

- [54] **AUGER WITH ROTATABLE CUTTERS** 3,024,856 3/1962 Henning..... 175/394 X
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 [73] Assignee: **Hughes Tool Company**, Houston, Tex. 3,092,190 6/1963 Gruere..... 175/394 X
 3,094,179 6/1963 Lines 175/394
 3,172,489 3/1965 Jones..... 175/394

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 [51] Int. Cl.² **E21B 9/24; E21C 13/04**
 [58] Field of Search **175/310, 323, 394, 335, 175/351-353, 371-373, 376, 377**

[57] **ABSTRACT**

An earth boring apparatus having an auger flight with a tapered portion and a plurality of rotating cutters mounted along the flight. The cutters are mounted to the tapered portion of the flight such that a selected relationship is achieved between the thrust and radial loading on each cutter and its bearing and support means. For the cutters shown, this is accomplished by providing a selected angle between the rotational axis of each cutter and a plane normal to the rotational axis of the auger.

- [56] **References Cited**
UNITED STATES PATENTS
 893,950 7/1908 Thomas 175/394 X
 1,747,908 2/1930 Seifert..... 175/351 X
 2,085,336 6/1937 Sandstone..... 175/394 X
 2,184,108 12/1939 Akeyson 175/394 X

6 Claims, 4 Drawing Figures

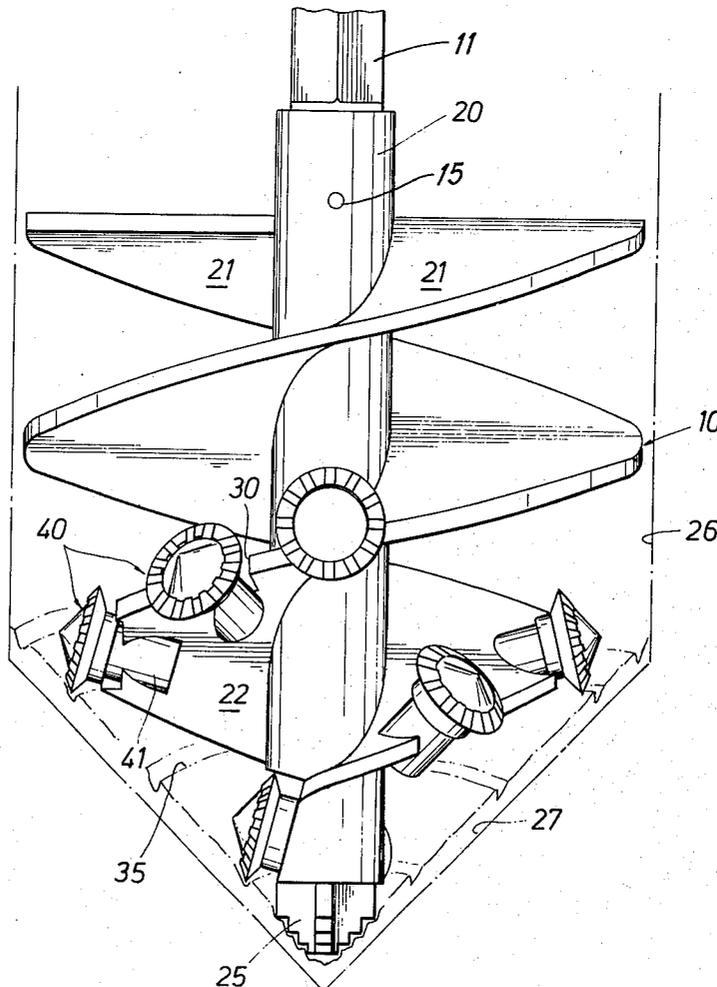


FIG. 1

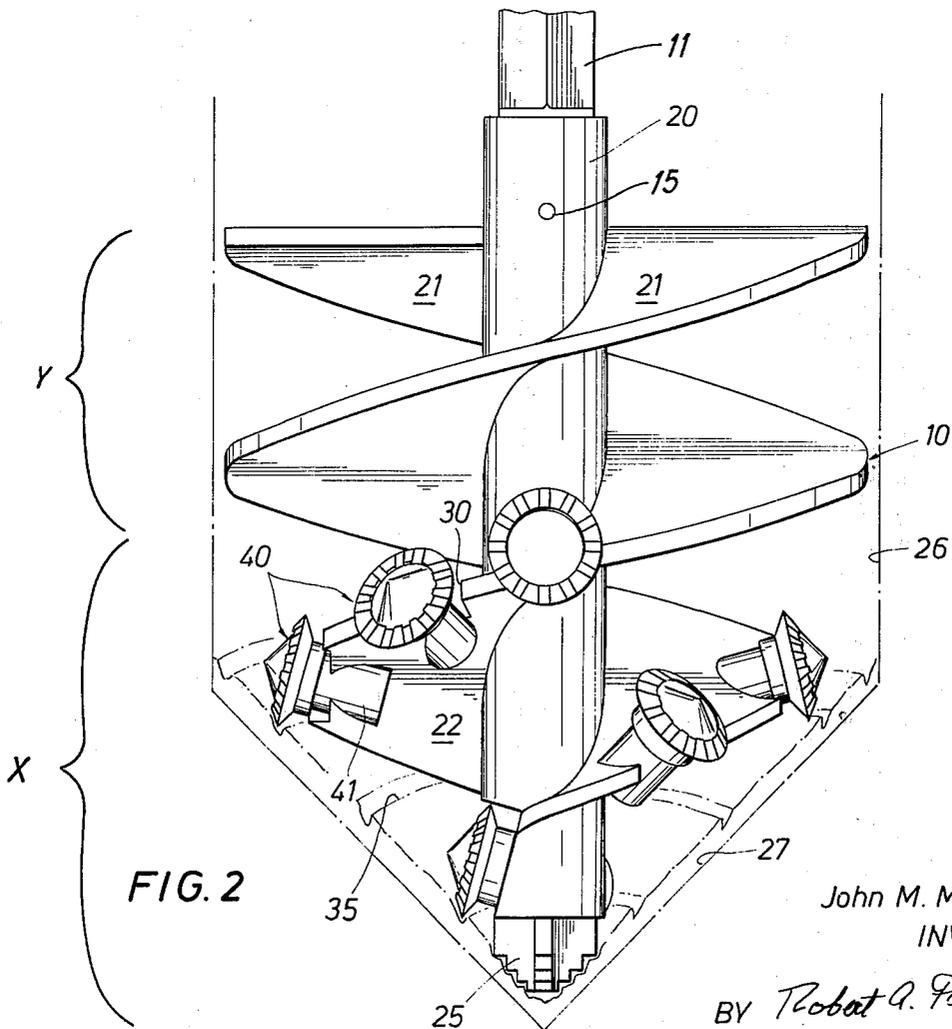
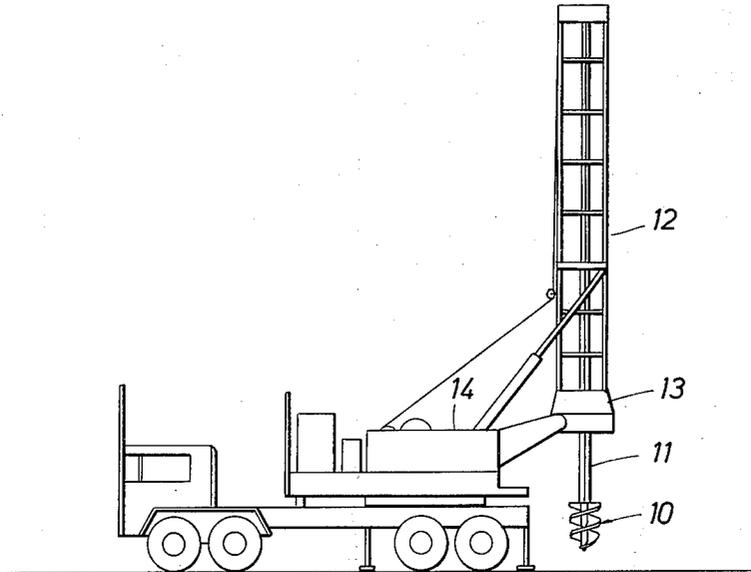


FIG. 2

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FIG. 3

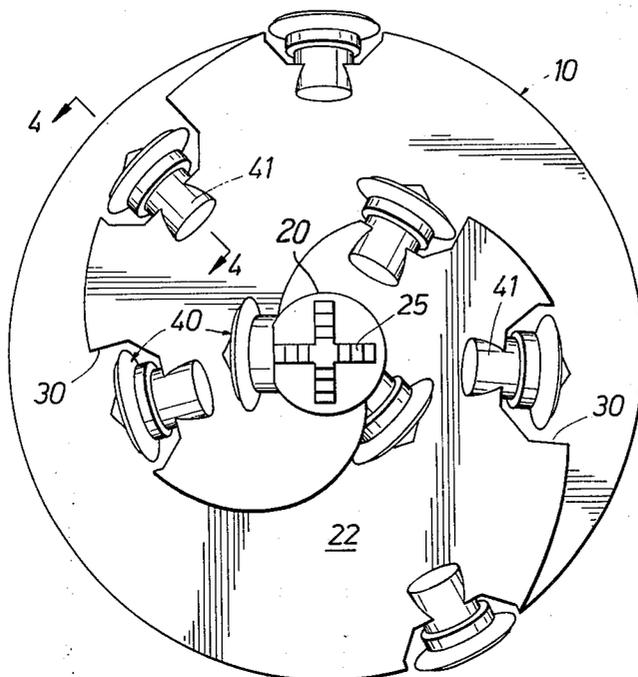
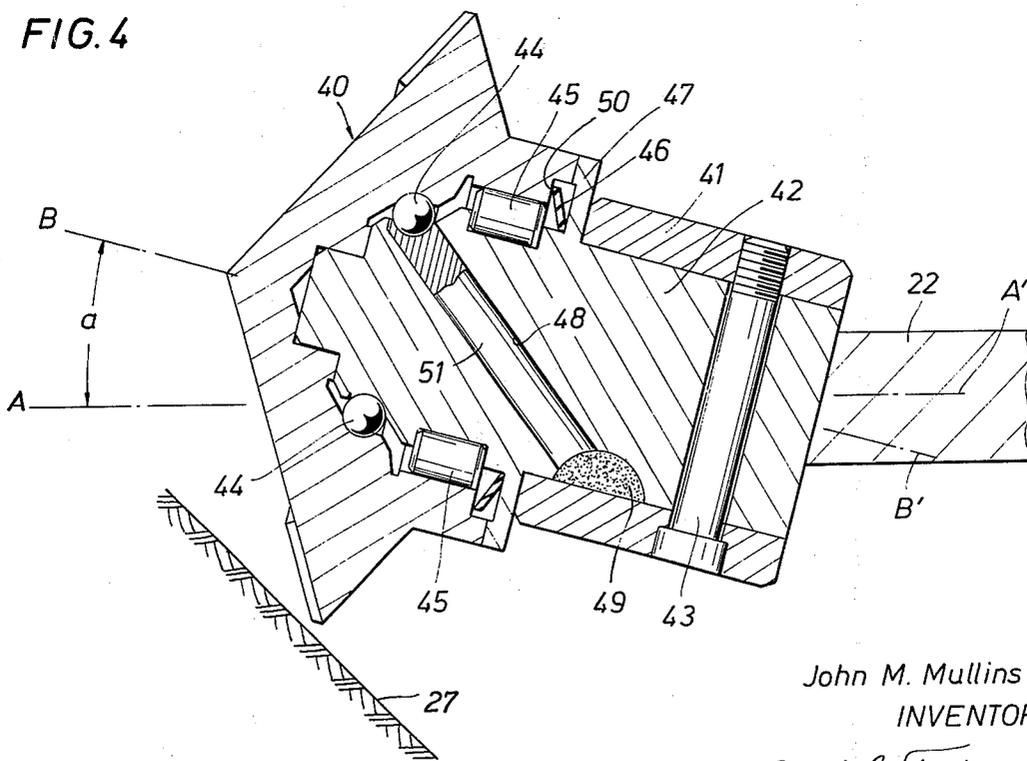


FIG. 4



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AUGER WITH ROTATABLE CUTTERS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The field of the invention is augers for boring into the earth without the use of a circulating fluid.

2. Description of the Prior Art

In order to provide the proper foundation for structures such as large buildings and bridges, large diameter holes must be drilled into the earth for the foundation piers. When these holes are drilled in soil, clay, or soft rock, use is made of drilling tools such as augers and core barrels that usually are equipped with drag type cutting elements. This type of cutting structure is effective in the softer materials but lacks the strength and durability to penetrate the harder or more abrasive rock formations.

The drag action of conventional tools is characterized by rough running that causes severe shock and impact stresses that damage the drive train and related equipment operating the tool.

When the harder rock formations are encountered, it is common practice to use plate bits that mount rolling cutters having a cutting structure of milled teeth or of tungsten carbide inserts. This type of drilling bit requires the circulation of a fluid such as water or air to clean the cutting structure and to remove the cuttings from the hole.

SUMMARY OF THE INVENTION

The invention contemplates an auger construction which will efficiently drill through hard rock formations and cobble or boulder strewn formations, as well as through ordinary soil, without the use of a drilling fluid circulation system. The invention comprises an auger having a tapered flight portion diverging outwardly and upwardly from the leading end of the auger to collect and retain cuttings from a bore hole, and a plurality of earth disintegrating elements spaced along a flight.

Bearing and mounting means releasably secure the elements to the flight to provide selected relationship between radial and thrust loading. In the embodiment shown, this is accomplished by mounting cutters for rotation about axes oblique relative to a plane normal to the longitudinal axis of the auger. Preferably, the rotating cutters are mounted within windows spaced along the periphery of the tapered flight.

The invention, by the rolling action of the cutters, overcomes the disadvantage of damaging rough running in tools of the prior art when rock or intrusions such as boulders and cobbles are encountered.

The invention further increases the penetration rate through hard rock and boulder-strewn formations and reduces the horsepower requirements as compared with the drag action of the prior art.

The invention extends the use of augers into the range of rock hardness that normally is drilled with equipment requiring a circulating fluid for cuttings removal.

Further, the mounting of the cutters increases their useful life through improved bearing loading characteristics.

Moreover, the provision of a tapered flight portion and a cylindrical flight portion increases the cuttings removal capacity of the auger.

Other objects, features and advantages of the invention will become apparent in the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawings show the inventor's presently preferred embodiment of the invention. In the drawings:

FIG. 1 is a side elevation view of the auger suspended from its drive train and support mechanism.

FIG. 2 is a side elevation view of the preferred embodiment of the invention, showing that embodiment within a hole being drilled.

FIG. 3 is a bottom view of the presently preferred embodiment, showing the angular spacing of the cutter elements about the longitudinal axis of the auger.

FIG. 4 is a detailed sectional view of one of the cutter elements and its bearing and mounting means, taken along line 4—4 of FIG. 3, showing the bearing pin angle relative to the flight on which it is mounted.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings, FIG. 1 shows the preferred embodiment of the invention, generally designated by the numeral 10, removably suspended by a drive shaft or kelly bar 11. Drive shaft 11 is supported by support structure 12, and means for driving auger 10, shown as a rotary table 13 and a suitable drive means 14.

FIG. 2 shows auger 10 in greater detail. Auger 10 includes a central support means or shaft 20, about which is disposed a plurality of tapered auger flights 21, that diverge outwardly and upwardly from the leading end of the shaft 20. The upper end of the shaft is adapted for connection with the drive shaft 11 by suitable means such as a connector pin 15. A single tapered flight would accomplish equally well the function of the invention, but the presently preferred embodiment has two flights 21. Flight 21 includes along its length a tapered portion 22, having spaced thereabout a plurality of earth disintegrating elements, which in this instance are in the form of disc cutters 40. As shown in FIG. 2, the flights of the preferred embodiment include a lower tapered portion *x* and an upper, cylindrical portion *y*. Secured to the lowermost portion of auger 10 is a pilot bit 25 for advancing the central portion of a bore hole 26.

FIG. 3 shows auger 10 from below, having pilot bit 25 mounted in the lowermost portion or leading end thereof. Disc cutters 40 are each mounted within a window 30 of the tapered portion 22 of flights 21. That portion of disc cutter 40 which will contact the face 27 of hole 26 being drilled may be constructed of any wear-resistant material capable of withstanding high compressive loading. Such materials may be alloy steel, tungsten carbide, or wear-resistant inserts, for example.

As in conventional augers, flights 21 perform the function of collecting and retaining cuttings for removal from the bore hole. The tapered portions 22 of flights 21 additionally support disc cutters 40 about their outer edge. As disc cutters 40 create cuttings by engaging the concave, generally conical, face 27 of hole 26, the cuttings (not shown) pile upon both tapered portion 22 and cylindrical portions 21. Disc cutters 40 are recessed in windows 30 to protect cutters 40 from impact and to position the edge of flights 22 near the conical hole bottom 27 for maximum cuttings removal. The mounting sockets 41 are attached within flights 22 to provide minimum obstruction to the move-

ment of cuttings along the flights. As the entire flights become loaded, drive shaft 11 (FIG. 1) is elevated, thereby withdrawing auger 10 from the hole. As auger 10 is raised above the surface of the hole, it is spun rapidly about shaft 20, thereby throwing off the accumulated cuttings.

As is shown in FIG. 3, disc cutters 40 are spaced about the edge of tapered portions 22 of flights 21. The lowermost of cutters 40 is also disposed the nearest to the longitudinal axis of auger 10. Each cutter is spaced higher on and at a greater distance radially from the longitudinal axis of auger 10. The plurality of cutters 40 contact conical face 27 of hole 26 in a plurality of concentric circles 35 when auger 10 is rotated during digging operations. The included angle between a plane normal to the axis of drilling and a cone element of conical face 27, referred to herein as the face angle, is preferably in the range 30° to 60°, with the optimum being about 45°.

FIG. 4 shows a detailed view of disc cutter 40 and its angular disposition relative to a line A—A', which lies in a plane normal to the longitudinal axis of the auger, or axis of drilling. In the preferred embodiment, the cutter bearing support is positioned inboard of the cutter, i.e., at a smaller radial distance from the longitudinal axis of the auger, than is the cutter. However, the same cutting action could be obtained by reversing this arrangement to place the bearing support at a point outboard of the cutter. Line B—B' represents the axis of rotation of cutter 40, and the angle "a", bearing pin angle, shows the relation between line A—A' and line B—B'.

The bearing pin angle is selected to obtain a bearing loading that is generally radial to the bearing axis. Inward thrust, or axial force, is exerted on the bearing by the action of the cutter rolling on an inwardly sloping face 27, with the magnitude of the force increasing with steepness of slope. In the case of the outermost, or gage cutter, the wall of the hole also produces an inward thrust. The bearing pin angle as illustrated in FIG. 4 produces an outward thrust that serves to substantially counteract the said inward thrust forces, thus providing selected relationship between thrust and radial loading. Since the gage cutter is subjected to greater inward thrust than the inner row cutters, its bearing pin angle is made approximately 9° greater than the latter.

Line B—B' is oblique relative to the line A—A' and in the preferred embodiment in which the said face angle is about 45°, the angle a is about 30° for the inner row cutters and about 39° for the gage cutter. For the preferred face angle range of 30° to 60°, angle a is between about 15° and about 45°, respectively, for the inner row cutters, and is between about 24° and about 54°, respectively, for the gage cutter. The preferred included angle between line B—B' and a plane normal to the longitudinal axis of the auger is, therefore, between about 15° and about 54°.

Each cylindrical mounting socket 41 is recessed within the auger flight, being secured, such as by welding to the radially innermost portion of window 30 and is arranged to receive a projecting shaft of a bearing pin 42 therein. However, the two innermost cutters are secured in sockets (not shown) formed directly in central shaft 20. Bearing pin 42 is secured within mounting socket 41 by connector means that in this instance is a fastener means, here a bolt 43 or the like extending through mating apertures in the mounting socket and

projecting shaft. The mounting structure enables easy maintenance of the cutter structure as, for example, when cutter 40 becomes worn and needs to be replaced. Bolt 43 may be withdrawn from mounting socket 41 and bearing pin 42 may be easily withdrawn as a unit with disc cutter 40.

Between bearing pin 42 and disc cutter 40 are interposed bearing surfaces and a plurality of ball bearings 44 and a plurality of roller bearings 45 which allow cutter 40 to freely rotate relative to bearing pin 42. To insure dust-free operation of roller bearings 45 and ball bearings 44, a circular bearing seal 46 is disposed between a shoulder 47 of bearing pin 42 and the inner periphery 50 of disc cutter 40. A cylindrical cavity 48 is included in bearing journal 42 for the purpose of admitting ball bearings 44 between bearing pin 42 and disc cutter 40. Prior to insertion of bearing pin 42 into mounting socket 41, cavity 48 is filled with steel plug 51 and closed by a weld 49 and smoothed to allow easy passage of bearing pin 42 into mounting socket 41.

The apparatus preferred by the inventor is an improved tool for most types of formations encountered when digging holes to anchor bridges, buildings and the like. It is capable of drilling soft formations, like a conventional auger, is superior to other types of apparatus for drilling hard formations, and has the additional benefit of drilling relatively smoothly, those formations interspersed with boulders and cobbles, thereby substantially reducing shock to the auger drive train.

Thus it can be seen that an improved auger for boring holes into the earth has been provided. Further modifications and alternative embodiments of the invention will be apparent to those skilled in the art in view of this description. Accordingly, this description is to be construed as illustrative only and is for the purpose of teaching those skilled in the art the manner of carrying out the invention. It is to be understood that the form of the invention herewith shown and described is to be taken as the presently preferred embodiment. Various changes may be made in the shape, size and arrangement of parts. For example, equivalent elements or materials may be substituted for those illustrated and described herein, parts may be reversed, and certain features of the invention may be utilized independently of the use of other features, all as would be apparent to one skilled in the art after having the benefit of this description of the invention.

I claim:

1. In an earth boring auger, the improvement comprising the combination of:
 - auger means for collecting and retaining cuttings from a bore hole bottom;
 - tapered auger flight means diverging generally outwardly and upwardly from a leading end of the auger means;
 - cylindrical auger flight means connected with said tapered auger flight means; and
 - a plurality of rotatable earth disintegrating elements spaced along a portion of at least the tapered auger flight means.
2. The auger defined by claim 1, wherein:
 - said tapered auger flight means includes a plurality of windows, and said earth disintegrating elements are secured in said windows.
3. The auger defined by claim 1, which further comprises: a central means; a pilot bit secured to the leading end of the central support means.

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4. The auger defined by claim 1, wherein:
bearing and mounting means secure said earth disintegrating elements to said auger flight means to provide selected relationship between radial and thrust load.

5. In an earth boring auger, the improvement comprising the combination of:
tapered auger flight means for collecting and retaining cuttings from a bore hole, and diverging generally outwardly and upwardly from the leading end of the auger;
a plurality of mounting sockets connected to the tapered auger flight means;
a plurality of bearing pins which each have a bearing

surface formed on one end and a projecting shaft formed on the other end to extend into mounting sockets;
connector means releasably securing the projecting shafts to the mounting sockets;
rotatable cutters adapted to envelop the bearing surfaces of the bearing pins; and
means securing the cutters to the bearing pins.

6. The apparatus defined by claim 5 wherein said connector means include a fastener means extending through a mating aperture in each associated mounting socket and in the projecting shaft of each associated bearing pin.

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