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[54] **GEODYNAMIC WING**
10 Claims, 4 Drawing Figs.

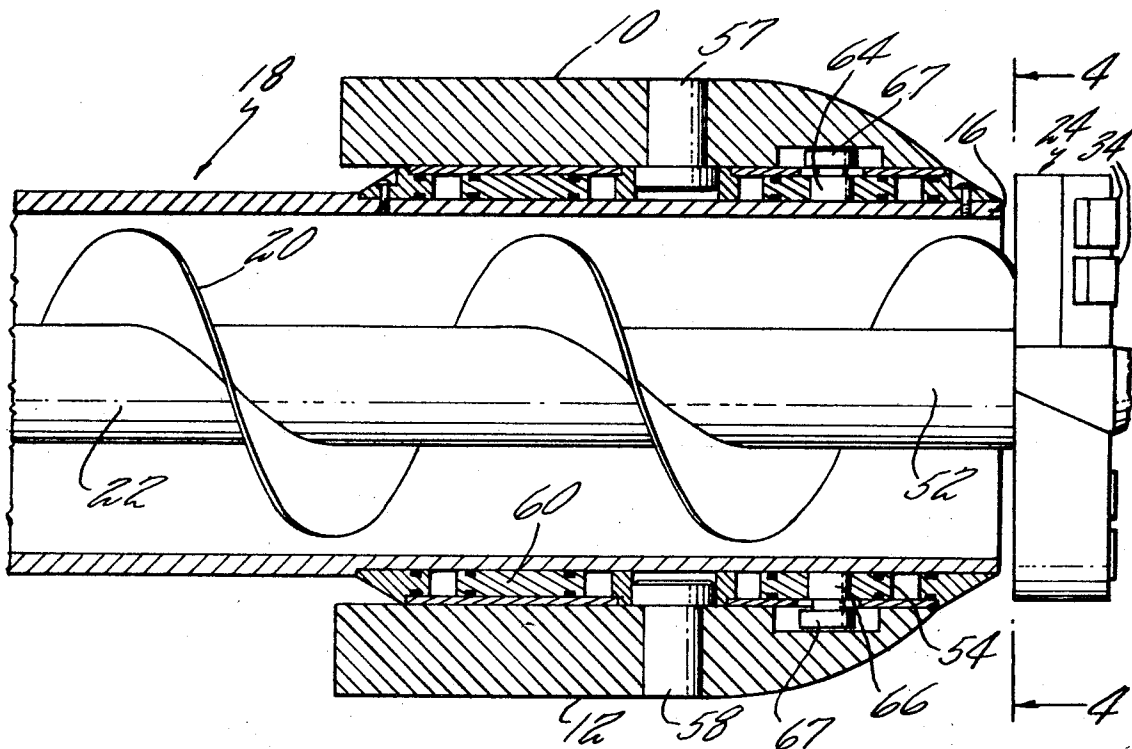
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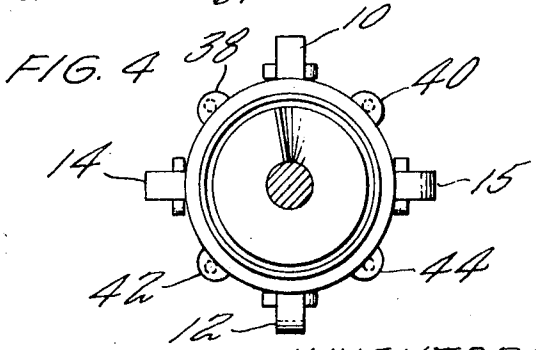
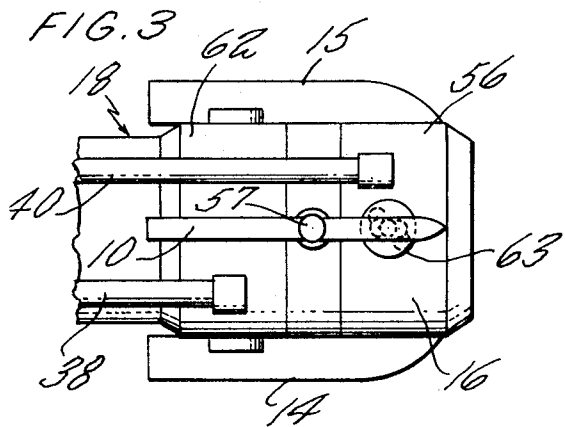
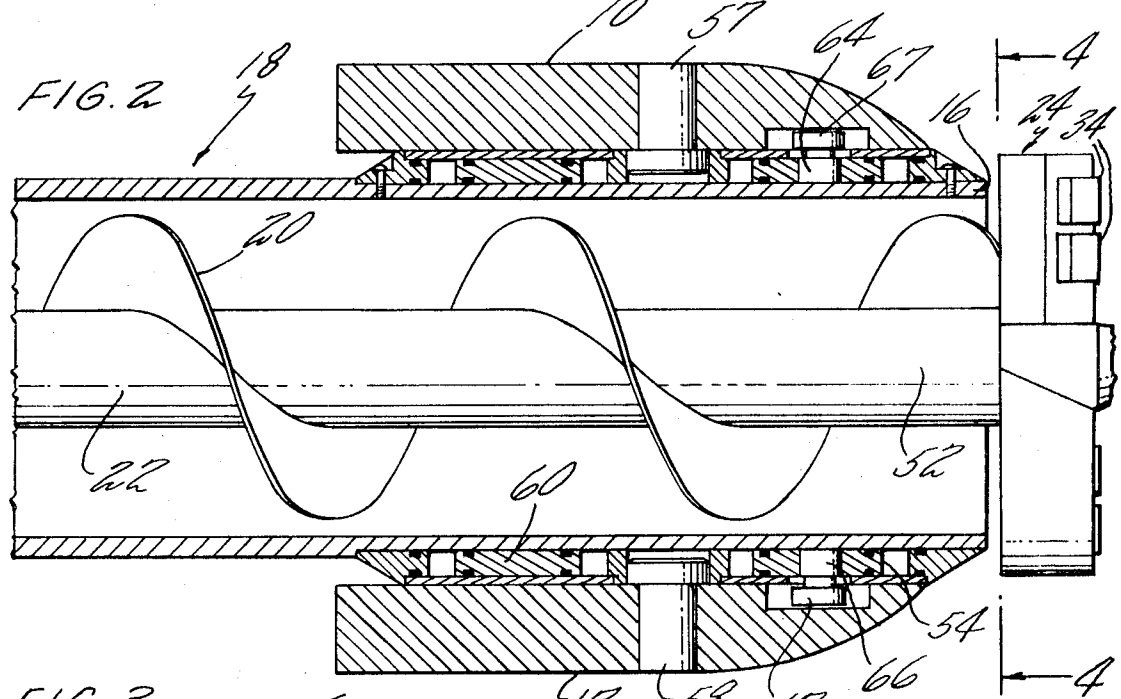
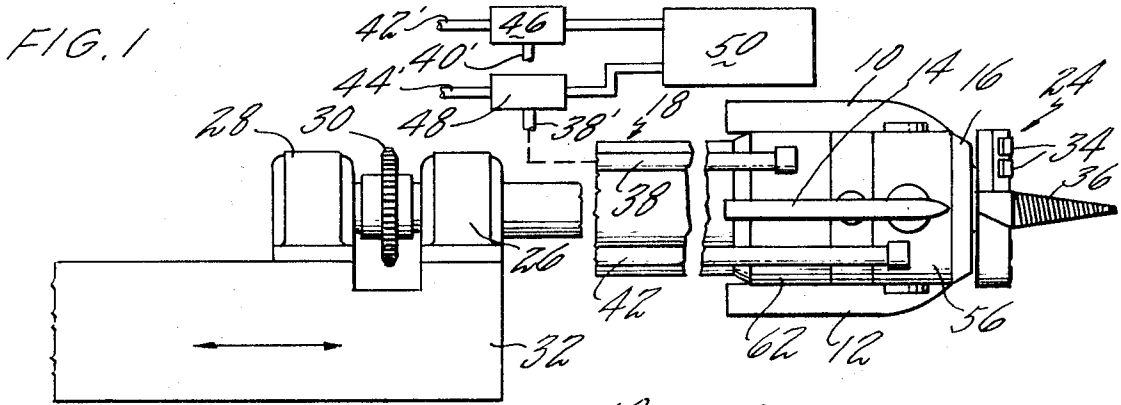
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ABSTRACT: Apparatus for exercising directional control over horizontal earth-boring machinery wherein oppositely disposed control vanes, such vanes being pivotably mounted on the exterior of the forward section of the casing which is jacked into the bore as it is extended, are deflected in pairs. Deflection of the vanes is accomplished by wraparound hydraulic cylinders and the vanes function first as wedges and thereafter, as the casing and boring tool move forward, as control surfaces to guide the machinery back onto the desired straight-line path.





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GEODYNAMIC WING

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to earth boring. More particularly, the present invention relates to the directional control of horizontal earth-boring tools. Accordingly, the general objects of the present invention are to provide novel and improved methods and apparatus of such character.

2. Description of the Prior Art

Utility companies have long recognized the costly labor expense and public opposition associated with the prior art method of installing distribution lines in excavated trenches. These problems have, of course, been aggravated when the breaking of pavement or the interruption of railway service was involved. The disadvantages inherent in trenching can be significantly reduced by using horizontal earth-boring tools for installing underground cables and conduits and accordingly horizontal augering has in recent years been specified in many situations requiring the placement of utility lines under roads and railroads.

Prior art horizontal augering equipment has, however, been plagued with a serious problem. This problem resides in the previously existing inability to exercise control over the direction of the drill string so that the drill may be redirected should it deviate from the correct drilling path. As is known, unpredictable drift in underground boring operations is caused by the flexibility of the boring tool. It is extremely difficult to make such tools stiff or rigid enough to withstand lateral thrust loads imposed on the drill head or bit by stone, or other soil discontinuities, or even by the rotational torque transmitted to the drill string from the driving apparatus.

The above-noted deflection or drift phenomena has been most pronounced when the ratio of drill string length to drill string diameter becomes large. In addition, since the location of the boring bit is not always readily apparent, the drill string may drift as much as 6 feet in 100 feet or more before being noticed and corrective measures attempted.

In the prior art, the only mode of directional control available has been the use of pickup or potholes located at intervals along the desired tunnel path, the bit being realigned if necessary as it passed each of the pickup holes. This technique is, however, only effective when bores are attempted without a casing and many times drill string deflection between pickup holes too slight to be visually noticed at pickup holes will make it difficult to later insert a casing or carrier pipe. Also, the use of pickup holes is subject to the same public opposition, albeit to a lesser degree, as trenching.

It has been recognized that a more accurate method for underground installation of a conduit encompasses augering through a casing while simultaneously jacking the casing. However, this method will also fail when the drill string is deflected since the auger will bind in the casing. Such binding sometimes results in a loss of a section of auger as well as loss of time spent in completing the tunnel.

In the drilling of wells, for example oil wells, techniques have been evolved for the directional control of the drill string. These techniques, however, are primarily of use in the drilling of slant bores and, for numerous reasons, are not suitable for the exercise of directional control over horizontal boring tools and where the ability to redirect in multiple directions is necessary.

SUMMARY OF THE INVENTION

The present invention overcomes the above-discussed and other disadvantages of the prior art and, in so doing, provides for the redirection of a horizontal augering tool when it drifts or is forced from the desired drilling path. In achieving these desirable improved results, the present invention permits the augering through a casing while simultaneously jacking the casing. Directional control is provided by means of hydraulically actuated, rotatable vanes or wings which extend outwardly from the forward section of the casing. Typically, there

will be four such wings or turning vanes mounted at 90° intervals about the casing, each of the vanes extending longitudinally along the casing. When directional correction is required, the blades will be deflected in pairs and will function as control surfaces to turn the auger and casing in the desired direction.

BRIEF DESCRIPTION OF THE DRAWING

The present invention may be better understood and its numerous advantages will become readily apparent to those skilled in the art by reference to the accompanying drawing wherein like reference numerals refer to like elements in the various FIGS. and in which:

FIG. 1 is a side elevation view of a preferred embodiment of the present invention.

FIG. 2 is an enlarged view, partly in section, of the directional control apparatus of the embodiment of FIG. 1.

FIG. 3 is a top view of the directional control apparatus of FIG. 2.

FIG. 4 is a front view, taken along line 4-4 of FIG. 2, of the preferred embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1, the auger redirection system of the present invention comprises rotatable, piston-actuated, earth engaging turning vanes or wings mounted 90° apart in a radial direction on the outside of the casing. In FIG. 1, three of the wings 10, 12 and 14 may be seen, the wings being mounted on a forward section 16 of a casing, the casing itself being indicated generally at 18. The fourth wing 15 may be seen in FIG. 4.

As may be seen from FIG. 2, an auger 20 is disposed within casing 18, the auger having a tubular center shaft 22. Auger shaft 22, hereinafter referred to as the auger pipe, terminates at one end in an auger head assembly, indicated generally at 24. Auger pipe 22 is supported at the end opposite to head assembly 24 by means of a pair of ears 26 and 28. Torque is transmitted to the auger, via a drive coupling not shown, by means of a sprocket 30 and chain drive. The details of the drive coupling do not comprise part of the present invention and thus the drive coupling has been omitted from the drawing in the interest of clarity. However, the drive coupling will typically be comprised of a male octagonal member fitting into a female octagonal member fitted with a shear screw to prohibit axial motion, the center of the connection being hollow and of the same diameter as the auger pipe 22.

Bearings 26 and 28 are mounted on a sliding frame 32 and thus, upon disconnecting of the drive coupling, the bearings may be moved axially of the auger and casing. Accordingly, as the bore progresses, additional sections or lengths of auger pipe may be coupled to the equipment to thereby extend the hole. Also, in the interest of clarity, the drive chain and driving mechanism for sprocket 30 have not been shown. These elements would either be mounted on slidable frame 32 or elsewhere and would move with frame 32. The means for moving frame 32 and thus the means for urging the auger forward will consist of the force from a large hydraulic cylinder, not shown, rigidly attached to the sliding frame 32 or to the boring machine. The cylinder exerts its force against the track upon which the frame slides thereby pushing the frame and auger apparatus forward with respect to the stationary track. The means for jacking the casing 18 may comprise the same hydraulic cylinder which urges the auger forward. An additional length of casing will be inserted each time the auger is extended, and the new section of casing will be welded where it abuts against the previous casing section as each length of casing is delivered to the borehole.

The auger head 24, as may best be seen from a simultaneous consideration of FIGS. 1 and 2, comprises a member which has, extending from its front face, a plurality of cutter teeth 34. The auger head assembly also comprises a pilot bit 36 which extends in a forward direction axially of the auger. As

previously noted, the auger head is affixed to the auger pipe 22 and thus will rotate therewith, earth loosened by the auger head being delivered back to the mouth of the borehole through the casing by auger 20.

As will be explained in greater detail below, hydraulic fluid for controlling the movement of wings 10, 12, 14 and 15 will be delivered to actuating means, which form a part of forward casing section 16, by means of hydraulic lines suitably attached to the outside of the casing. These hydraulic lines may best be seen from FIGS. 3 and 4 and are indicated at 38, 40, 42 and 44. For the reasons to be explained below, hydraulic lines 38 and 44 are connect to a first or rearwardly disposed wraparound hydraulic cylinder while hydraulic lines 40 and 42 communicate with a forwardly located wraparound hydraulic cylinder. Thus, opposite hydraulic lines are paired, one line of each pair being for the purpose of delivering high-pressure fluid to the forward side of a piston within one of the wraparound hydraulic cylinders and the other of each pair of hydraulic lines delivering fluid to or bleeding fluid from the end of its associated cylinder to the rear of the piston. In the usual instance, the hydraulic lines are welded to the outside of the casing. The ends of the hydraulic lines on each casing section will be provided with quick disconnect couplings, now shown, to facilitate the extension of the lines as the borehole progresses and thus the casing gets longer. Also, in the usual instance, the hydraulic lines will be attached to the sections of the casing in the course of fabrication thereof.

The delivery of pressurized fluid to the hydraulic lines and thence to the wraparound cylinders to control the wings on the casing is regulated by control valves 46 and 48. Valves 46 and 48 respectively control the delivery of hydraulic pressure from a pressurized fluid source 50 to hydraulic lines 42' and 40' and hydraulic lines 44' and 38'. It is to be understood that valves 46 and 48 may be controlled either manually or automatically.

The need for directional correction will be determined by suitable sensors for detecting the direction of motion of the auger, such sensors typically being mounted within a forward section 52 of the auger pipe 22. These sensors do not form a part of the present invention and will not be described herein. The sensors in instrumented auger pipe section 52 will detect undesired drift of the auger and will provide signals commensurate therewith. The signals commensurate with drift may either be applied to suitable indicators so as to enable the exercise of manual control over valves 46 and 48 or the drift signals may be employed to automatically control the hydraulic system of the present invention to thereby cause proper corrective action. In either event, when the drill string is deflected off path, a pair of turning vanes will be activated for redirection.

As previously noted, and as may best be seen from FIG. 2, the present invention comprises a pair of wraparound hydraulic cylinders which are affixed to or in part defined by the forward section 16 of casing 18. The piston 54 in the forward hydraulic cylinder 56 is operated under the control of valve 46 and causes rotation of oppositely disposed turning vanes 10 and 12 about their respective pivot shafts 57 and 58. The wraparound piston 60 in the rearwardly disposed wraparound hydraulic cylinder 62 is under the control of valve 48 and controls the rotation of turning vanes 14 and 15 about their pivot points. As may best be seen from a joint consideration of FIGS. 2 and 3, angularly disposed cam slots, such as slot 63, are provided in the plates which define the outer walls of the hydraulic cylinders. The application of hydraulic pressure to one side of either of pistons 54 or 60 will thus result in both axial and radial motion of the piston. The motion of the piston is transmitted directly to its associated pair of turning vanes the motion of piston 54 being coupled to vanes 10 and 12 via members 64 and 66 which are respectively associated therewith. Members 64 and 66 comprise studs which are pressed into the body of the piston and which carry rollers 67. The rollers 67 are disposed within suitably shaped recesses in the turning vanes. When the piston moves, the bolts travel in

the cam slots and the rollers exert force on the sidewalls of the recesses in the turning vanes while moving longitudinally in such recesses. Accordingly, considering wing 10 of FIG. 3, movement of the wraparound piston in cylinder 56 will cause the forward end of the turning vane to tilt up or down, the vane pivoting around pivot shaft 57.

To summarize operation of the present invention, four wings or turning vanes are mounted 90° apart in a radial direction on the outside of the forward section of bore casing, such mounting typically being achieved by 5/8-inch diameter steel shafts, such as shafts 57 and 58. Wings or turning vanes located on opposite sides of the casing are rotated as a pair to either side of the zero point by force from a wraparound hydraulic piston, wings 10 and 12 being controlled by forward piston 54 while wings 14 and 15 are controlled by the rearwardly disposed piston 60. In response to the application of 3000 p.s.i. pressure to one side of one of the wraparound pistons via either of valves 46 and 48, the energized piston will produce approximately 17,000 pounds of force for redirection purposes. When the drill string is deflected off path, a set of turning vanes is activated, via either manual or automatic control of the proper valve, in order to achieve redirection. Initially, the turning vanes act as wedges for pushing the casing back on line, but if this is not enough for correction, the forward movement of the drill string and casing will cause the casing to be deflected back on path, the turning vanes acting as control surfaces as the casing moves forward.

While a preferred embodiment has been shown and described, various modifications and substitutions may be made thereto without departing from the spirit and scope of the present invention. According, it is to be understood that the present invention has been described by way of illustration and not limitation.

We claim:

1. Directionally controllable earth boring apparatus comprising:

- an elongated rotatable auger;
- a tubular casing surrounding said auger and being substantially coaxial therewith;
- actuator means mounted on said casing adjacent the forward end of the auger;
- a plurality of turning vanes mounted on the exterior of said casing, said vanes normally extending longitudinally of said casing and being rotatable about respective axes perpendicular to the axis of the casing;
- means operatively connecting said actuator means to said turning vanes whereby said vanes may be deflected from their normal angular relationship to the casing axis; and
- means associated with said actuator means for causing energization of said actuator means in response to the sensing of undesired drift of said auger.

2. The apparatus of claim 1 wherein said turning vanes comprise:

- four vanes mounted at 90° intervals about the casing.

3. The apparatus of claim 1 wherein said actuator means comprises:

- a cylinder mounted on the exterior of said casing; and
- a fluid operated piston disposed for movement within said cylinder.

4. The apparatus of claim 2 wherein said actuator means comprises:

- a pair of hydraulic cylinders mounted on the exterior of a forward section of said casing; and
- a piston disposed for movement in each of said cylinders.

5. The apparatus of claim 4 wherein said means operatively connecting said actuator means to said turning vanes comprises:

- means mechanically coupling each of said pistons to a pair of said vanes whereby said vanes may be deflected in pairs.

6. The apparatus of claim 1 wherein each of said turning vanes comprises:

- a bladelike member; and

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pivot means for mounting said bladeliike member on the exterior of said casing.

7. The apparatus of claim 5 wherein each of said turning vanes comprises:

a bladeliike member; and

pivot means for mounting said bladeliike member on the exterior of said casing.

8. The apparatus of claim 7 wherein said turning vanes further comprise:

a slot in the base of each of said bladeliike members.

9. The apparatus of claim 8 wherein said mechanical coupling means each comprises:

a roller disposed in the slot in the base of an associated turning vane; and

a piston rod connecting said roller to its associated piston.

10. The apparatus of claim 9 wherein said hydraulic cylinders are wrapped around said casing and wherein said vanes are disposed adjacent the outer surface of said cylinders.

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