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Svirschevsky et al.

[11] **3,926,267**

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[54] **DEVICE FOR DRIVING HOLES IN THE GROUND**

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[52] **U.S. Cl.** **175/19;** 175/55; 175/94; 175/106

[51] **Int. Cl.**[2] **E21B 11/02**

[58] **Field of Search** 175/19, 20, 21, 55, 106, 175/96, 348, 345, 346, 347, 334, 335, 343, 349, 97, 98, 94

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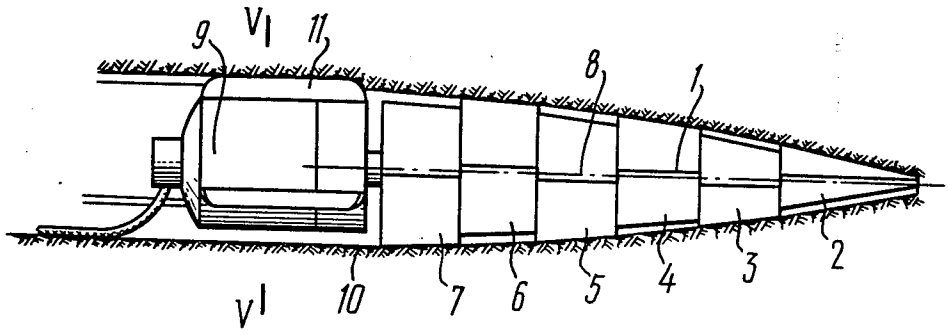
Assistant Examiner—Richard E. Favreau
Attorney, Agent, or Firm—Holman & Stern

[57] **ABSTRACT**

A device for driving holes is provided with a crankshaft on which accommodated on respective crankspins with a provision for free rotation, is a cone-shaped member at the front end followed by a succession of tapered rollers which are the transverse parts of a conically shaped body. The apparatus is provided with means ensuring its longitudinal travel in the hole. When the crankshaft is rotated, the cone-shaped member and tapered rollers start rolling over the wall of the hole, gradually enlarging the latter and compacting the wall by laterally displacing the ground. The device is capable of driving holes with a diameter as large as 800 mm in any compactable ground thus, producing firm and stable walls.

8 Claims, 10 Drawing Figures



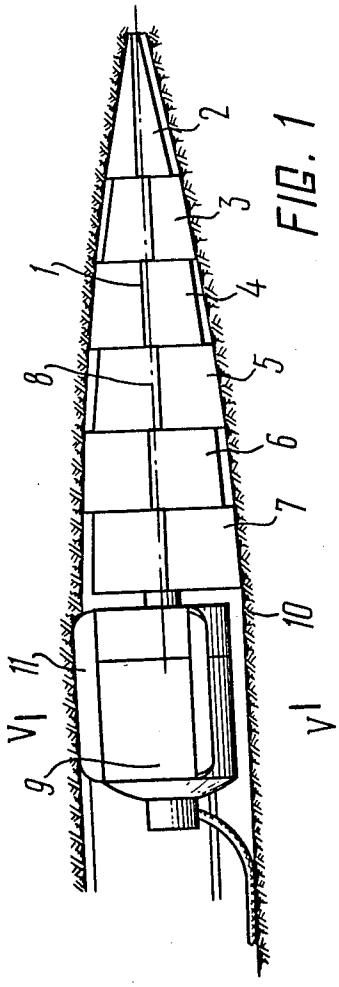


FIG. 1

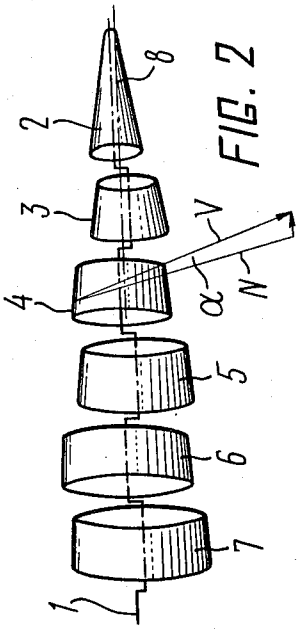


FIG. 2

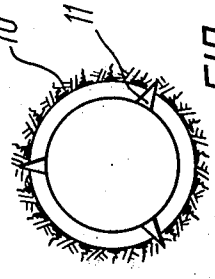


FIG. 5

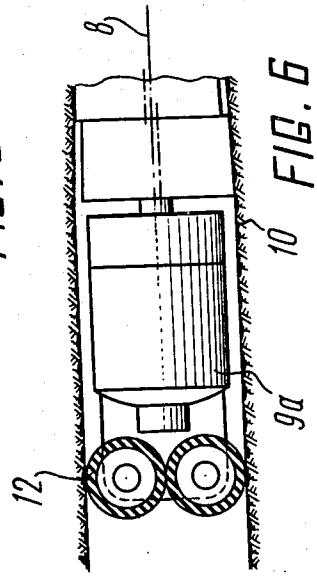


FIG. 6

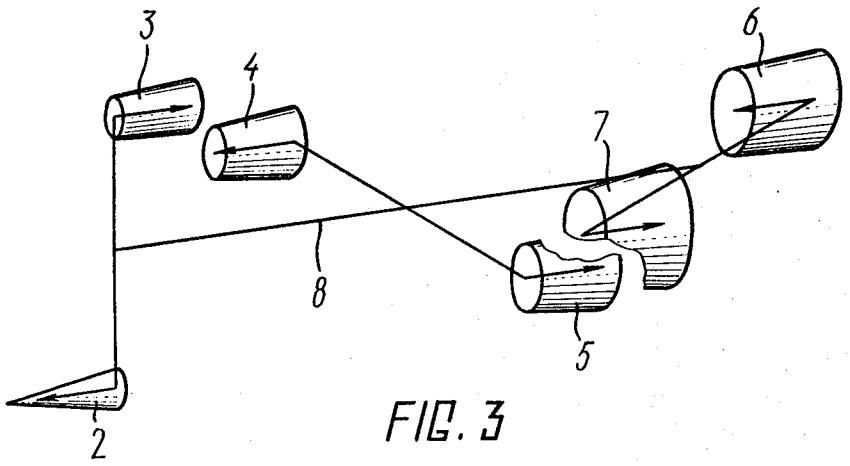


FIG. 3

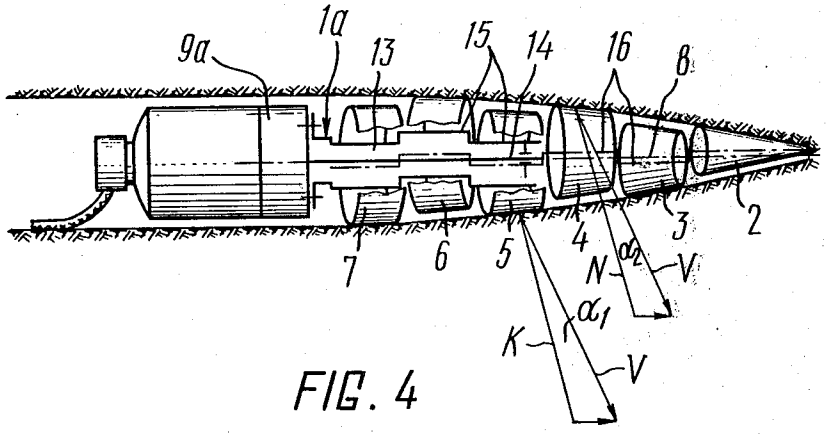


FIG. 4

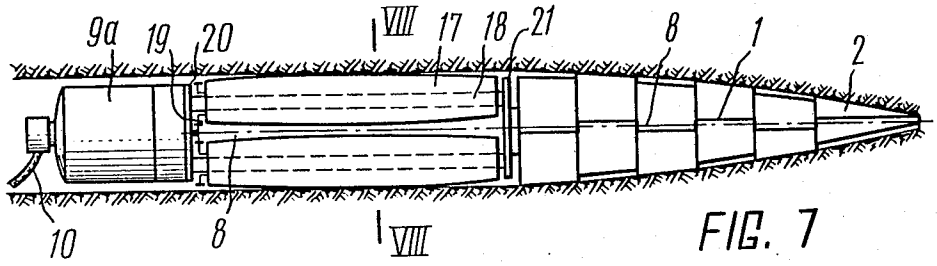


FIG. 7

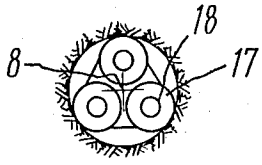


FIG. 8

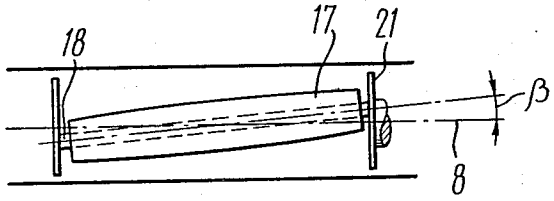


FIG. 9

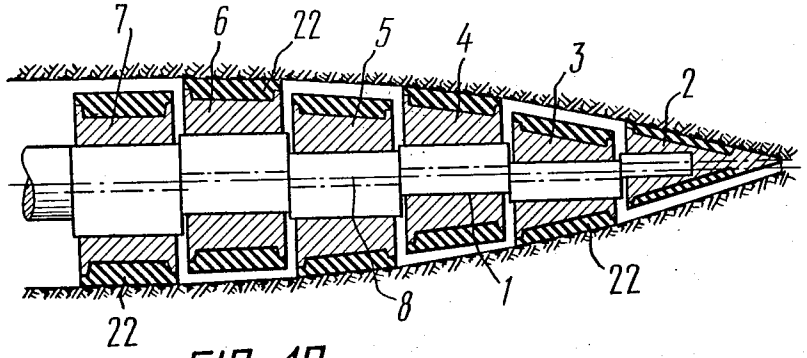


FIG. 10

DEVICE FOR DRIVING HOLES IN THE GROUND

BACKGROUND OF THE INVENTION

The present invention relates to rolling holes underground and more specifically to devices for rolling holes in the ground, particularly by compacting the ground without the removal thereof.

PRIOR ART

These techniques are used at present for driving holes with a diameter of up to 500 mm, using machines of the percussion type which have come into widespread application. Such machines feature a pointed cylindrical body containing a percussion mechanism serving to force the machine into the ground which is displaced and compacted by the walls of machine body.

Similar holes are driven by forcing a cone-shaped member into the ground with the aid of hydraulic jacks installed on the surface of the collar.

Practical experience shows that such devices cannot be used for driving holes over 500 mm in diameter due to a sharp increase in the resistance of the ground, resulting in a failure of the machine.

Also known is a method of driving holes without the removal of ground, in which the latter is gradually compacted by enlarging the hole with the aid of a cone-shaped member describing a spatial spiral while rotating about an axis which is in fact the longitudinal axis of the hole being driven. The device embodying said method consists of a cylindrical body carrying at its fore end, a cone-shaped member mounted on a crankshaft and moving along a spatial spiral line in the way above-described. The cylindrical body contains a drive causing the crankshaft to rotate and the device to progress longitudinally.

A disadvantage of said device resides in the unbalance of the forces acting on the working member and which unbalance results in the device being extremely hard to operate.

Also known is a device for driving holes by compacting the ground without removal thereof, in which a pilot auger is provided at the fore end which is forced into the ground and loosens the same. Disposed in the wake of the auger are tapered rollers which diverge outwardly and are arranged all the way along a circle described about the longitudinal axis of the device. The rollers are free to rotate on their fulcrum pins and the pins in their turn are capable of rotating about the longitudinal axis of device coincident with the center line of the desired hole. The device is propelled by a drive at the surface which sets the auger into motion, rotates the tapered rollers as described above and causes the device to progress longitudinally. The auger penetrates and loosens the ground and the tapered rollers apparently serve to compact this ground by pressing it laterally into the walls of the hole.

A disadvantage of said device is in its inability to form firm walls in the hole because the diameter of compacting tapered rollers is by far smaller than that of the hole enlarged by rolling. According to the authors' concept, arranged in the cross-section of the hole, are more than one compacting roller and voids of considerable extent are formed between the rollers, with the result that the earth often caves off the wall.

Also known are devices for enlarging pre-drilled vertical boreholes. In said devices, the working member is

a pointed cylindrical body attached to a universal-joint shaft and actuated by a drive installed at the surface. The device advances longitudinally by gravity. The borehole is enlarged due to the centrifugal forces promoted by the rotating pointed cylinder as it rolls on the interior surface of the hole.

Said devices have failed to come into practical application as a means of enlarging holes because the working member must be rotated at a speed sufficiently high to produce centrifugal forces of a magnitude capable of compacting the ground as required. An increase in the speed of the working member brings about a sharp increase in the resistance of ground to a point which renders the apparatus incapable of operation.

In addition, known in the art are devices for drilling vertical boreholes. Each device is provided with a cutter head serving as the drill and a tapered roller for compacting the soil loosened by the cutter head. Said roller is attached to a crank-shaft which also imparts rotary motion to the cutter about an axis practically coincident with the center line of the borehole. Longitudinal advance of the device in the borehole is also due to gravity.

A disadvantage of said devices resides in a low efficiency resulting from the unbalance of the forces acting on the working member which is the cutter head in conjunction with the tapered roller.

OBJECT AND SUMMARY OF THE INVENTION

It is an object of the present invention to provide a device for rolling holes in the ground with a diameter of at least 500 mm, with a simultaneous compaction of the ground in the hole to a sufficient degree so as to obtain firm and lasting walls.

Another object of the present invention is to provide a device to increase the efficiency of hole formation.

A further object of the present invention is to provide a device to reduce the power requirements of the device.

A still further object of the present invention is to provide a self-propelled device adapted to perform both advancing and retreating movements and to eliminate the need in additional means of moving the device in the hole, particularly when recovering it from the hole upon completing the rolling operation.

Other objects and advantages will become evident from the description of the present invention.

These objects are attained in a device for rolling holes in the ground with the aid of a cone-shaped member disposed at the front end of the device on a crankshaft and forced into the ground as the device is longitudinally advanced behind the cone-shaped member in which there is, according to the invention, a succession of tapered rollers freely rotating on respective crankpins, with said rollers being substantially individual parts of a conically shaped body.

An arrangement of this character enables the compacting of ground to be effectively performed and to a requisite degree by gradually enlarging the hole with the aid of a succession of tapered rollers with progressively increasing diameters. Furthermore, since in each cross section of the hole, there is only one compacting tapered roller, each of the successively arranged rollers can be of a diameter sufficiently large to occupy almost all the cross-section area, with the possibility of the ground falling off the wall being eliminated during the process of enlarging the hole by each of the rollers and a high degree of compacting of the ground at the rollers

is also attainable.

To facilitate the advancing of the device into the ground, it is preferred to dispose the crankpins at an angle to the longitudinal axis of the device in a plane which is substantially parallel to said axis.

To ensure optimal balance of the rotating components of the device and eliminate any runout of said components, it is expedient to dispose the crankpins spatially with respect to the longitudinal axis of the device and pairwise in opposite phases.

This feature of the crankshaft construction reduces spatial oscillations of the longitudinal axis of the device to a negligibly small magnitude during the driving operation with the result that each roller is loaded more evenly and a high driving rate is achieved.

The device is made self-advancing by preferably having the crankshaft formed by two concentrically disposed sections, with the tapered rollers being attached to both concentric sections and the crankpins of one of the concentric sections being disposed with respect to the longitudinal axis of the device at an angle which is opposite to the angle at which the crankpins of the other concentric section are arranged and the outside concentric section is rigidly attached to the casing of the drive.

Another way of imparting to the apparatus the ability to advance by itself is to provide the drive imparting motion to the crankshaft and disposed in close proximity to the body of the device, is a contrivance for holding fast the drive against the wall so as to prevent it from rotation. In a preferred embodiment, said contrivance for fixing the drive against rotation consists of radial projections on the casing of the drive. In another embodiment, said contrivance consists of wheels disposed radially on the drive.

To enable the device to be self-propelling not only when advancing but also when withdrawing from the hole, it is expedient to link up movably the drive of the crankshaft with cylindrical rollers whose axes are disposed at an angle to the longitudinal axis of the device in different planes which are substantially parallel to said axis. The cylindrical rollers in turn must be movably linked with the crankshaft.

To prevent the ground from peeling off the wall, it is expedient to line or cover the surface of the tapered rollers in contact with the wall with a resilient material.

The present invention will be best understood from the following detailed description of a preferred embodiment thereof when read in conjunction with accompanying drawings. in which:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a side elevation of a device for rolling holes in the ground, according to the invention, shown in the hole;

FIG. **2** is an embodiment of the device in which the crank-shaft is made with the crankpins disposed at an angle to the longitudinal axis of the device;

FIG. **3** is a schematic diagram illustrating the spatial arrangement of the tapered rollers pairwise in opposite phases;

FIG. **4** is another embodiment of the device in which the crankshaft is made up of two concentric sections;

FIG. **5** is a section on line V—V of FIG. **1** illustrating a method of fixing the casing of the drive to the wall of hole;

FIG. **6** is another modification of the arrangement serving to fix the casing of the drive to the wall of hole;

FIG. **7** is a side elevation of the device in a further embodiment according to the invention with a provision for traveling in reverse;

FIG. **8** is a section on line VIII—VIII of FIG. **7**;

FIG. **9** is one of the cylindrical rollers of FIG. **7** shown turned through an angle with respect to the longitudinal axis of the device; and

FIG. **10** is a side view partly in section of the device for rolling holes in still another embodiment according to the invention in which the surface of tapered rollers is lined or covered with a resilient material.

DETAILED DESCRIPTION OF THE EMBODIMENTS

The apparatus for rolling holes in the ground incorporates a crankshaft **1** (FIGS. **1, 2, 7, 8** and **10**) accommodating on the crankpins a freely rotating cone-shaped member **2** (FIGS. **1, 2, 3, 4, 7** and **10**) at the front end followed by what is a succession of tapered rollers **3, 4, 5, 6** and **7** which are, in essence, transverse parts of a conically shaped body.

The crankshaft **1** is rotated and the device is longitudinally advanced by means of a self-contained drive at the surface (not shown).

If the crankpins of the crankshaft **1** are arranged at a certain angle α (FIG. **2**) with respect to a longitudinal geometrical axis **8** (FIGS. **1, 2, 3, 4, 6, 7** and **9**) in planes which are parallel to said axis **8**, this arrangement substantially facilitates the driving of the device into the ground. (The angle α is shown in FIG. **2** out of true proportions as an angle formed by a normal N to the longitudinal geometrical axis **8** and a vector V of the linear velocity at which the hole is enlarged by the corresponding rolling roller **4**).

If the crankshaft **1** is rotated from a drive **9**, **9***a* (FIGS. **1** and **6**) arranged in a hole **10** next to the device and the casing of the drive **9**, **9***a* is provided with means preventing its rotation in the hole **10** (FIGS. **1, 4, 5, 6, 7** and **10**), the device becomes self-propelled in the direction of driving. As said means for preventing the casing of the drive from rotation can be either projections **11** (FIGS. **1** and **5**) extending radially or wheels **12** (FIG. **6**) also installed radially.

During the driving operation, said projections **11** or wheels **12** prevent the casing of the drive **9** from rotation. This feature in conjunction with the above construction of the crankshaft **1** when the crankpins are disposed at an angle α to the longitudinal geometrical axis **8** of the device provides for the self-screwing of the body of the device into the ground without being forced thereinto axially from the outside. The angle α is about 1° wide.

Another way of rendering the device self-propelled is to make the crankshaft **1a** (FIG. **4**) in two concentric sections **13** and **14**, accommodating the tapered rollers **5, 6** and **7** on the section **13**, while the cone-shaped member **2** and the tapered rollers **3** and **4** are mounted on the section **14** of the shaft **1**. In this case, the concentric section **13** is rigidly attached to the casing of the drive **9***a* and rotates integrally with the same. The crankpins **15** of the concentric section **13** and the crankpins **16** of the concentric section **14** are to be disposed with respect to the longitudinal axis **8** of the device so as to intersect the axis at angles α_1 and α_2, (FIG. **4**), respectively, which are each about 1° wide but of opposite directions. (The angles α_1 and α_2 are shown in FIG. **4** out of true proportions in the same way as the angle α in FIG. **2**).

Due to the above arrangement the sections **13** and **14** of the crankshaft **1***a* rotate, during driving, in opposite directions, causing the device to screw into the ground and advance down the hole on its own. For the withdrawal of the device in the above embodiments from the hole upon completion of the driving, recourse is made to conventional means.

To render the device self-propelling not only during the driving stage but also for the withdrawal from the hole, it is suggested to connect the crankshaft **1** to the drive **9***a* with the aid of cylindrical rollers **17** (FIG. **7**) arranged one along another all the way around a circle described about the longitudinal axis **8** of the device as shown in FIGS. **7** and **8.** The rollers **17** are free to rotate on their axes **18** and are all driven in the same direction by a reversible drive **9***a* through gears **19.** The ends of the axes **18** of the rollers **17** are rigidly secured to flanges **20** and **21.** The flange **21** is rigidly attached to the crankshaft **1** and the flange **20** to the casing of the reversible drive **9***a* so that rotation is transmitted to the crankshaft **1.**

The axes **18** of rollers form angles β with the longitudinal geometrical axis **8** of the device (FIG. **9**) in different planes parallel to said axis.

By analogy with the angle α, the angle β does not exceed 1° and is directed towards the rear end of the device.

By virtue of the above arrangement of the axes **18** at an angle β, the cylindrical rollers **17** serve as supports, permitting an effective torque to be obtained at the crankshaft **1** when the drive shaft is rotated in one direction. If the drive is reversed, the same cylindrical rollers cause the device to screw on its own out of the ground so as to be withdrawn from the hole under its own power without the use of any additional means.

In all embodiments of the invention it is expedient to arrange the crankpins of the crankshaft **1** or **1***a* spatially pairwise in opposite phases with respect to the longitudinal geometrical axis **8,** avoiding thereby the runout of the rotating components of the device, i.e., of the tapered rollers **3, 4, 5, 6, 7** and the cone-shaped member **2.**

To prevent the ground from peeling and falling off the wall of the hole when moving through loose ground and give the wall a requisite amount of compactness and firmness, the surface of all tapered rollers in contact with the wall of hole is preferably coated with a layer **22** (FIG. **10**) of resilient material, e.g., rubber or the like.

Preparatory to rolling, a hole is made in the ground using an auger or similar drilling tool, of a length sufficient to accommodate three or four foremost tapered rollers. Thereafter the drive is set into operation, causing the crankshaft **1** or **1***a* to rotate. As a result, the rollers **3** through **7** and the cone-shaped member **2** start rotating about their own axes coinciding with the axes of the crankpins and about the longitudinal geometrical axis **8** of the device. Since the device is advancing in the hole under its own power or due to a drive of any other kind, the rotary motion of the rollers is transformed into a motion along a spiral so that the cone-shaped member **2** enters the ground and starts initial rolling over the wall of the hole. The successive tapered rollers **3** through **7** one after another gradually enlarge the face. As each of the tapered rollers rolls over the face, it compacts the ground, giving the hole wall an adequately high amount of compactness and firmness.

The disclosed device is capable of rolling holes with a diameter as large as 800 mm in any compactable ground, with the walls being adequately firm and lasting. Such holes are suitable for laying pipelines, cables etc., and can serve the purpose of driving tunnels.

What is claimed is:

1. A device for rolling holes in the ground and said device having a longitudinal axis comprising: a crankshaft; substantially tapered rollers having a smooth surface, said tapered rollers being essentially the transverse parts of a conically-shaped body and mounted in succession on said crankshaft; said tapered rollers having axes, the axes of the tapered rollers being arranged at an angle to the longitudinal axis of the device and disposed in planes essentially parallel to the longitudinal axis; and a drive having a casing, said drive imparting rotary motion to the crankshaft and axially displacing the device in the hole.

2. The device as claimed in claim **1,** wherein the axes of said tapered rollers are disposed spatially and pairwise in opposite phases with respect to the longitudinal axis of the device.

3. The device as claimed in claim **1,** wherein the crankshaft is defined by two concentrically disposed inner and outer sections; the tapered rollers being arranged on both concentric sections so that the axes of the tapered rollers of one of the concentric sections are disposed at an angle to the longitudinal axis of the device, said angle being opposite to the angle at which the axes of the tapered rollers of the other concentric section are disposed; and the outer concentric section of the shaft being rigidly attached to the casing of the drive.

4. The device as claimed in claim **1** wherein the drive of crankshaft is movably linked up with substantially cylindrical rollers having axes, the axes of the substantially cylindrical rollers being disposed at an angle to the longitudinal axis of the device in different planes which are substantially parallel to said axis; and said substantially cylindrical rollers being movably linked up with the crankshaft.

5. The device as claimed in claim **1** wherein the surface of tapered rollers in contact with the hole wall is covered with a resilient material.

6. The device as claimed in claim **1,** wherein the drive is a reversible drive disposed in close proximity to the device is provided with means of securing the casing to the hole wall so as to prevent the casing from rotation.

7. The device as claimed in claim **6,** wherein a means of securing the casing of the drive so as to prevent rotation are projections disposed radially on the casing.

8. The device as claimed in claim **6** wherein the means of securing the casing of drive so as to prevent rotation are wheels disposed radially on the casing.

* * * * *