexible drill string 16) can provide support as well. The guide tube 50 is preferably connected to the plates 42 on a side of the friction wheels 36 opposite from the alignment tube 40.

[0022] With returning reference to FIG. 1, the HDD system 10 further comprises a staging unit 54 adapted to store the flexible drill string 16. The staging unit 54 preferably comprises a support frame 56 and a rotatable reel 58. The reel 58 is bearingly mounted (not shown) on the support frame 56. Although not so illustrated in FIG. 1, the support frame 56 may be constructed onto an undercarriage or trailer for improved mobility. Earth anchors (not shown), common to machines in the HDD industry, may also be incorporated to react the forces involved in creating the borehole 12 and in installing the product pipe or cable.

[0023] This flexible dual-member drill string 16 may be deployed (uncoiled) from its storage reel 58 – or reinstated (coiled) thereon – as the bearingly supported reel is rotated. Rotation of the reel 58 about an axis of support may be under the control of a hydraulic motor drive arrangement 59. The drive arrangement 59 may be a hydraulic motor or otherwise powered. Preferably, the drive arrangement 59 will be operated in cooperative coordination with the traction drive 34. One skilled in the art will appreciate the drill string 16 may be deployed from the reel 58 merely by operation of the traction drive 34, but that operation of the drive arrangement 59 facilitates the boring operation.

[0024] Preferably the reel 58 is sufficiently large to store multi-layered wraps of the flexible drill string 16. Whenever the reel 58 is wider than twice the outer diameter of the drill string 16, the reel may store the drill string in side-by-side wraps. More preferably the reel 58 will be of sufficient width and diameter to store 100 feet or more of the flexible drill string 16 in multiple layers of side-by-side wraps. For such large reels 58, a commonly-known "level-wind" (not shown) may be utilized to maintain the uniformity of the layered wraps.

[0025] The HDD system 10 further comprises a rotary drive system 60 for rotating the inner member of the dual-member drill string 16. The rotary drive system 60 supplies rotational torque to the inner member 26 of the drill string 16. By way of the inner member's 26 connection to the directional downhole tool assembly 18 and the drill bit 32, the borehole 12 may be formed.

[0026] Referring now to FIG. 3, shown therein is the rotary drive system 60 in greater detail. The rotary drive 60 may be powered by a hydraulic motor 62 and supported on the frame 14. Preferably, an output shaft 64 of the motor is aligned coincident with the rotational axis of the reel 58. The motor 62 may further be supported on the frame 14 by way of a drilling fluid swivel 66. Alternately, the motor 62 may be supported on the reel 58 when an additional drilling fluid swivel and swivel connections (not shown) for hydraulic power and return lines are located coincident with the rotational axis of the reel. The fluid swivel 66 allows drilling fluid to be pumped (pump and hosing not shown) through the annulus 28 in the drill string 16, between the outer member 24 and the inner member 26.

[0027] The output shaft 64 of the motor 62 is attachable to the inner member 26 by way of an uphole drill string connector 68. Preferably, the uphole connector 68 is secured to the inner member 26 of the drill string 16. The uphole connector 68 may be internally threaded, for instance, in the form of an SAE face-seal connector. The output shaft 64 is connected to the uphole connector 68 and the inner member 26 by way of an uphole inner drive coupling 70 and a retaining pin 72. The retaining pin 72 may also serve to transmit or react the rotational torque of the motor 62 into the inner member 26. Alternately, torque transferal may be accomplished by use of slip-fit torque-transmitting mating geometric shapes on the coupling 70 (internal) and on the uphole connector 68 (external). A geometrically shaped connection of this nature is disclosed in U.S. Pat. No. 5,682,956, the contents of which are incorporated herein by reference. One or more seals 74 and o-rings 76, in or around the uphole coupling 70, prevent ingression of drilling fluid into the drilling fluid swivel 66.

[0028] With continued reference to FIG. 3, a preferred construction for the directional downhole tool assembly 18 and its connection to the inner member 26 is shown. The directional downhole tool assembly 18 comprises the drill bit 32, a bearing housing 78, a bearingly supported drive shaft 80, and a bit holder 82. The bearing housing 78 comprises an end cap 84 adapted to be connected to the downhole end 22 of the outer member 24 of the drill string 16. The drill bit 32 is secured to the bit holder 82, preferably in a known manner such as by bolting.

[0029] The drive shaft 80 rotationally couples the inner member 26 to the bit holder 82. The drive shaft 80 comprises an intermediate shaft 85 for connection to a downhole drill string connector 86 secured to the inner member 26. The connection between the intermediate shaft 85 and the downhole connector 86 may be similar to that described for the inner member 26 connection to the rotary drive 60. Retaining pins 88 and 90 may be used to hold the slip-fit connections in place.

[0030] The bit holder 82 is rotationally fixed to the drive shaft 80 by matingly formed geometric shapes, such as a splined connection, further held in place by a retaining pin 92. Additionally, the downhole tool assembly 18 may also include a planetary gear arrangement (not shown) used to multiply the torque the inner drive member 26 delivers to the drill bit 32.

[0031] Various bearing and seal arrangements may be used in the end cap 84 and the bearing housing 78 to prevent drilling fluid and other external contamination from reaching the drive shaft 80. Suitable torsional stiffness in the flexible outer member 24 may be utilized to hold the bearing housing 78 substantially without rotation about its axial centerline when acted upon by reactionary forces such as rotational drag on bearing and seal arrangements 94 and 96 supporting the drive shaft 80. A fluid passage 98 in the bearing housing 78 is used to allow communication of drilling fluid from the drill string 16 annulus 28 to the drill bit 32. An o-ring 100 prevents the escape of drilling fluid through the splined connection.

[0032] With reference now to FIG. 4, shown therein is an alternate embodiment for the staging unit to store the flexible drill string 16. In this instance, the traction drive 34 and alignment tube 40 of FIG. 2 are associated with a drum 102 for storing the drill string 16. The rotary drive 60 is again attached to the drum and operatively connected to the drill string 16 to rotate the inner member 26.

[0033] The drum 102 is rotatably supported on the frame 14 (shown in FIG. 1). A plurality of drum support arms 104 provide for operatively connecting the drum 102 to the traction drive 34. Preferably, the traction drive 34 and the alignment tube 40 are aligned in approximate coincidence with an axial centerline of the drum 102. As shown in FIG. 4, a flange 106 connected around the alignment tube 40 provides support and connection for the drum support arms 104. One skilled in the art will appreciate the traction drive 34 will rotate with the drum 102 when connected in this way.

[0034] The flexible drill string 16 is stored on the inside of the drum 102 in one or more layers of side-by-side coils. When the drum 102 is rotated in the direction opposite of the winding of the coils, the windings are forced against the drum and attempt to expand in diameter. This expansion tendency tends to push the end of the nearest winding into the traction drive 34. This effect will continue so long as the drum delivers the windings faster than a linear discharge rate of the traction drive 34. An automated control system (not shown) may be utilized to maintain a useful balance between a rotational speed of the drum 102 and a drive speed of the traction drive 34. Similarly, thrust forces of the traction drive 34 may be augmented by the unwinding action of the drum 102 without slippage of the drill string 16 through the friction wheels 36.

[0035] One skilled in the art will appreciate rotation of the drum 102 may cause the deployed length of the drill string 16 to also rotate about its axial centerline in the same direction and at the approximate speed (revolutions per minute) of the drum. As is known in the art, this drill string 16 rotation may be usefully applied toward counter-acting the previously mentioned continual steering bias incorporated into certain embodiments of the directional downhole tool assembly 18. When a directional change or steering correction is desired in the progression of the borehole 12, the rotation of the drum 102 may be stopped at the proper orientation of the directional downhole tool assembly 18. During the steered segment of the borehole 12, the drill string 16 (and downhole assembly 18) is advanced solely by the traction drive 34 while the drum 102 is held without rotation. Thus steering may be accomplished "on the go" by sensing a position of the downhole tool assembly 18 and controlling the rotation of the drum 102.

[0036] With reference now to FIG. 5, shown therein is an alternate embodiment for the HDD system 120. The system 120 uses the previously described flexible dual-member drill string 16 wound upon a storage reel 130. A rotary drive (not shown), such as that described in previous embodiments, may be operatively connected to the inner member 26 of the drill string 16 for rotating the inner member. The drill string 16 is spooled and unspooled from the reel 130 by the coordinated action of a reel drive arrangement 134 and a traction drive 138, in much the same manner as described for previous embodiments. The traction drive 138 is represented in the embodiment shown in FIG. 5 by a series of opposed pairs of friction wheels 144.

[0037] The storage reel 130 and its drive arrangement 134 are preferably supported within a cage 150, which in turn is supported on a series of rollers 154. The cage 150 comprises a reel support 156 and drive supports 158. The reel support 156 provides a structure to rotatably support the reel 130 and the rotary drive 132. The drive supports 158 are attached to the traction drive 138 so that the traction drive can rotate with the reel 130.

[0038] A drive motor 160 is used to rotate the cage 150 on the rollers 154. The cage 150 could be rotated continuously whenever its rotation is initiated. However, to simplify connection of its drilling fluid and hydraulic circuits and other circuitry (not shown), the rotation of the cage 150 is preferably limited to one or two revolutions in a particular direction (for instance clockwise). A reversal in direction (e.g., counterclockwise rotation) is therefore required if further rotation is desired once a limit is reached.

[0039] A useful result of such rotation of the cage 150 is to apply rotational torque to the drill string 16. With regard to the embodiments of both FIGS. 1 and 5, this rotation transfers down the borehole 12 to orient the directional feature of the directional downhole tool assembly 18. Such an arrangement gives the opportunity to simplify and reduce the amount of apparatus included within the downhole assembly 18. For instance without the ability to rotate the outer member 24 of the drill string 16 about its central axis, some type of "downhole orienter" may be necessary to direct the drill bit 32 along the desired borepath. Such a device is commonly employed in coiled tubing drilling applications in other industries. Other options for initiating a steering correction include: (1) the use of angled discharge nozzles (US Pat. 4,674,579) that are properly oriented by the point of stoppage of the inner drive member 26 rotation, (2) coordinated pulse fluid jets, (3) hydraulic or electrically activated steering devices, (4) linear displacement of the inner drive member 26 relative to the outer member 24, controlling tension on the inner drive member 26, and (6) utilization of an offset bit 32.

[0040] Various modifications can be made in the design and operation of the present invention without departing from the spirit thereof. Thus, while the principal preferred construction and modes of operation of the invention have been explained in what is now considered to represent its best embodiments, which have been illustrated and described, it should be understood that the invention may be practiced otherwise than as specifically illustrated and described.

CLAIMS

1. A horizontal directional drilling machine comprising:

a frame;

a flexible drill string supported by the frame, the drill string comprising:

a tubular outer member having an uphole end and a downhole end, the uphole end connected to the frame; and

an inner member disposed within the outer member, the inner member rotatable independent of the outer member and comprising an uphole end and a downhole end;

a downhole tool assembly operatively connected to the downhole end of the inner member;

a traction drive system supported on the frame, the traction drive system adapted to advance and retract the drill string; and

a rotary drive system operatively connected to the uphole end of the inner member, the rotary drive system adapted to rotate the inner member.

2. The machine of claim 1 wherein the frame comprises:

a support member;

a reel rotatably supported on the support member; and

wherein the drill string is stored on the reel.

3. The machine of claim 2 wherein the rotary drive system is attached to the reel.

4. The machine of claim 2 further comprising a reel drive assembly adapted to rotate the support member.

5. The machine of claim 1 wherein the frame comprises a rotatable drum and the drill string is stored in the drum in a coil.

6. The machine of claim 1 wherein the traction drive system comprises:

a plurality of friction wheels;

an alignment tube adapted to receive the drill string and position the drill string to engage the friction wheels; and

at least one motor adapted to rotate the plurality of friction wheels.

7. The machine of claim 6 wherein the traction drive system further comprises a guide tube positioned on a side of the friction wheels opposing the alignment tube and adapted to receive the drill string and position the drill string at an entrance to a borehole.

8. The machine of claim 1 wherein the rotary drive system comprises:

a motor comprising an output shaft;

a first coupling attached to the output shaft and adapted to operatively connect with the uphole end of the inner member;

a second coupling attached to the motor and adapted to connect to the uphole end of the outer member.

9. A method for drilling a horizontal borehole using a continuous dual member drill string comprising a tubular outer member and an inner member rotatably disposed within the outer member, the method comprising:

storing the drill string in a coil on a staging unit;

rotating the inner member of the drill string; and

advancing the drill string by applying frictional forces to the outer member of the drill string.

10. The method of claim 9 further comprising rotating the staging unit to counter rotation of the outer member as it is removed from the coil.

11. The method of claim 9 further comprising steering the drill string by rotating the outer member.

1/5

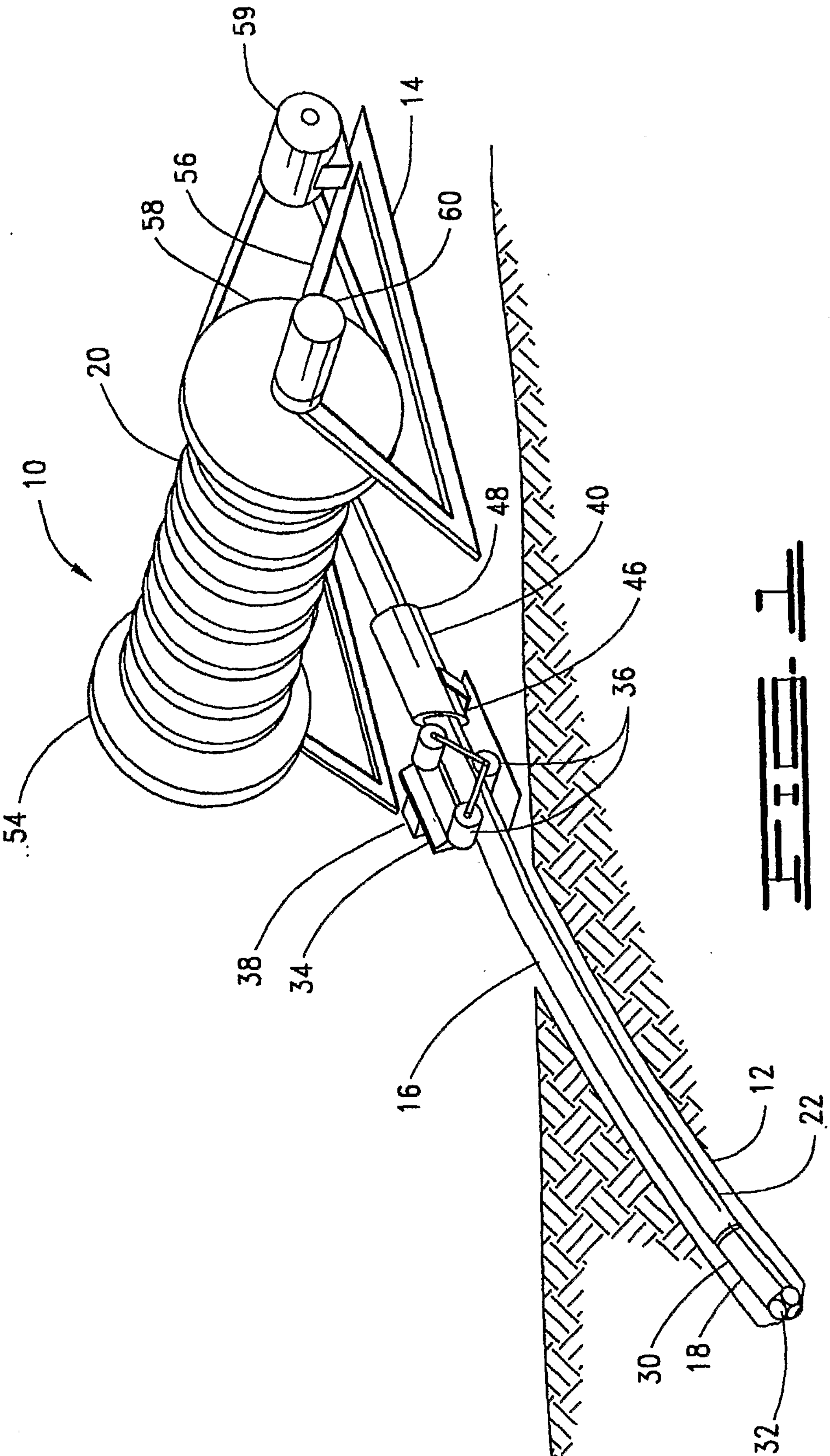


FIG. 1

2/5

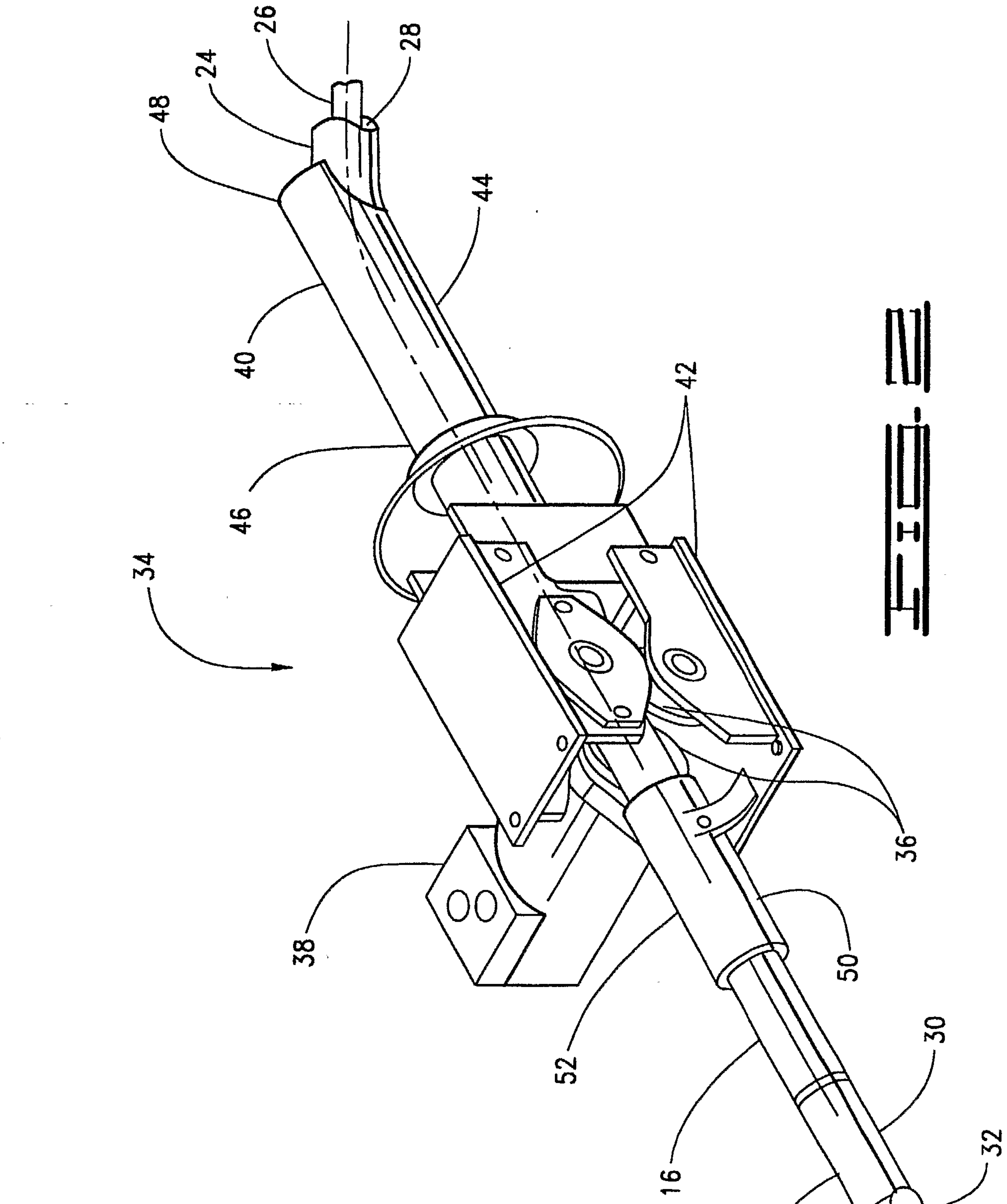
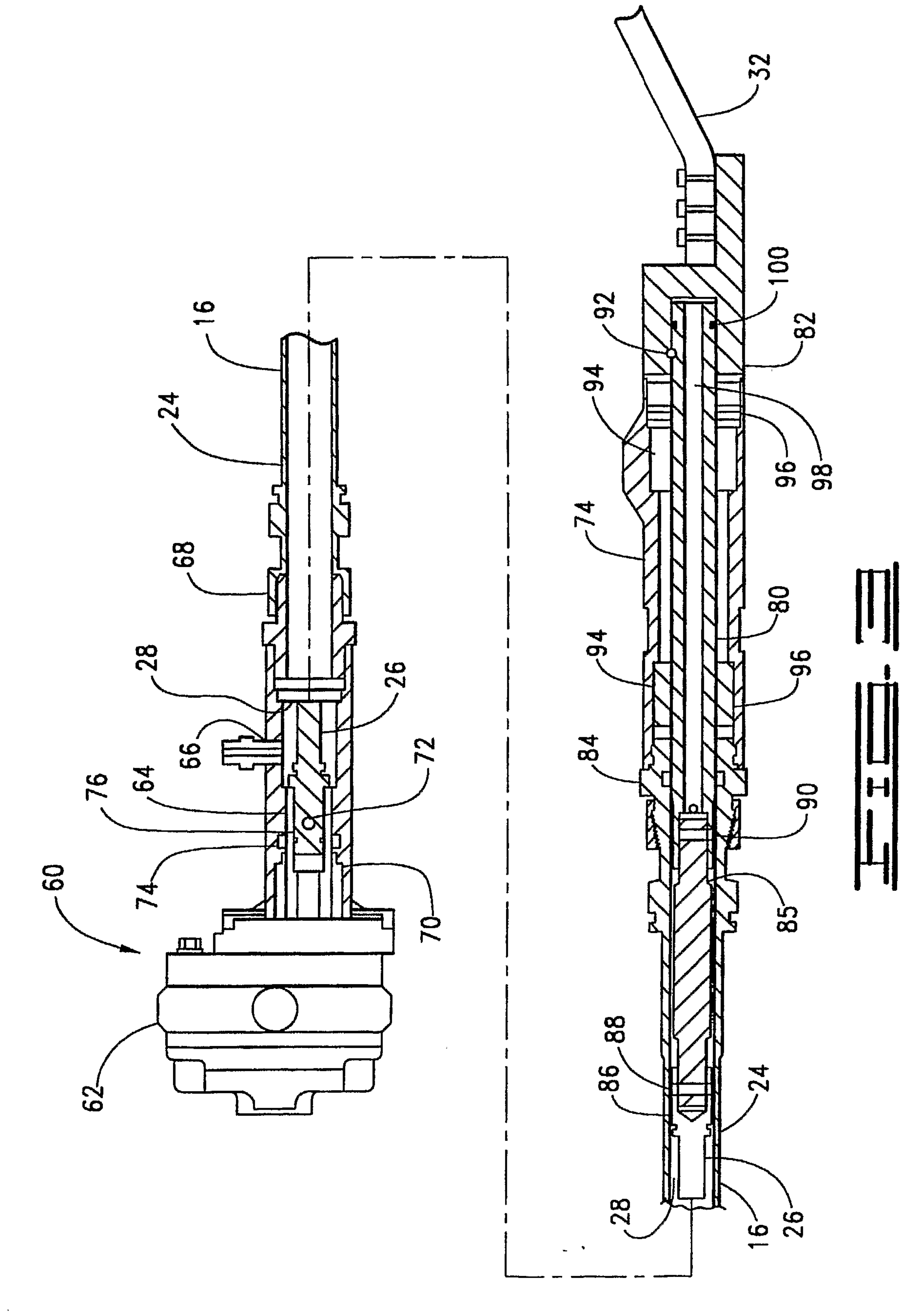


FIG. 2


16
24
68
28
26
66
72
64
76
74
60
70
62
32
100
92
82
94
96
98
80
84
90
85
88
86
28
16
26

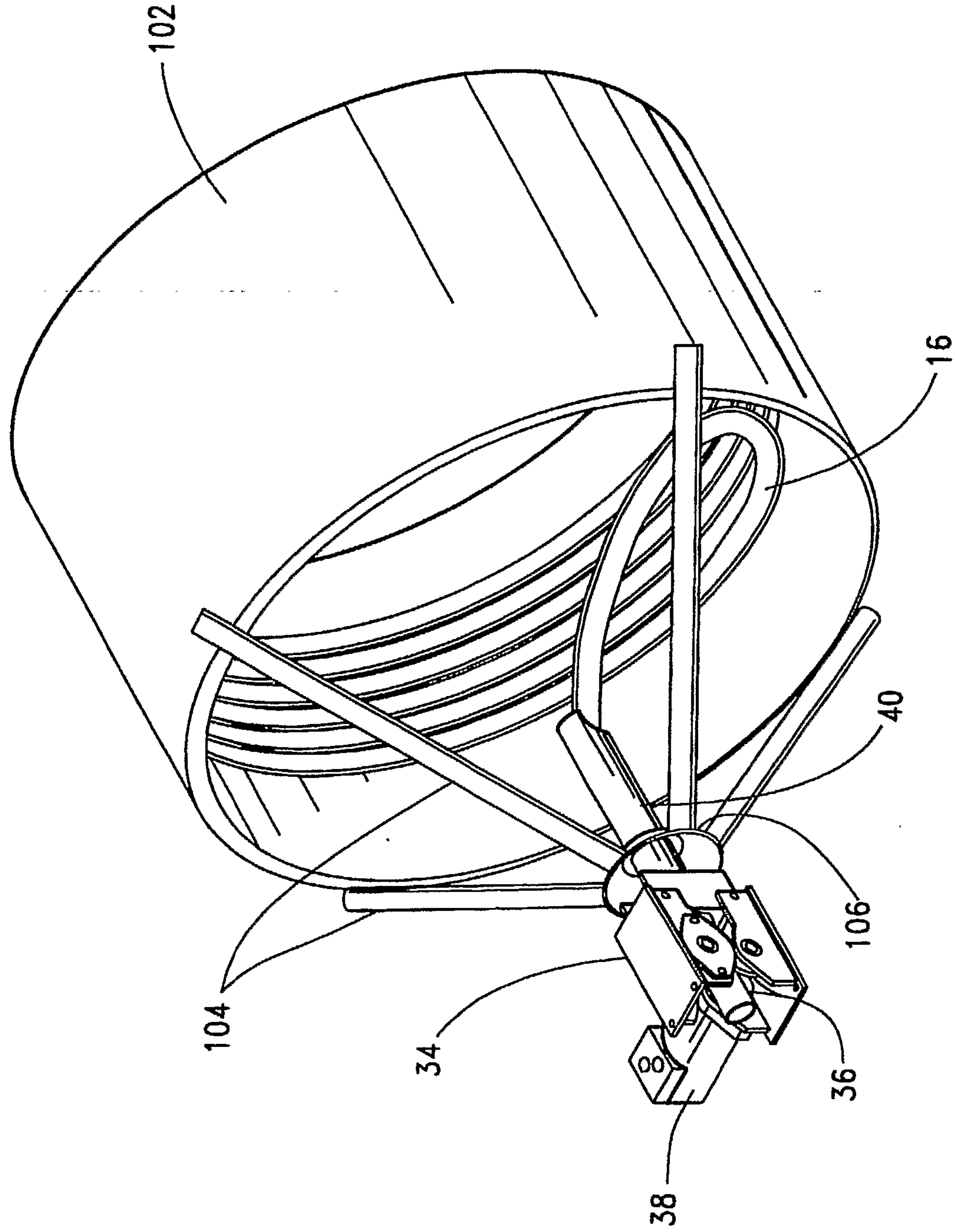


FIG. 4

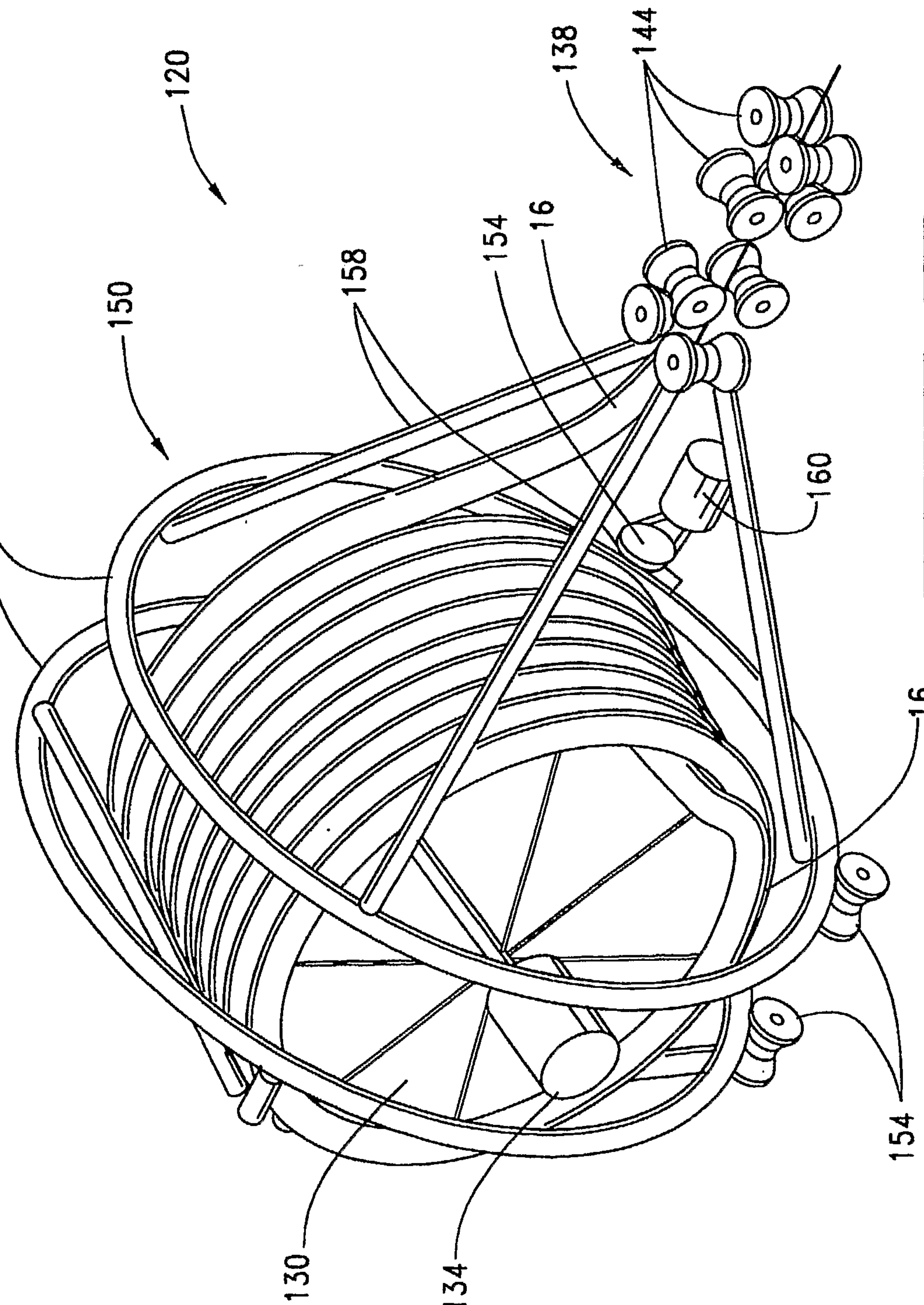


FIG. 3