United States Patent

[11] **3,550,698**

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[21] Appl. No. **747,671**
[22] Filed **July 25, 1968**
[45] Patented **Dec. 29, 1970**

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[54] **PENETRATION METHOD AND APPARATUS**
8 Claims, 4 Drawing Figs.

[52] **U.S. Cl.** **175/57,** 175/19, 175/62, 175/106
[51] **Int. Cl.** **E21b 3/08**
[50] **Field of Search** 175/19, 45, 61, 57, 73, 97, 298, 106

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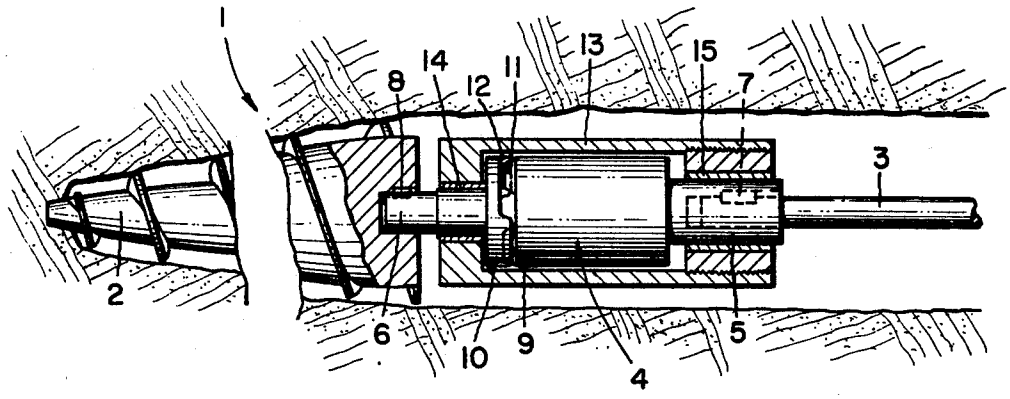
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ABSTRACT: A method of penetrating the earth, or tubes, piping, conduits and the like, and apparatus for its practice; the method teaches the provisioning of, and the apparatus teaches a structure having, an auger, a rotating input shaft, and a rotary impacting torque unit couplingly disposed therebetween. The unit transforms input-rotating torque of given value to an impacting rotating torque output of greater value and imparts the latter to the auger.



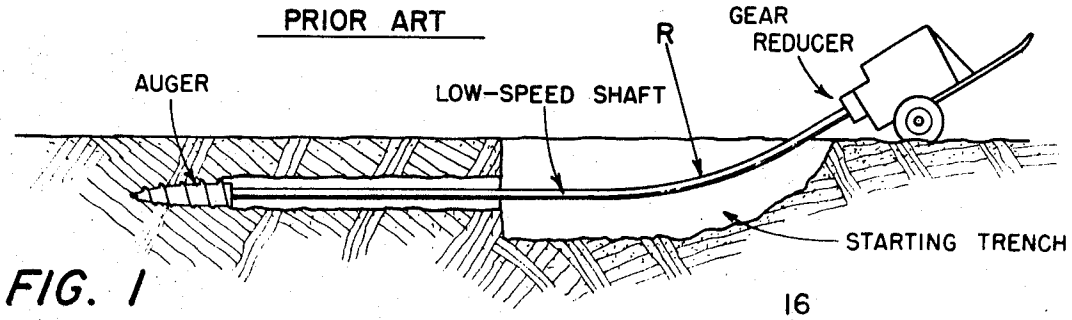


FIG. 1

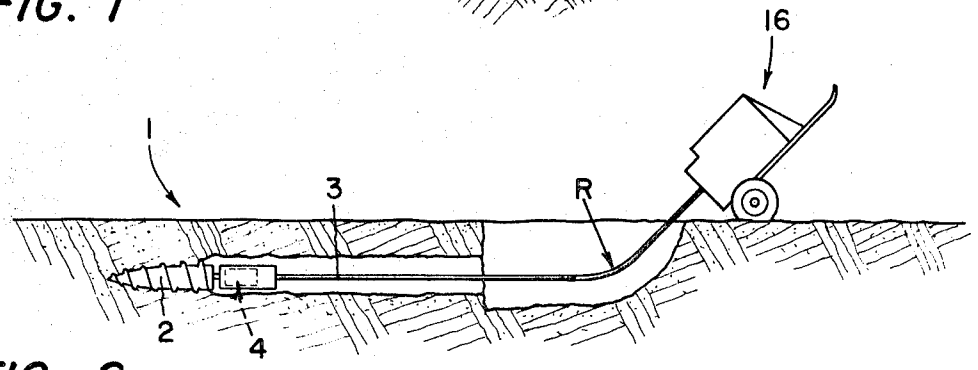


FIG. 2

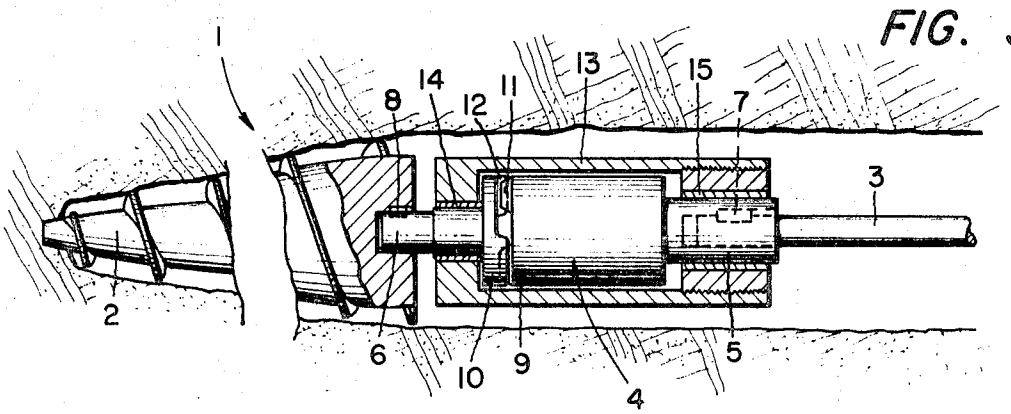


FIG. 3

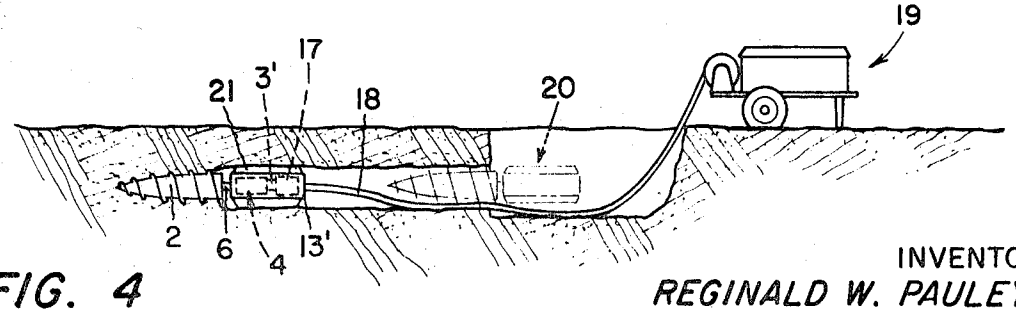


FIG. 4

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PENETRATION METHOD AND APPARATUS

In the prior art, methods of penetrating the earth, or tubes, piping, conduits and the like, and apparatus for the practice thereof, involve implements, such as augers, which burrow into the earth or turn through tubing, in the same manner as does a screw or drill bit into wood. A compacting auger comprises a conical element having spiral threads formed thereon which threads react against the soil, in earth-boring penetration, and force the auger forward. As the compacting auger penetrates the earth it compacts the same thereabout in the manner of a wood screw. A spoil auger comprises a long spiral-threaded shaft which ends in a cutting head. The spoil auger digs forward—through the earth or tubing or pipe and, by its rotation, carries the dirt backward, in earth-boring penetration, or carries away the encrusted wall-deposits, or whatever, in tube or pipe penetration; the cutting head being effective to dig out the dirt or to free the deposits or cut loose other such obstructions. Customarily, such augers are driven by a relatively low-speed (i.e., up to approximately 100 r.p.m.) large diameter, flexible rotating shaft which is directly drive-coupled thereto.

At the present time, the public utility companies are largely involved in a program of burying power lines, communication lines, and the like, and this involves a considerable degree of site preparation. The practice is to use a portable, customarily a wheeled, power plant for powering the auger and the rotatable drive shaft attached thereto. The drive shaft, according to known practices, is driven through a gear reduction unit. At the place where the boring is to be accomplished, the power plant is positioned and steadied, and an elongated trench is dug in front thereof in which to accommodate a portion of the flexible shaft, and to facilitate the boresighting of the auger in the bottom of the trench. In soft earth, the known practices are reasonably satisfactory, and the apparatus used is usually adequate for the work. But in firm soil, requiring high rotary torque to overcome the resistance met by the auger, difficulties arise. As resistance to the auger, in its penetration of the earth, increases, the shaft rotation speed reduces. Due to the rising torque characteristic of the power plant high torque values develop, the same ranging perhaps to 500 lbs-ft. This high torque causes an overturning reaction at the power plant. Further, because of the high torque values involved, it is necessary to have shafts of large diameters and solid cross section to carry the high torque. Such shafts have a large bend radius. Site preparation, therefore, is made more time consuming and expensive, requiring the excavation of a considerably extended trench. A considerably extended trench. A considerably extended or lengthy trench is necessary to receive the bore-sighted auger and the protracted length of the large diameter shaft which is necessary to negotiate the large bend radius between the trench floor and the ground level on which the power plant is positioned.

Accordingly, it is an object of this invention to teach a penetration method, and apparatus for the practice thereof, especially useful in earth boring, which avoid the aforementioned difficulties. An object of this invention is to teach a penetration method which comprises the provisioning of a source of a given-value rotary torque of, say, less than N pounds-feet, and the provisioning of means for transforming the torque of the source into a rotary, impacting torque ranging up to not less than N pounds-feet.

A feature of this invention comprises a penetration method, and apparatus for its practice, involving the use of a penetration implement and a source of rotary torque, and intercoupling of the two by interposing therebetween a rotary impacting device.

Further objects and features of this invention will become more apparent by reference to the following description taken in conjunction with the accompanying FIGS. in which:

FIG. 1 is a side elevation view of a directly drive-coupled earth-boring apparatus and the power plant therefor, according to what is used in practices known in the prior art;

FIG. 2 is a side elevation view of a penetration apparatus, and the power plant therefor, according to the invention;

FIG. 3 is an enlarged, side elevation, partly in cross section, of the auger-coupled end of penetration apparatus according to FIG. 2, the apparatus being of a type usable in the practice of the novel penetration method of my invention; and

FIG. 4 is a side elevation view of an alternate embodiment of a penetration apparatus, and the power source therefor, according to the invention.

As shown in FIG. 1 the prior art types of penetration apparatus, and methods for their use, in earth boring, for instance, comprise an auger, for example, which is directly drive-coupled to a low-speed, rotatable input shaft driven, through a gear reducer, by a power plant. The shaft, because of its considerable cross-sectional diameter, has a large bend radius R. This necessitates the digging of an extended starting trench to facilitate this protracted length of bent shaft together with the bore sighted auger. As resistance to the earth penetration of the auger increases, shaft speed reduces and the torque value increases. If the auger has difficulty in penetrating the earth, a torque reaction is received by the portable power plant which often enough will cause the power plant to overturn.

According to the invention a penetration apparatus **1**, as shown in FIG. **2** and **3**, usable in earth-boring for example, comprises a penetrating implement **2** and a high-speed, rotatable input shaft **3** of solid cross section, the two being coupled together by an impact unit of the nonstall type; this latter is a rotary impacting device **4** disposed therebetween. The device **4** has a hollow drive shaft **5**, and a solid driven shaft **6**. Shafts **5** and **6** are coupled, by means of keys **7** and **8**, respectively to shaft **3** and implement **2**. The teaching of the use of keys **7** and **8** is arbitrary. The coupling could just as well be effected by splining, or other means as will occur to those skilled in the art.

The impact unit, device **4**, is of a type well known and widely used in power and torque transmission arts. It comprises a hammer **9** and an anvil **10** being disposed for rotation about the axis of implement **2**. Hammer **9** has equally spaced and projecting jaw members **11**, and anvil **10** has complementary jaw members **12**, disposed for mutual engagement. Hammer **9** is resiliently constrained into such jaw member engagement with anvil **10** so as to communicate thereto the rotary input of shaft **3**. As a resistance to implement **2** rises, jaw members **11** and **12** proceed to disengage due primarily to a ball and cam drive; hammer **9** removes from anvil **10** against the means which normally constrain it in engagement. Ball elements located in angular camming troughs (within hammer **9**) allow hammer **9** to avoid rotation, as it is forced to remove from anvil **10**, while it is "storing up" energy imparted thereto by the still continuously rotating input shaft **3**. Subsequently, jaw members **11** and **12** clear each other, and hammer **9** is then free to rotate in response to shaft **3**. As it commences rotation, hammer **9** releases its stored energy, and again proceeds to engage anvil **10**. Thus, jaw members **11** impact with great force against jaw members **12**; the impact develops great rotary torque on anvil **10**.

In the absence of resistance, then, device **4** communicates steady rotation therethrough. In the presence of resistance, growing resistance to implement **2**, device **4** repeatedly impacts, communicating an interrupted, massive, and repetitive rotary torque to implement **2**. Thus, device **4** automatically transforms the given rotary torque of shaft **3** into a greater impacting torque for implement **2**. Device **4** includes a housing **13** for confining therewithin, and to shield, both hammer **9** and anvil **10**. Sleeve bearings **14** and **15**, carried in either ends of housing **13**, receive shafts **6** and **5**, respectively. Power plant **16** provides high-speed, rotary drive for shaft **3** by direct coupling; i.e., no gear reduction is required.

Impact units of the nonstall type, such as that of device **4**, are exemplified by U.S. Pat. Nos. 2,049,273 and 2,160,150, issued July 28, 1936 and May 30, 1939, to R. H. Pott, and F. A. Jimmerson et al., respectively, the former being for an "Impact **1001**," and the latter an "Impact Wrench."

According to my invention it is no longer necessary to use a low-speed, large diameter input shaft to communicate rotary

torque to the implement 2. Shaft 3, as evidenced in FIG. 2, has a smaller diameter, as a smaller shaft can impart the lesser, steady, rotary torque. So, the smaller shaft 3 has a smaller bend radius. Shaft 3, together with device 4 and implement 2 can be disposed in a short trench, in an earth-boring application, reducing the time involved in site preparation. Further, where it is necessary to drive implement 2 with a torque of a value ranging to not less than N pounds-feet, it is not necessary ever to drive shaft 3 with a torque of that value. The inherent energy storage feature of device 4 automatically transforms a continuous input rotary torque of considerably less than N pounds-feet, into repeated output impacting torque of not less than N pounds-feet, and, for the purposes of discussion, let it be assumed that a torque of the latter value must be achieved to insure effective earth penetration by implement 2. Earth penetration, earth-boring is discussed here, and implement 2 is shown as a oompacting auger, in FIGS. 2 and 3. However, as earlier noted, a spoil auger can be used, and our invention comprises the teaching of the method, and apparatus for its practice, comprising the penetration of tubes, piping, conduits and the like. The discussion of compacting-augering earth-boring is presented only by way of example.

To continue, then, it is to be noted that through the torque transformation of device 4 of the apparatus, and the practice of the method of my invention, avoids the possibility of the portable power unit being overturned. Very simply, a torquing reaction which is great enough to overturn the power unit is never experienced by shaft 3. So also, as noted, it is not necessary to rotate the shaft 3 through a gear reduction unit. As high torque is not communicated by shaft 3, the full speed of the power unit can be imparted to shaft 3, and the shaft can rotate continuously, at the power unit speed without substantial variation therefrom. The high speed drive, then, greatly accelerates the earth-boring process.

In the prior art, where high torque has needed delivery via a large diameter flexible shaft, precautions had to be observed to protect the power plant. It has been customary, for instance, to "weight" the power plant against overturning. Also, only wide track portable power plants could be used, or power plants having extensible jack legs, or the like, to secure the footing thereof. The apparatus and method of my invention avoids the necessity for undertaking such precautions. The low-torque, small diameter shaft 3 of my teaching can be powered by a light, narrow track power plant 16, as the shaft 3 and plant 16 need not provide high rotary torque.

In the alternate embodiment of my invention, according to FIG. 4 where same or similar index numbers signify components which are the same as or similar to components in FIGS. 2 and 3, the auger 2 is coupled by driven shaft 6 to the rotary impacting device 4. However, a fluid or electrical motor 17 is carried underground with the auger for travel together therewith. The motor 17 is directly coupled to device 4 by means of an input shaft 3' of solid cross section. A housing 13' confines the two coupled units: device 4 and motor 17. A conduit 18, for a fluid or electrical medium follows behind the coupled units in the borehole, passes through the trench to couple with the fluid or electrical source 19 which remains above ground. The starting position 20, of this alternate embodiment of the apparatus, is shown in dashed outline disposed for making an initial penetration of the earth after having been properly boresighted in accordance with methods well known in the art. Housing 13' carries integral, radially extending vanes 21. Vanes 21 are provisioned to cooperate with the walls of the borehole to absorb any minor torque reaction that may occur. This embodiment completely eliminates any difficulties with, and any need to accommodate for, a bend radius of the flexible shaft 3 represented in FIGS. 2 and 3 of the first embodiment.

Shaft 3', like shaft 3 of the first embodiment, is a high-speed, low torque, small diameter shaft; it may be rigid or flexible—as desired. Further, shaft 3' is also directly coupled to device 4; a gear reduction unit needs not be interposed therebetween.

Motor 17 travels with auger 2 and device 4, being enclosed within housing 13' together with device 4. Accordingly, it remains only to supply force—electromotive or fluid—via conduit 18, from source 19, to motor 17 to enable my novel apparatus. Conduit 18, in being even more compliantly flexible than shaft 3 of the first embodiment, poses no bend radius problems of any significance. The starting trench necessary for employment of this alternate embodiment of my apparatus, then, can be smaller—having sufficient length to accommodate only the length of the working assembly of auger 2 and housing 13'.

In the first embodiment of my invention, some small reaction torque would be present at power plant 16 thereof. In the alternate embodiment, however, the small reaction torque would be communicated to motor 17 via shaft 3'. However, the radial fins 21 extending from housing 13' absorb this minor torque.

In accordance with the foregoing, my invention teaches a penetration apparatus for earth boring, and for tube, piping, and conduit penetration and a new and improved method of penetration which can be practiced by said novel apparatus. My new penetration method sets forth the steps of providing a penetrating implement 2, providing a source, such as shaft 3 or 3', of rotary torque of given torque value, providing means such as device 4, for transforming a rotary torque input of given torque value into a rotary, impacting torque output of greater torque value, and drivingly coupling, as by means such as keys 7 and 8 said source with said input and said implement with said output. My inventive method comprises the provisioning of an implement 2 having a given configuration, and being of such measure and weight, as render it effective, for instance, for penetrating earth only in response to a rotary torque, by way of example, which ranges up to not less than N pounds-feet. In addition, my method teaches the provisioning of a source, shaft 3 or 3', of rotary torque which is less than N pounds-feet. Accordingly, the novel method then sets forth the provisioning of means, such as device 4, capable of transforming the torque of the source, shaft 3 or 3', into a rotary, impacting torque of the requisite value.

The embodiments of FIGS. 2 and 3, and 4, represent the penetrating implement 2 as an earth-borer. However, as clearly noted heretofore, implement 2 represents a means for penetrating tubes, piping, conduits, and the like, for the purposes of cutting away and removing encrusted wall-deposits, silt, roots, and other such obstructions. Thus, the method of its use, explained in connection with earth-boring, is equally applicable to tube, piping, and conduit, or the like, penetration.

While I have described my invention in connection with specific embodiments of apparatus, it is to be clearly understood that this is done only by way of example and not as a limitation to the scope of my invention as set forth in the objects thereof and in the accompanying claims.

I claim:

1. A penetrating apparatus, for penetrating the earth, and tubes, piping, conduits, and the like, comprising:
- a penetrating implement;
- a source of rotary torque;
- means for transforming a rotary torque input into a rotary, impacting torque output;
- means drivingly coupling said source with said input;
- means drivingly coupling said implement with said output wherein;
- said implement has a given configuration, dimension, and weight which, as a consequence thereof, render said implement responsive, for effecting earth penetration, only to a rotary torque ranging to not less than N pounds-feet, such as is communicable thereunto by a steadily rotatable shaft, of solid cross section, having a bend radius of not less than X, directly drive-coupled to said implement; and
- said source comprises a steadily rotatable shaft, of solid cross section, having a bend radius of less than X.

2. The apparatus of claim 1, wherein: said implement comprises an auger.

3. The apparatus of claim 1, wherein: said source comprises a flexible, high-speed rotatable input shaft.

4. The apparatus of claim 1, wherein: said coupling means comprise keying means.

5. The apparatus of claim 1, further comprising: a housing and wherein said housing confines said torque transforming means therewithin.

6. The apparatus of claim 1, wherein: said source provides a rotary torque of less than N pounds-feet; and said torque transforming means automatically converts said less-than-N pounds-feet of rotary torque into a rotary, impacting torque of not less than N pounds-feet.

7. A penetration method, for earth-boring, and for penetrating tubes, piping, conduits, and the like comprising the steps of:

providing a penetrating implement;

disposing said implement in contact with a surface or facing of earth to be penetrated;

providing a source of rotary torque of given torque value;

providing means for transforming a rotary torque input of greater torque value;

drivingly coupling said source with said input; and

drivingly coupling said implement with said output; and wherein

said implement-providing step comprises the provisioning of an implement having a given configuration, dimension, and weight which, as a consequence thereof, render said implement responsive, for penetrating the earth, only to a rotary torque ranging to not less than N pounds-feet such as is communicable thereunto by a steadily rotatable shaft, of solid cross section, having a bend radius of not less than X, directly-coupled to said implement; and

said source-providing step comprises the provisioning of torque via a steadily rotatable shaft, of solid cross section, having a bend radius of less than X.

8. The method of claim 7, wherein: said source-providing step further comprises the provisioning of torque of less than N pounds-feet; and said means-providing step comprises the provisioning of torque-transforming means capable of and automatically operative for transforming input rotary torque of less than N pounds-feet into rotary, impacting torque ranging to not less than N pounds-feet.