June 29, 1937. H. D. SANDSTONE 2,085,336

ROTARY EXCAVATOR

Filed Dec. 21, 1932 3 Sheets-Sheet 1

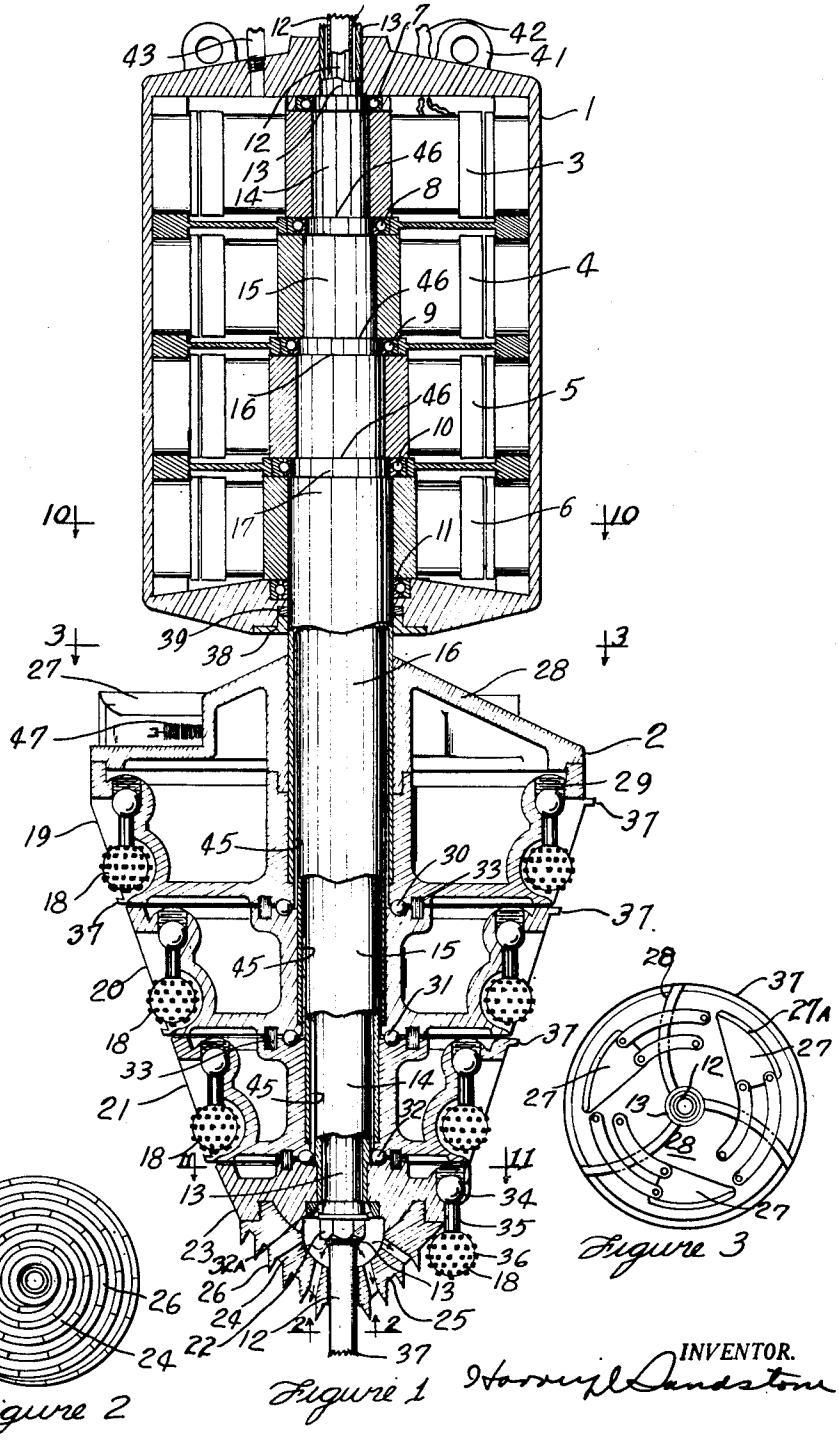


Figure 1

Figure 2

Figure 3

INVENTOR.

Harold D. Sandstone

June 29, 1937. H. D. SANDSTONE 2,085,336

ROTARY EXCAVATOR

Filed Dec. 21, 1932 3 Sheets-Sheet 2

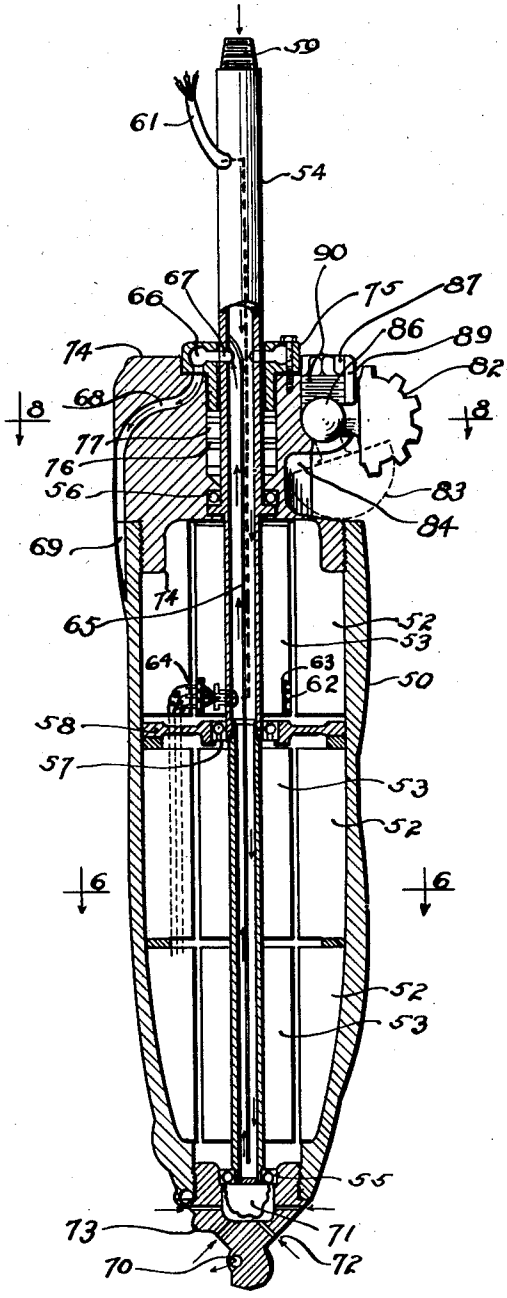


Figure 4

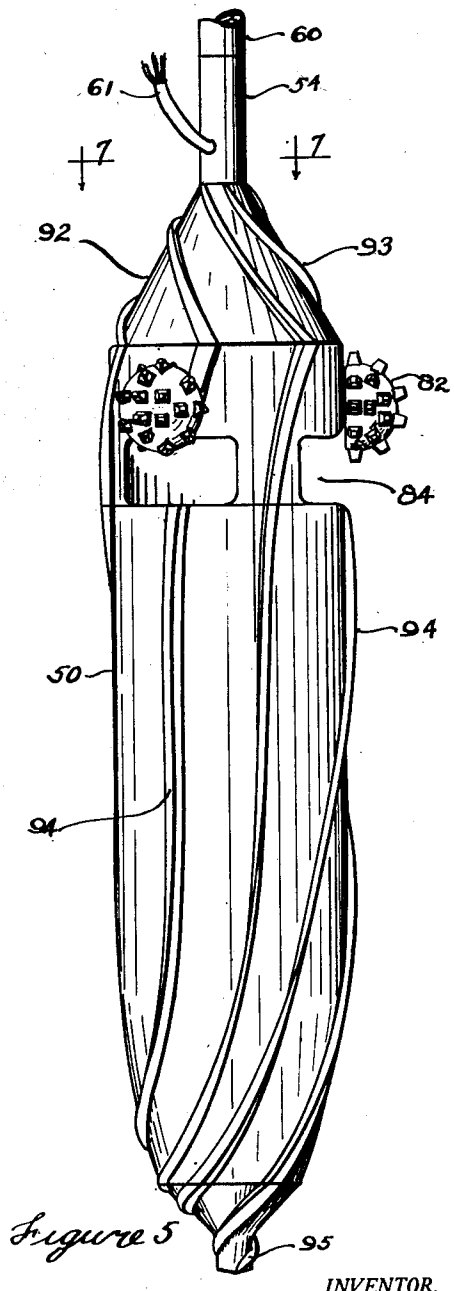


Figure 5

INVENTOR.

Harvey D. Sandstone

June 29, 1937. H. D. SANDSTONE 2,085,336

ROTARY EXCAVATOR

Filed Dec. 21, 1932 3 Sheets-Sheet 3

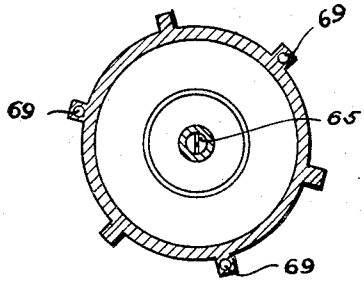


Figure 6

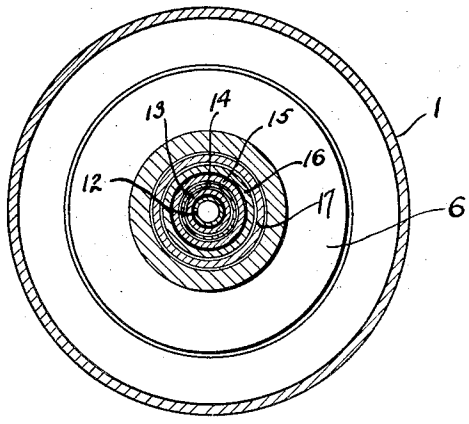


Figure 10

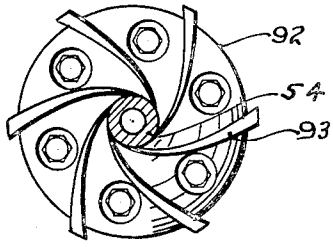


Figure 7

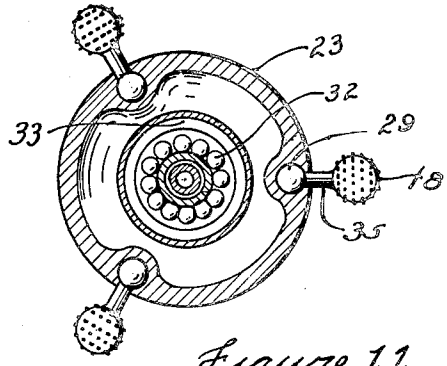


Figure 11

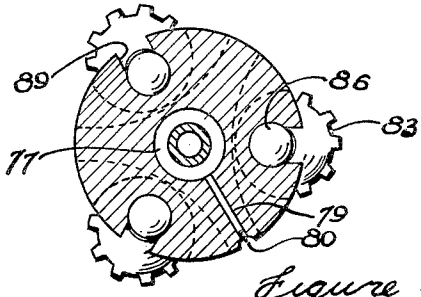


Figure 8

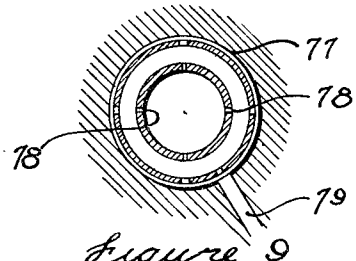


Figure 9

INVENTOR.

Harvey D. Sandstone

Patented June 29, 1937 2,085,336

UNITED STATES PATENT OFFICE

2,085,336

ROTARY EXCAVATOR

Harvey D. Sandstone, Oakland, Calif.

Application December 21, 1932, Serial No. 648,247

6 Claims. (Cl. 255—4)

This invention relates to an apparatus for boring deep excavations and removing the debris therefrom, as for mine shafts, submarine footings, and deep wells; small ones from inches in diameter to larger ones of feet in diameter; and has for its principal object the provision of a high-speed rotary excavator, especially adapted to be connected to the standard rotary drill-stem now being used in the oil fields.

A further object of the invention is to provide for the increase of the use of the rotary drilling equipment, by increasing the size of the hole, by filling a much needed mechanism for sinking mining shafts, tunnels, and sub-marine borings for footings and foundations, with the minimum loss of life.

To provide a rotary cutting bit, consisting of individually propelled units or sections, allowing these sections to be added, thus increasing the size to accommodate the particular diameter of the hole desired.

To provide a cutting bit or reamer with variable-speed cutting units or sections, so constructed as to allow the rim foot travel per minute to be the same in the smaller diameter sections as that of the larger sections.

To provide a boring bit so constructed as to allow part of the cutting members to travel in the opposite direction to the other cutting members, thus decreasing the torque of the bit and eliminating much superstructure and torque resisting means.

To provide a cutting means allowing self-contained motors, with the housing revolving so as to form a base and weight to accommodate the cutting or reaming elements.

To provide a cutting means as above mentioned with the outward parts, larger than the drill stem revolving, cigar- or pineapple-shaped, with motive power completely enclosed, within a revolving turret armoured on its outer side with cutting or reaming elements.

To provide a boring mechanism so constructed that it can be attached to a supporting stem, eliminating the danger of cave-ins on a stem with a large knob on its lower end, this invention of mine will eliminate this danger as it is cigar-shaped, and completely enclosed with revolving cutters, top, bottom, and all sides, allowing the operator to raise and lower when spinning as an egg beater or powerful mixer.

Another important feature is that I have produced a boring element with spiral cutting edges, which, when revolving in the proper direction, will lead into the formation and have the tendency to raise the cuttings upwardly, and, when stuck, or for some other reason it is reversed in rotary action, it will extricate itself from its crowded position and work towards the entrance of the hole.

Another object is to produce such a bit, as above described driven by several motors, thereby distributing the energy evenly to the revolving skin, also to have the motors cut in series, allowing a higher voltage on the line, thereby diminishing the size of the cable and cutting down the voltage of motor and allowing thinner insulation of the motors.

To produce an excavating tool so constructed as to have all parts working in oil, to eliminate all foreign matter from the motor chambers by having them operating under liquid pressure, automatically regulated to equalize the interior with the exterior pressure in the hole.

To provide a boring mechanism which can be used within a casing, or lowering the casing as the hole is being made, under reamers are necessary, I have provided automatically expanding, load-regulating reamers, these reamers so balanced as to return to the apertures in the housing when the motors become overloaded, thus cutting down the load on the motors until they regain their speed, when the reamers are expanded again to their cutting position.

Other objects and advantages residing in my invention, and objects relating to details and arrangements of parts thereof, will be readily apparent in the course of the detailed description to follow.

The accompanying drawings illustrate by way of example a representative form of my invention, in which:

Figure 1 is a vertical sectional elevation of the drilling device, showing the superimposed, variable-speed cutting sections, and for clarity the motors are not self-contained, being placed adjacent above.

Fig. 2, view of under side of cutting head Fig. 1, showing teeth in spiral formation.

Fig. 3 is a view of top side of drilling device Fig. 1, at plane 3—3, showing the centrifugally expanded, hollow and ported smoothers and steadiers and top-side reamers.

Fig. 4 is a vertical sectional elevation of the drilling device shown in a singular form, with self-contained motors and with only one revolving unit or housing.

Fig. 5 is a side elevation of Fig. 4, with body line reamers in vertically spiralled position, and the one set of expanded ball cutters.

Fig. 6 is a cross section at plane 6—6 Fig. 4, showing motor, housing, and body line reamers.

Fig. 7 is a view of the top end of the drilling device Fig. 5, showing spiral top reamers and bolt method of fastening on the hood.

Fig. 8 is a view of the cross section at plane 8—8, showing the expanding ball cutters located in housing in non-operating position.

Fig. 9 is an enlarged sectional view of the stuffing box gland, showing the ported, hollow, grease-containing bearing and packing separator, and method of applying grease with the grease gun not shown.

Fig. 10 is a section through the superimposed motors taken at plane 10—10, showing the telescoping hollow drive shafts which connect their respective motors and revolving cutting sections together, also the hollow supporting drill stem, with operably connected core barrel therein.

Fig. 11 is sectional view of the lower cutting unit of Fig. 1, taken at plane 11—11, and showing the ball cutters in a centrifugally expanded position, and one set of ball bearings upon which the superimposed sections revolve on, and gradually reducing, their respective speeds, upwardly.

While I have shown only the preferred forms of my invention, it should be understood that the various changes or modifications may be made within the scope of the claims hereto attached without departing from the spirit of the invention.

The power plant for my rotary excavator comprises a motor housing 1, having field windings 3, 4, 5, and 6, secured thereto, and armatures connected to individual hollow shafts at 14, 15, 16 and 17, revolvable in the fields. The hollow shafts terminate at some distance from the bottom of the motor housing into and connected to their respective rotary cutting units, or sections, 19, 20, 21, and 23, revolvably mounted on their respective ball bearings, 30, 31, 32, and 32A, and protected from foreign matter by the circular packing 33, which also holds the oil from leaving the bearings. The conically shaped bottom portion of the bit 25 armoured on its bottom face with cutting teeth placed in spiral formation. The hollow supporting stem, which is adapted to raise and lower the mechanism as desired, terminates at the bottom side of the lower section 23, which revolves on bearing 32A and supporting the mechanism, being held in place by the large nut 22 threaded on the lower end of the drill stem 13; a coring barrel 12, with cutting teeth at its bottom end 37A, is operably mounted within the hollow drill shaft 13, allowing enough space between core barrel 12 and drill stem 13 to form the passageway for the circulating or flushing liquid, which is exhausted through the lower ports 24 in bottom of cutter face 25.

The cutting elements 18, which I prefer to show as heavy steel balls covered with cutting edged points, are centrifugally expanded, being held in their sockets 34, by the small ball-joint 29 and by the connecting neck 35, allowing a free revolving and expanding action when the revolving sections are put into motion.

Fig. 3 is a top view of plane 3—3 of Fig. 1, showing the return cutters 28 used in coming out of the hole, I have employed centrifugal expanders which are used to steady the upper section of the drill against the walls of the formation, these expanders are hollow, adaptable to hold cement or other material to smooth or line the hole with, the cement seeps out the port holes 27A on the contact side, as the mechanism is brought into play. The core barrel is represented by 12, located within the hollow drill stem 13. A spiral cutting edge 37, which encircles each section, is but one type which could be employed on the surface of these revolving sections. The upper end of the drilling mechanism is provided with eyes 41 for engagement with auxiliary hoisting lines or stays. The motors are furnished power from the source of electrical supply through power cable 42 connected thereto. 43 shows a hollow conductor connected to the source of oil supply under pressure, which furnishes the reserve oil under pressure contained in my motor chambers. The motor chambers being kept full, the oil seeps into the spaces between the hollow driving shafts at 46, filling these spaces at the lower end 45. I have provided packed rings 33 to retard the oil from escaping or the outside foreign matter from entering the bearings 30. One method of keeping the foreign matter out of the motor chamber and mechanism is shown by the stuffing gland 38 compressing the packing 39.

Mounted within the housing 50 of my single unit, Figs. 4 and 5, are a plurality of field coils 52 which are fastened to the inner side of housing 50, and cause the housing to revolve. Being free, these fields revolve around the armatures 53, which I show as stationary, being solidly connected to the shank or supporting shaft 54, which is kept from rotating by mechanism not shown. The housing 50 is journaled upon the shaft 54 by means of an annular bearing 57 and two thrust bearings 55 and 56 designed to provide against axial displacement. The spider 58 affords structural support for the housing 50 as will as forming the mounting for the annular bearing 57. The stationary supporting shaft 54 is threaded at its upper end 59, shown in Figure 5 as connected with the torque resisting shaft 60. 61 represents the power cable, which furnishes power from the source of electric supply not shown, and as shown by the dotted lines, transmits the energy to the metallic conductor rings 62 on end of armature. These rings are insulated as shown at 63. The energy is transferred to the revolving fields through the contact brushes 64 mounted in insulators. The three dotted lines represent the power leads to the other field coils.

It is advantageous to supply a flushing liquid to the cutting bit points when possible, as well as necessary if the hole is full of water, and the grindings are to be flushed out the top of the hole by the return circulation. To accomplish this, flushing liquid is impelled through the shaft-channels separated by the partition 65 and flows therethrough in the directions indicated by the arrows in Figure 4, thus furnishing a cooling medium for the armatures. After thus passing through the shaft 54 the liquid enters the hollow stuffing gland cap 66 through the hole in the stem 67, through the duct in the casting 68, through the hollow cutting ridges 69, to the botom cutting surface of the tool through the outlet port 70.

This singular drilling unit is more adapted for smaller holes and much deeper penetration into the earth's surface, and it might not be practical to make a conductor line contact with the source of oil supply at the surface, so, in order to protect the inner mechanism from the contact of foreign matter in the hole, I have adopted a flexible oil supply reservoir 71 which furnishes a supply of oil in addition to the amount of oil which is contained in the housing, which is full of oil. To operate this equalizing pressure system, I show small liquid intake ports which allow the hydrostatic pressure to enter through these

intake ports 72, and, causing pressure to be applied to the under and outer side of the flexible reservoir 71, compressing the liquid up into the motor chambers, and thusly building up interior pressure to equal the exterior pressure thereof.

The simplicity of construction and making repairs is shown. The lower end of the housing 50 is equipped with a threaded opening, allowing free and easy access to the lower end by removing the lower section or cutting face 73, which is a threaded plug with cutting members mounted on its outer surface, and having apertures therethrough.

The upper end of the housing also has a threaded opening into which a somewhat larger member 74 is connected. This member shows three liquid conveying ducts 68 therethrough, forming the connection between ends of the hollow vertical cutting ridges 69 and the cap 66 of the stuffing box bland 75, compressing the packing 76 with hollow metallic packing separators 77 between the packing rings. These hollow packing separators have a bearing material on their inner sides which come in contact and revolve around the main shaft 54. This bearinged surface has apertures through which oil or grease oozes to lubricate the bearing. There being proper apertures in the supporting main end member 74 to supply the lubricant. The bearings are replenished with grease through aperture 79, having a grease gun connection 80 at its outer end.

In order to ream the hole a little larger so as to allow follow-up casing, automatic expanding reamers are shown as indicated by 82, and are in a cutting position expanded, the dotted line 83 indicates the position of the ball cutters when not in action, and apertured in the side of the upper end body member at 84. In order to eliminate the extra mechanism of governor or motor load regulator, I have adapted a flexible cutting member, having a free action on its ball socket end 86. In case the operator crowds the bit and the work becomes too heavy for the motor power, thus slowing up the same, the cutters immediately retract into the housing, lessening the motor load until the motors regain their normal speed, at which time the governed cutters come back for more.

To be able to replace these flexible reamers without dismantling the whole drill, I have shown apertures 87 in the top side of head member 74 connected with the larger side body apertures 88 by a channel 89. To replace these cutters, the smaller ball end is dropped into the smaller top aperture and the larger end drops into its respective place. The smaller top aperture is threaded to allow the entrance of the aperture plug 90 as indicated, forming the top side of the ball socket and holding the cutter intact while in its centrifugal motion.

The conical shaped cap member, indicated as 92, not only protects the top end from cave-ins, but, having spiral cutters 93, eliminates the danger of being buried under a cave-in and not being able to extricate itself.

From the foregoing, the operation of my improved rotary excavator will be readily understood. The electric motors which operate this device, receive their energy through the power cables 42 and 61 of Figs. 1 and 4–5 connected to the source of electrical supply.

The rotary action of said motors cause the several cutting sections, 19, 20, 21, and 23, Fig. 1, to rotate by an individual motor, for each section, connected to a hollow shaft. This is desired so that the smaller cutting section can be speeded up to about 1,000 R. P. M., the next larger to 650 and 450, while the top, or largest section to about 250 R. P. M., thus making the peripheral speed of each section the same.

The motors 3, 4, 5, and 6, in Fig. 1 are supplied with cooling oil which is kept at about the same pressure as the hydrostatic pressure under which the motors are running. This oil is re-imbursed from a pressure supply tank above, (not shown), through the hollow conductor 43 of Fig. 1.

The motor chambers being full, the oil seeps down and fills the spaces between the telescoped hollow driving shafts, which transmit the rotary motion from the revolving armatures to their respective rotating superimposed cutting sections below Fig. 1.

In order to counteract the increased torque in on the stationary stem 13, especially in a large hole, one of the sections should be revolved in the opposite direction from the other sections. The oil follows the spaces separating the telescoped hollow shafts, and not only lubricates the ball bearings at their respective elevations, but also relieves any friction between the interposed hollow shafts.

In order that the oil might not escape, or the foreign matter enter the working parts, the packing gland 38 is provided, and also packing rings 31, 32, 33, between the revolving sections.

It has been proven that a high speed cutting bit, where the formations are irregular, such as boulders encountered in sandy soil, should be equipped with flexible cutters, so as to give when the boulders are encountered, but at the same time deliver a substantial blow and cutting action to disintegrate said boulder or to drive same into the walls of the hole. I have designed the revolving centrifugally expanded ball cutters, 18, 82 and 83, Figs. 1, 4, 5, 8, and 11, operating in ball and socket joints 29 and 86, Figs. 1 and 4. These ball cutters, traveling at 5000 feet per minute, are very speedy cutters and drive the greater portion of the cuttings into the wall's formation, Fig. 1. Some formations are not inclined to stand up until cased, so I have provided smoothers and steadying elements, 27, which are hollow, allowing a supply of cement to be enclosed for distribution. When in centrifugal action, they are pressed against the finished walls of the hole and plaster it up with cement when desired, and also act as steadying elements for the upper portion of the drill.

There are times when it would be very advantageous to be able to core the formation, bringing up the core for examination while the apparatus is operating in the hole. For this purpose, I have devised a core barrel 12, with cutters at lower end 37A. If coring isn't desired, this barrel can be used as a return circulation by pump suction, the downward flushing circulation being made through the space between the coring barrel 13 and the drill stem 12, and is ejected through the port holes 24, at cutting face below, Fig. 1.

Figs. 4 and 5 show the smaller drilling unit, as the base cutter without the superimposed sections being added. The operation of this smaller and singular revolving unit is much the same, only that the armatures 53 are connected to a stationary shaft and the fields 52 revolve. Said fields being fast to the outer housing, causing it to revolve at a high speed if desired, there being no reduction gears or other apparatus to get out of order and to cause trouble. As you will

see on Fig. 5, the cutter surface of the housing is equipped with cutting elements **94** in a spiral shape the full length of the body **50**, as you will notice, there are no stationary parts exposed other than the torque resisting shaft **60**, Fig. 5, being held fast above, (not shown), and does not revolve; causing the fields to revolve and thus including the housing which has cutting surfaces outwardly exposed. This bit is not easily stuck in a cave-in or in a tight place, the reversed action applied to it will worm it out of a pinch. This bit makes a high speed bit with self-contained motors a success, as the whole surface outwardly revolves, eliminating the danger of putting down a long stem with a stationary knob (motor housing) at its lower end and having only the cutting face at the bottom to revolve.

The principle of circulating the flushing liquid employed now in the rotary drilling rigs is used, only that in order to eliminate a stuffing box at the bottom of the shaft and expose the gland fitting to the wear at the cutting surface. I desire to place a partition **65** Fig. 4 in the hollow shaft **54** nearly the full length of the drill body, and terminating at a short distance from the lower end of the said hollow shaft **54**, which has a plug in its lower end, thus forcing the circulation to return back up the other side of the partition as shown by the arrows, Fig. 4. This partition makes a contact with the hollow shaft adjacent above the outlet port **67** shown in the shaft, allowing the circulating liquid to enter into the hollow in the gland cap **66**, through the water ducts **68**, and side hollow cutting edges **69** down to the circulation outlet **70** at the bottom of the bit. I might add that the circulation liquid does not make the return trip through the partitioned hollow shaft, as just enough is needed to act as a cooling medium for the armatures. The balance of the cooling liquid is passed directly from the said ports in the hollow shaft **54**, through the water duct **68**, and the same path as above mentioned.

The electrical energy is supplied through the power cable **61**, which follows the dotted line to the three metallic contact rings **62** on the lower end of the top armature **53**, Fig. 4. These metallic rings are insulated as at **63**. Brush contacts **64** transmit the energy to the fields, and the leads continue from there to the other field coils **52** shown by the dotted lines.

In order to construct a working device giving the best service possible, the housing is rotated on ball bearings, the end bearings **55** and **56** being bearings capable of taking the necessary end thrust, and the center bearing taking the side play. To steady the upper portion of the housing, I have applied a hollow grease containing bearing **77**, also used as a packing separator. The inner wall of this bearing is of a bearing material, ported, **78**, Fig. 9, revolving around the stationary shaft as the housing rotates. The bearing is supplied with grease through a grease gun fitting **80** Fig. 8.

The smaller sized drills are better adapted for holes of great depth, such as oil wells, etc., and it may not be practical to carry a hollow oil pressure conductor from the source of supply above to the bit housing below, so I have adapted a flexible oil reservoir **71**, Fig. 4, at lower end of rotated housing. In this type of drill, and to its best operating conditions, it is necessary to have the hole full of water, and thus stepping up the hydrostatic pressure at the bottom of the hole as the drill progresses downwardly. As the hydrostatic pressure increases, the pressure on the flexible reservoir through the ports **72** increases accordingly, thereby equalizing the oil pressure inside of the rotated housing with the outside, or, hydrostatic pressure. I prefer to use a non-electrical conducting liquid which will have a greater advantage in keeping the motors cool during operation, as well as being more efficient than air in keeping foreign matter from entering the mechanism when under equalized pressure.

In order to make a hole, cutting means are necessary. I have shown here a vertical spirally inclined cutting edge. The spiral is useful in leading the bit into the formation, and when reversed in rotary action, unscrews itself out of the formation in which it is buried. To increase this drilling mechanism's efficiency and safety in operation, I have placed a hood **92** over the top end of the drill which is connected by bolts shown in Fig. 7 to the upper end member **74**, which is connected to and revolves with the housing **50**. This cutter armoured conical hood, revolving at a high speed has about the same cutting efficiency in digging out as the lower cutting face has in digging in. In order to be in practical use where a follow up casing or cribbing is placed, while the hole is being made, I have applied under reamers **82** of flexible design, and turning and expanding freely in its ball joint **86** under centrifugal action of the drill proper. Plug **87** forms the top bearing face for the ball joint **86** and keeping it in place while in action. To replace the under reamers, remove the screw plug, **87**, and lift the reamer out, a channel **89** being cut to allow the passage of the connecting neck Fig. 4.

What I claim is:

1. A rotary excavator, comprising, a tubular shell or housing, a stationary drill-stem extending longitudinally within said housing, an armature mounted upon said drill-stem, field coils detachably mounted within and on said housing, said housing being armed with cutting bits on its outer surface.

2. A rotary bit embodying a tubular housing tapering at its lower end and terminating in a substantially pointed form, a hollow shaft projecting into said housing through its upper end and extending coaxially therewith to a point removed from the first mentioned end, said housing being rotatably mounted on said shaft, electric motor means within said housing for rotating said housing upon said shaft wherein the stationary coils of said motor are mounted upon said shaft and the moving coils are mounted upon the interior walls of said housing, a plurality of spaced cutting elements mounted on the outer wall of said housing and extending spirally from end to end thereof, said cutting elements having inner passageways for conveying water to the point of said housing, said shaft having a passageway discharging at both ends thereof, another passageway in said shaft communicating with the first mentioned passageway in the shaft at its lower end and connecting with the passageways in the aforesaid cutting elements at a point near the upper end of the housing.

3. A rotary bit comprising, a tubular housing having a tapered earth penetrating lower end, a stationary shaft extending through the upper end and lengthwise thereof, said housing being rotatably mounted upon said shaft, electric motor means within the same for rotating said housing upon said shaft, including stationary mounted coils upon said shaft and moving coils

mounted on interior portions of said shell, spiral rib cutting members upon the exterior wall of said housing and extending from end to end thereof, and passageways in said ribs for conducting flushing fluid to the lower end of said bit.

4. A rotary bit comprising, a cylindrical boring member having a tapering earth penetrating lower end and provided with spiral cutting ribs on the outer face thereof, said member being rotatable upon its axis, a stem stationary relative to the rotative movement of the aforesaid member and constituting a support therefor, said stem extending coaxially into the interior of said cylindrical member, and power means within said cylindrical member secured to said stem and engaging said cylindrical member to rotate the same about said stem.

5. In the invention as set forth, a tubular stem, a bit formed with cooling ducts rotatably mounted upon said stem, and means within the bit for rotating it with regard to said stem, wherein the cooling ducts in said rotatably mounted bit communicate with the bore of said tubular stem.

6. A rotary bit comprising a tubular casing rotatably disposed about the stationary tubular stem, said tubular casing being filled with a lubricating fluid, means within the casing for imparting rotation to the casing, a plurality of cutting elements spirally disposed about said casing, said cutting elements having passageways therethrough, communicating means disposed between said tubular stem and said passageways of the cutting elements for circulating a flushing fluid, means disposed adjacent the lower end of the tubular casing for equalizing the pressure between the lubricating fluid within the casing and the flushing fluid without the casing, and a plurality of centrifugally expanding hubbed cutters disposed adjacent the upper end of the casing.

HARVEY D. SANDSTONE.