March 5, 1957 G. F. CARLE ET AL 2,783,971

APPARATUS FOR EARTH BORING WITH PRESSURIZED AIR

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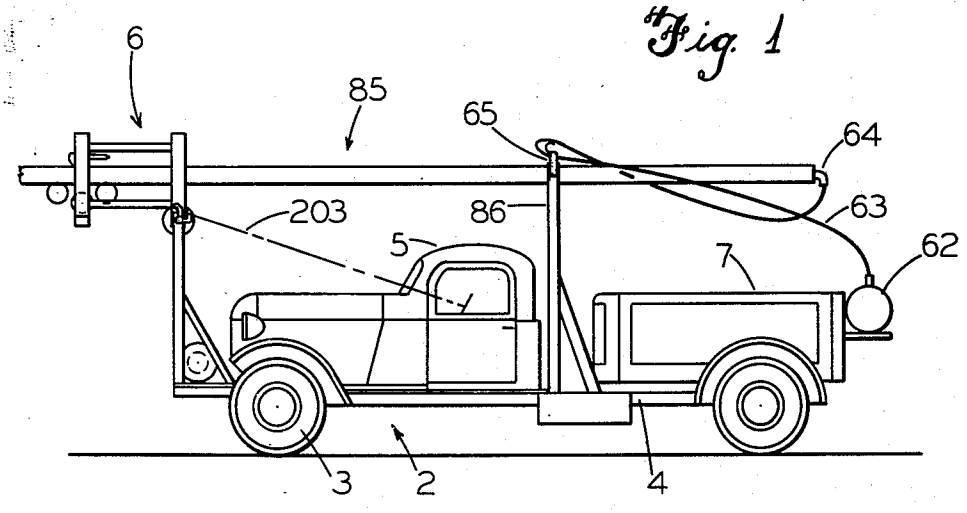
Fig. 1



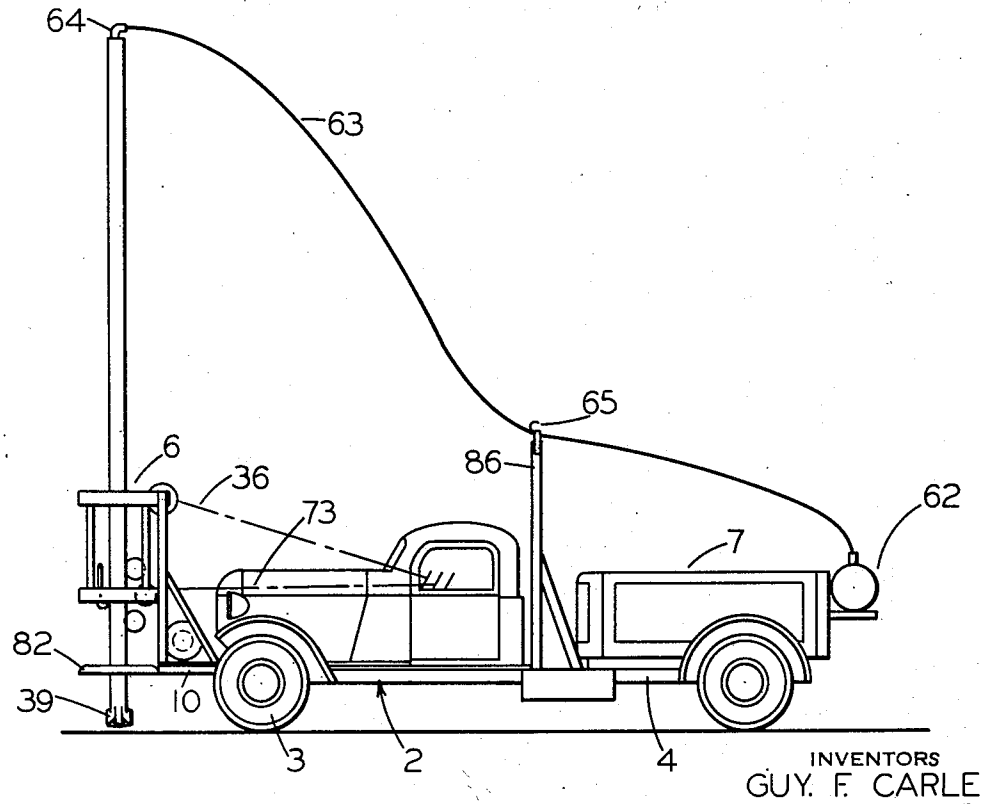


Fig. 2

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APPARATUS FOR EARTH BORING WITH PRESSURIZED AIR

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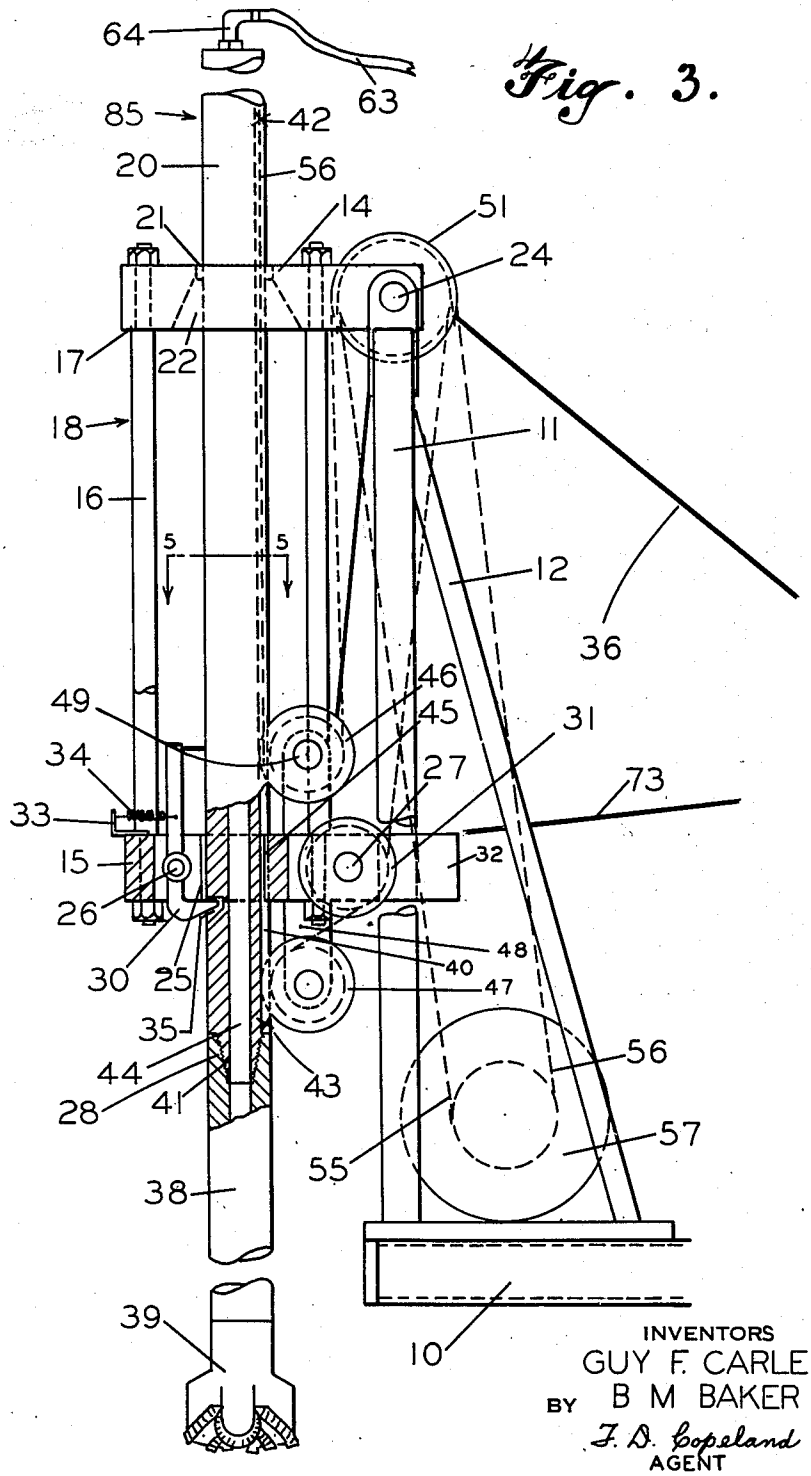
Fig. 3.



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APPARATUS FOR EARTH BORING WITH PRESSURIZED AIR

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Fig. 4.

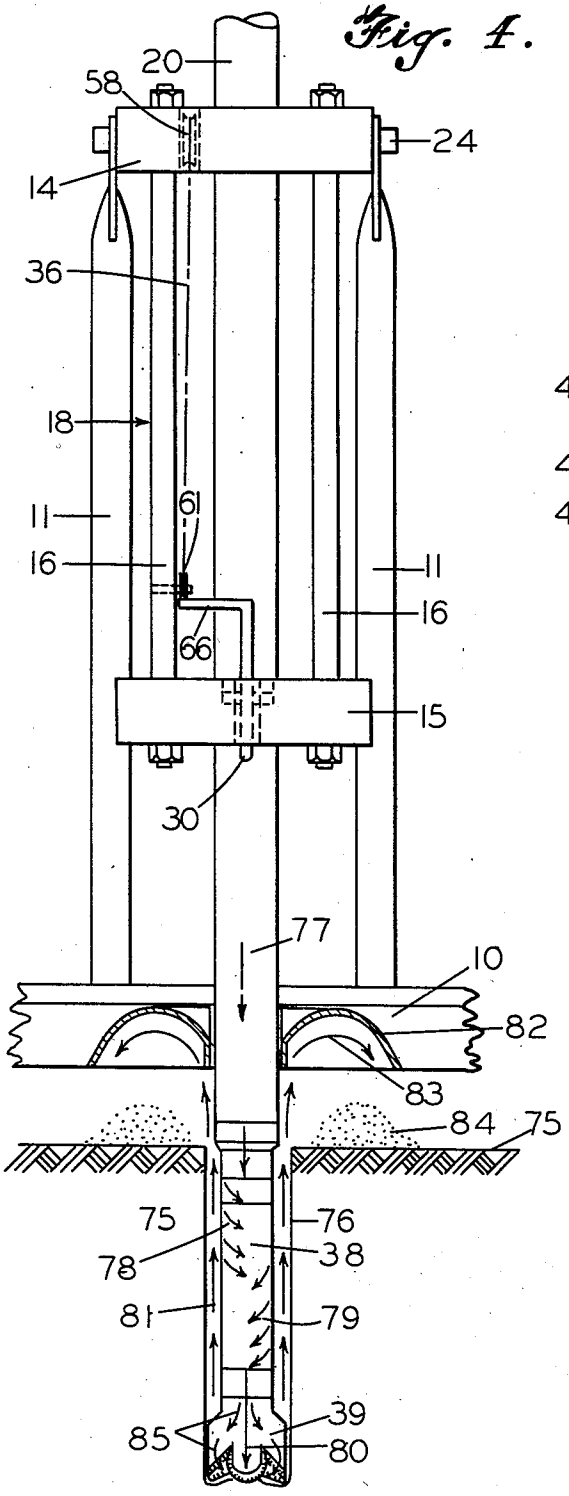
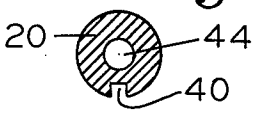


Fig. 5.



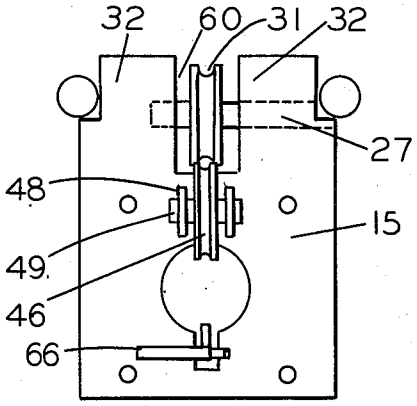


Fig. 6.

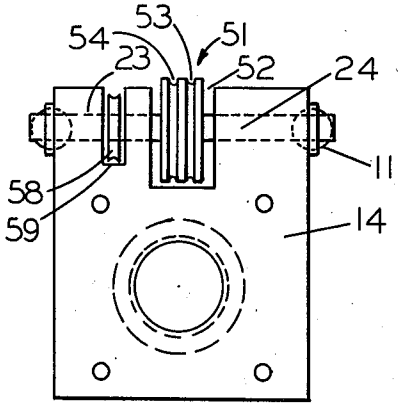


Fig. 7.

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APPARATUS FOR EARTH BORING WITH PRESSURIZED AIR

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Fig. 9.

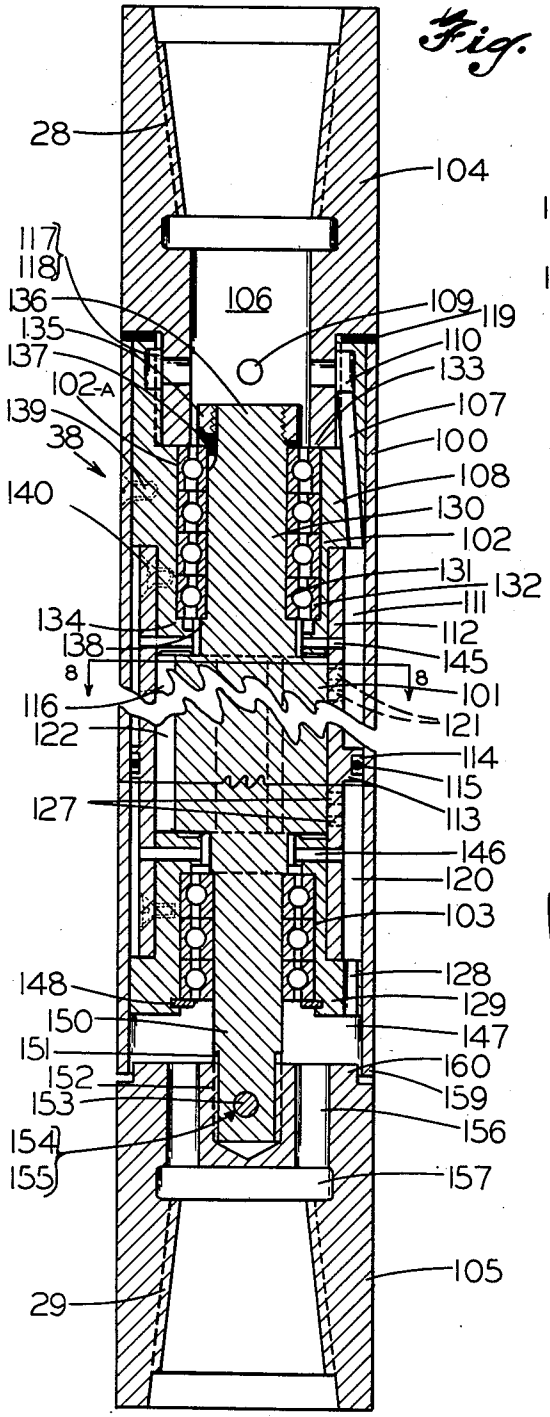


Fig. 8.

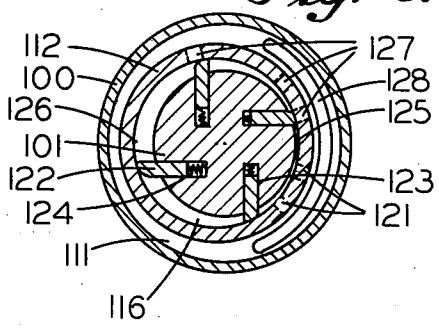
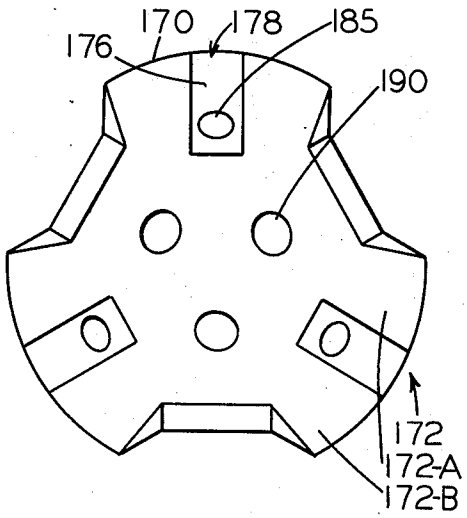


Fig. 11.



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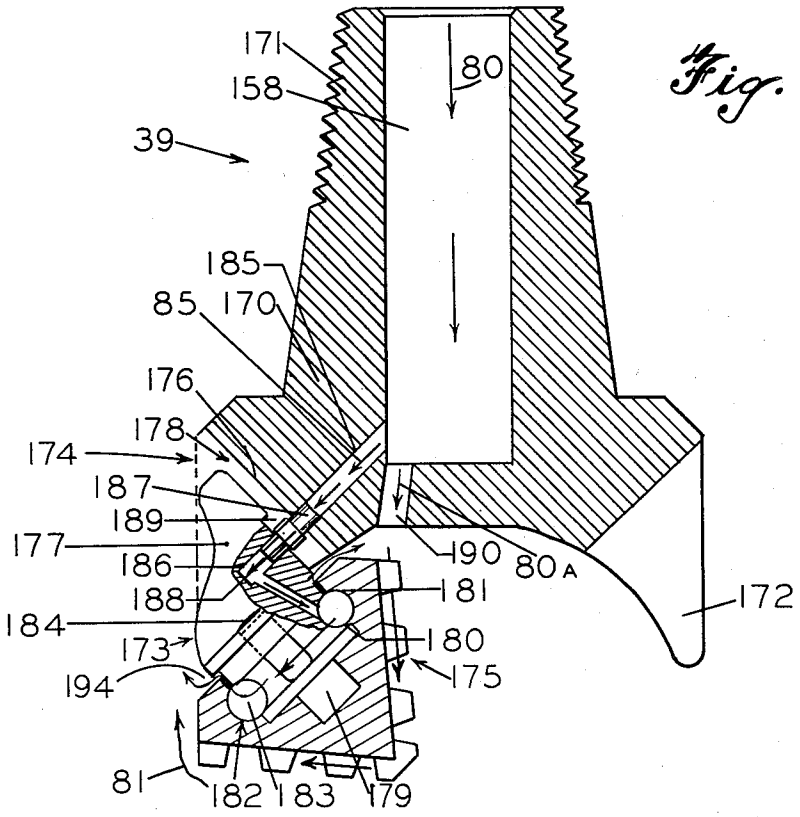

Fig. 10.

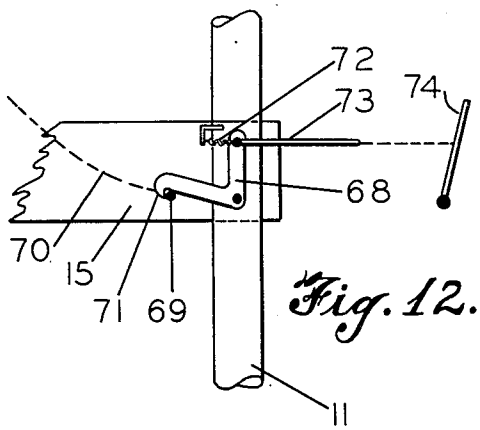

Fig. 12.

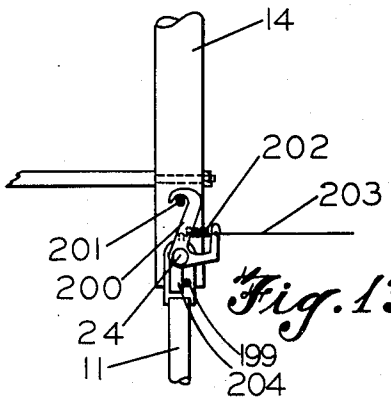

Fig. 13.

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APPARATUS FOR EARTH BORING WITH PRESSURIZED AIR

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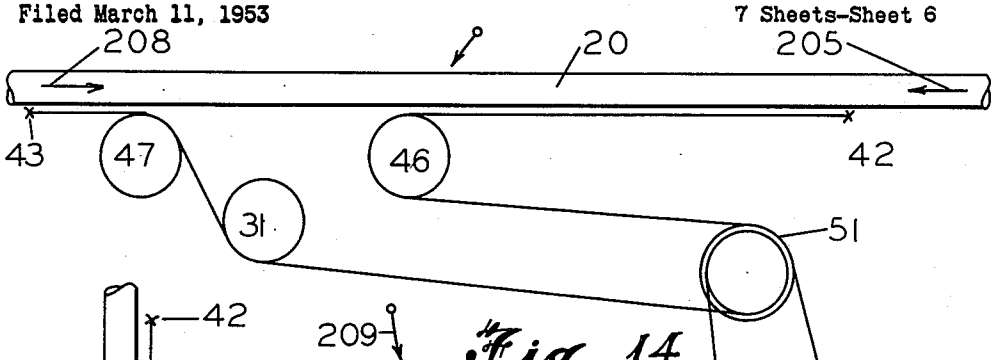

Fig 14.

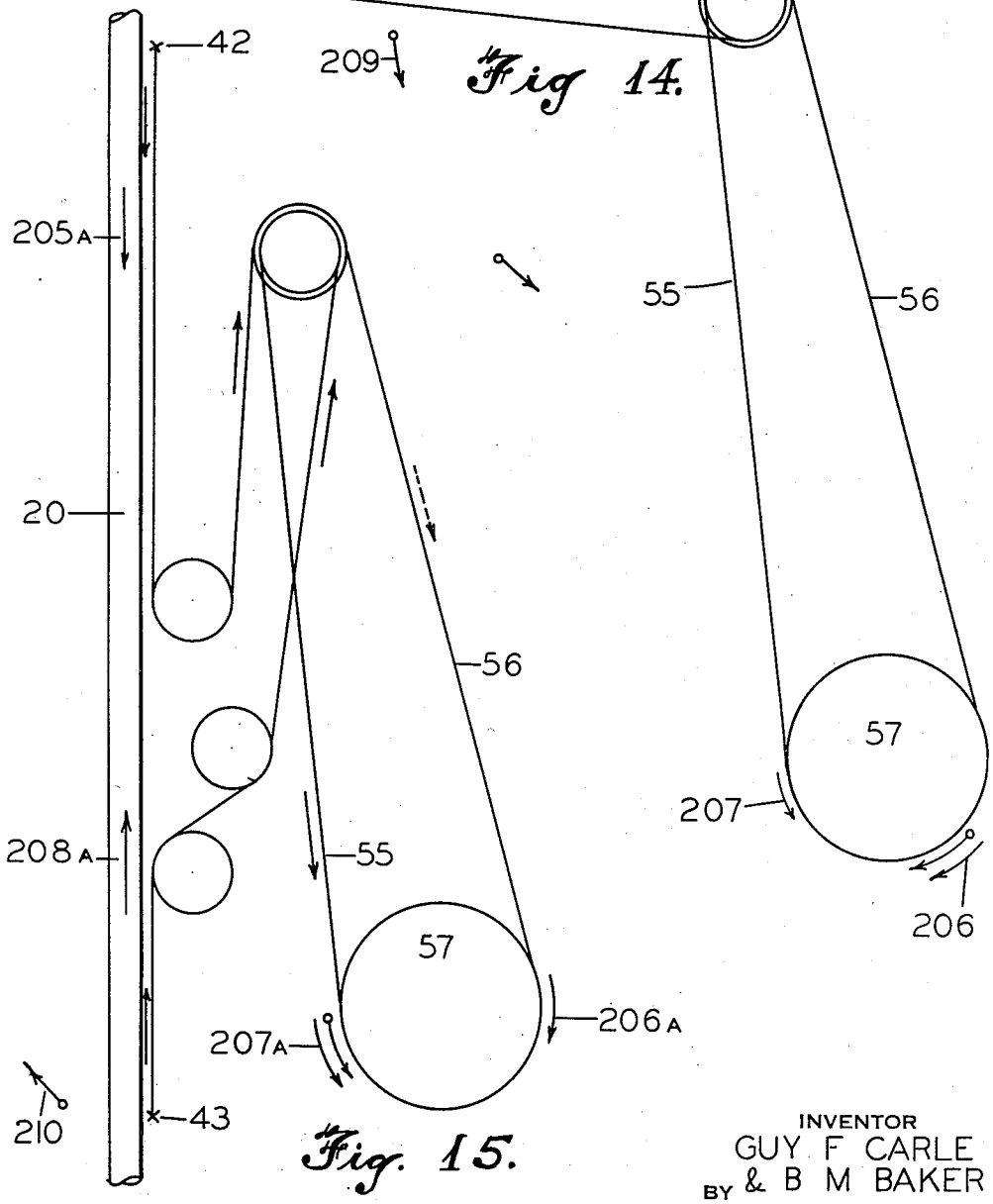

Fig. 15.

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APPARATUS FOR EARTH BORING WITH PRESSURIZED AIR

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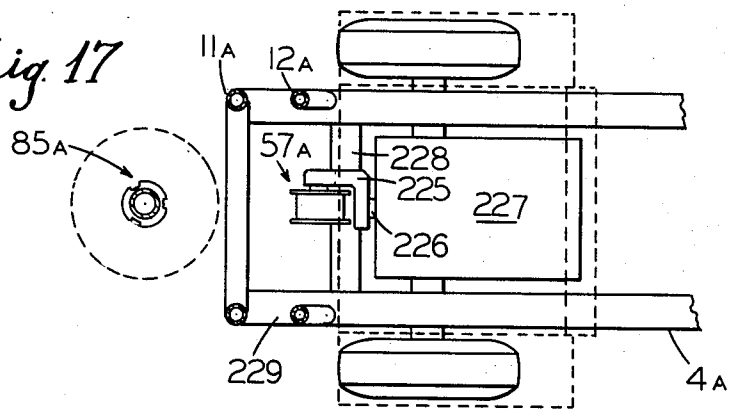
Fig 17



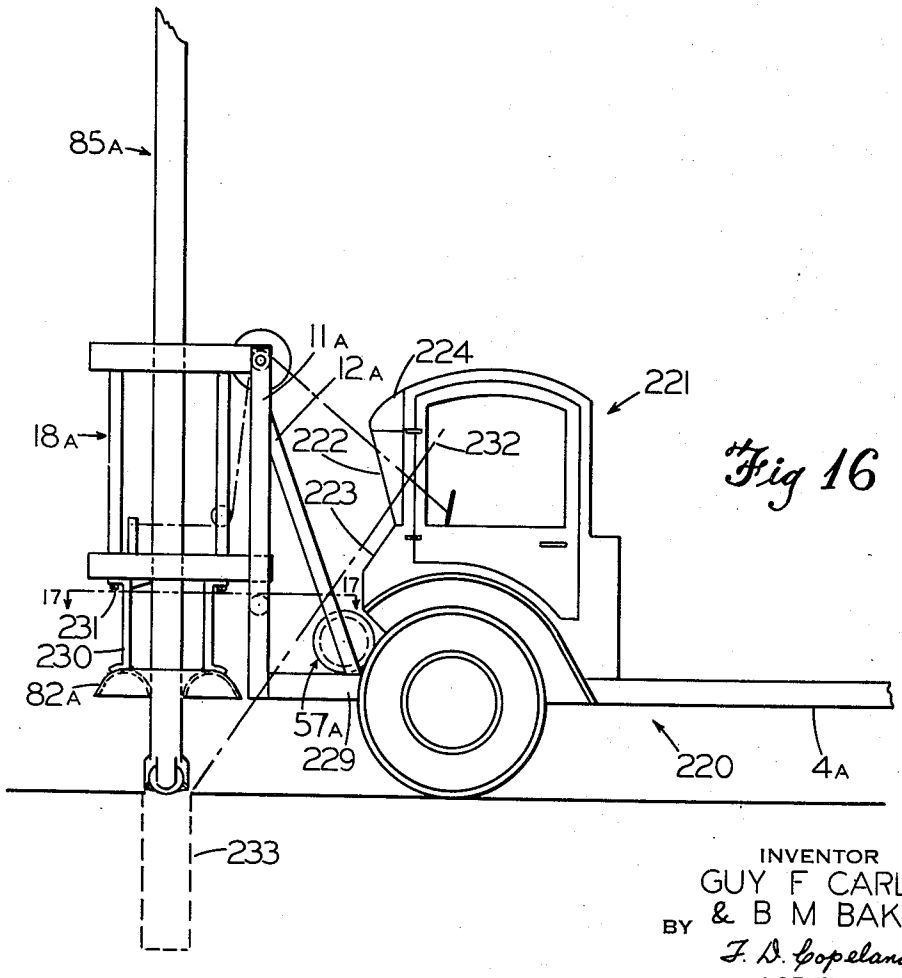


Fig 16

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APPARATUS FOR EARTH BORING WITH PRESSURIZED AIR

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Application March 11, 1953, Serial No. 341,742

1 Claim. (Cl. 255—4)

This invention relates to the art of earth boring and more particularly to drilling holes through dirt, rock or other formations for water wells, oil exploration work, and holes for blasting, either vertical or horizontal, or for other purposes.

The primary object of this invention is to provide a rotary method and apparatus for earth boring which utilizes pressurized air to rotate the drill bit in the hole by an air motor located near the bottom of the hole adjacent the drill.

Another object is to provide a method and apparatus for drilling holes wherein pressurized air is utilized to rotate the drill bit, cool the bearings, and flush cut material from the bottom of the hole.

A still further object of this invention is to provide a relatively long tubular air motor for use in drilling bore holes whereby the air motor is directly inserted in and becomes a part of the string of drill pipe.

Yet another object is to provide a longitudinal air motor for rotary drilling which receives its air supply axially through the drill string at one longitudinal end and after expanding a portion of the energy in the air expells it through the other end in a rarified and cooled condition for cooling the drill bit spindle bearings; the initial pressure of the air being such that sufficient pressure remains after turning the air motor to carry cuttings back up the bore hole to the surface.

A still further object is to provide a method and apparatus of drilling holes which is truck mounted and wherein the driver may remain in the truck and proceed to the location and drill one or more holes as required in oil exploration work without ever getting out of the cab.

Other objects and advantages of the invention will become apparent from the following description, and for the purposes of illustration, but not of limitation, an embodiment of the invention is shown in the accompanying drawings in which:

Fig. 1 represents a side elevational view of the complete mobile drilling rig of this invention with the drilling unit in transport and/or horizontal drilling position.

Fig. 2 represents a side elevational view of the mobile drilling rig with the drilling unit in a vertical position preparatory to commencing the drilling operation.

Fig. 3 represents a side elevational view, partially in section of the drilling unit with the drill stem in its raised and locked position.

Fig. 4 is a front elevational view of the drilling unit shown in Fig. 3 except here the drill stem is in its operating position.

Fig. 5 is a cross section of the drill stem taken about the line 5—5 of Fig. 3.

Fig. 6 is a detail plan view of the bottom plate of the drill cage shown in Fig. 3.

Fig. 7 is a detail plan view of the top plate of the drill cage shown in Fig. 3.

Fig. 8 is a cross sectional view of the drill motor taken along the line 8—8 of Fig. 9.

Fig. 9 is a sectional elevational view of the drill motor of this invention.

Fig. 10 is a sectional elevational view of the drill bit detached from the drill motor.

Fig. 11 is a bottom view of the drill bit of Fig. 10, but with cutters and spindles removed.

Fig. 12 is a detail fragmentary view of the bottom plate and rear uprights showing the hold down lock of the drill cage.

Fig. 13 is a detail fragmentary view of the top plate and rear uprights showing the up position lock of the drill cage.

Fig. 14 is a diagrammatic view of the cable reeving and movements involved when lowering the drill cage from the position shown in Fig. 1, and in moving the drill stem horizontally.

Fig. 15 is a diagrammatic view of the cable reeving and movements involved in raising the drill cage from the position shown in Fig. 2, and in moving the drill stem vertically.

Fig. 16 is a fragmentary elevational view of a drilling rig of this invention employing a special cab.

Fig. 17 is a fragmentary plan view of the rig shown in Fig. 16 in partial section about the line 17—17.

Referring now more particularly to the characters of reference on the drawing, the complete mobile drilling rig of this invention is seen in Figs. 1 and 2 to consist basically of a conventional truck chassis 2 including at least four wheels 3, a frame 4 and cab 5; and a drilling unit 6 attached to the frame ahead of the cab 5, and an air compressor 7 mounted at the rear of the cab and separately powered or driven by a power take-off (not shown) from the truck engine, if desired.

The drilling unit 6 is supported from a platform 10 which is rigidly attached to the frame 4 and includes vertical members 11 and braces 12 as seen in Fig. 3. Top and bottom plates 14 and 15 are connected by bolts 16 which include shoulders 17 whereby the plates and bolts form a sturdy rigid cage 18 for guiding and supporting the non-rotatable drill pipe 20 as will be shown. Top plate 14 includes a vertical bore 21 with a tapered section 22 for reception of and guiding for drill pipe 20, and a horizontal bore 23 for insertion of pivot pin 24. Bottom plate 15 includes a vertical bore 25 for passage of the drill stem and includes horizontal pins 26 and 27 on which are mounted latch 30 and sheave 31 respectively. Plate 15 also includes lips 32 which guide plate 15 by vertical members 11 and prevent sidewise lateral movement of drill cage 18 when the unit is in vertical operation. A bracket 33 attaches to plate 15 adjacent latch 30, and spring 34 urges latch 30 into engagement with notch 35 of non-rotatable drill pipe 20 when the latter is in its raised and locked position (Fig. 3). Latch 30 may be released by a pull on line 36 from a lever 37 in the cab 5. Drill pipe 20 includes a groove 40 which acts as a combination cable guide and keyway, and the lower end of this stem terminates in a threaded pin 41 for connection with threads 28 of drill motor 38, which is attached by threads 29 to drill bit 39. Near the upper and lower ends of the drill stem are cable anchors 42 and 43 respectively, and a central bore 44 provides an air passage through the stem. Lower plate 15 includes an inward projecting key 45 which cooperates with groove 40, as do sheaves 46 and 47 supported from plate 15 by vertical arms 48 and pins 49. Sheave 51 is mounted in cut-out 52 centrally of top plate 14 and includes two grooves 53 and 54 receive lift and lower cable leads 55 and 56 respectively which are oppositely wound on power winch 57. Line pulley 58 is also journalled to shaft 24 and is located in cut-out 59 of top plate 14. Sheave 31 is located in cut-out 60 of plate 15 and is journalled on shaft 27 which is inserted partially through plate 15. Referring to Figs. 5, 6, and 7,

the relationship between the sheaves and their supporting plates may be seen.

By reference to Fig. 4 the operation of line 36 in releasing latch 30 may be observed. A second line pulley 61 is supported from vertical bolt 16 at a position whereby line 36 passing thereover will be substantially horizontal relative to the offset arm 66 of latch 30. Since the center line of pulley 58 coincides with the centerline of the pivoting action of cage 18, no allowance is required for extension of line 36 to allow for increased length when cage 18 is in its raised position.

The compressor 7 includes an air storage bottle 62 which connects by way of flexible hose 63 to air fitting 64 at the top of drill pipe 20. Hose 63 is supported intermediate its length by bracket 65.

Winch 57 is powered from the truck engine by any convenient means such as chain drive, power take-off, or electric motor. Cable lead 55 is wrapped counterclockwise (when viewed in Fig. 3), and acts to lift drill stem 20, by means of the following reeving: cable 55 passes upwardly from winch 56 to and around one groove 53 of sheave 51 and down and around sheave 31 and over sheave 47 to anchor 43 at the lower end of the nonrotary drill pipe 20. Cable lead 56 is wrapped clockwise about winch 57, and this lead may be used to apply down pressure to drill bit 39 through the following reeving: cable 56 passes up and over a second groove 54 of sheave 51 from winch 57 and thence down and about sheave 46 and upward to anchor 42 near the top of drill pipe 20.

When drill cage 18 and pipe 20 are in the vertical or drilling position a spring actuated hold down lock 68 engages a lug 69 on bottom plate 15 to keep the drilling unit 6 rigid relative to truck 2. Fig. 12 shows the path 70 which lug 69 follows when cage 18 is lowered to its vertical position. When lug 69 strikes the tapered surface 71 it extends spring 72 and raises lock 68 sufficiently to permit lug 69 to pass by surface 71 and to the position shown, whereat spring 72 retracts lock 68 to grasp lug 69 and hold plate 15 securely to upright 11. Line 73 leads from the top of lock 68 to lever 74 inside the cab 5 to permit release of lock 68 prior to raising cage 18 to travel position.

Operation

When a drill site is selected, the operator may drive truck 2 toward the selected site with attached drilling unit 6 in travelling position as shown in Fig. 1. Upon arrival at the drill site, the drilling unit 6 is lowered to the postion shown in Fig. 2, by rotating the winch 57 in clockwise direction. Since latch 30 is closed when the unit 6 is in travelling position, a downward pull applied by cable 56 to anchor 42 will not pull drill pipe 20 down but rather will cause the entire unit 6 to rotate about pivot 24 until it reaches its vertical position at which point cage lock 68 automatically engages lug 69 to hold cage 18 in rigid vertical position during drilling.

With the truck 2 braked in position shown in Fig. 2, the air compressor 7 is placed in operation to supply pressurized air to bottle 62 and the through line 63 and fitting 64 to the central bore 44 running through stationary drill pipe 20 to drill motor 38 and drill bit 29 which the pressurized air rotates in a manner to be hereinafter described. With the motor and bit thus rotating the operator moves lever 36 to release latch 30 and then rotates winch 57 in a clockwise direction to apply a downward pull on pipe 20 through cable 56 and anchor 42. Drill bit 39 will commence to dig when it contacts the surface of the earth 75 and will continue to dig downward due to the down pressure exerted by winch 57 and the weight of drill pipe 20 until a hole 76 of the desired depth has been excavated. The pressurized air represented by broken arrow 77 of Fig. 4 enters the pressure side of the drill motor 38 as indicated by arrows 78 and after performing work passes through the exhaust side of the drill motor as indicated by arrows 79. The now cool and expanded air indicated by arrow 80 passes axially through bit 39 to blast out cuttings in the bottom of the hole and return upward (arrows 81) carrying the cuttings with it until they strike deflector 82 which causes the cuttings to follow the curvature of the deflector in the path shown by arrow 83 and build up at pile 84. At the point where air as represented by arrow 80 passes downward through the drill bit 39 for flushing purposes, other paths are provided for air streams as represented by arrows 85 to cool the bearings of bit 39 with the now expanded and cooled air stream. Additionally the bearings may be lubricated as well as cooled by the addition of an atomized spray or drops of oil into the air stream. When the hole 76 has reached the desired depth, the operator shuts off the air supply and engages a control (not shown) in cab 5 to rotate winch 57 in a counter-clockwise direction to reel in cable 55 and thus apply a lifting force through anchor 43 to drill pipe 20 to raise the entire drill stem 85 out of the hole 46 to a height sufficient to permit latch 30 to engage notch 35 and lock the drill stem 85 in its up position. At this point the complete mobile drill rig may be moved to adjacent drill sites and the drilling operation may begin again. If, however, there is no further drilling in the immediate area, then the lock 68 is released by the operator by a pull on lever 74 and line 73, so that continued rotation of winch 57 will raise cage 18 and drill stem 85 until the drill pipe 20 rests in support 86 as seen in Fig. 1 and schematically in Fig. 12. The rig is now in its travelling condition and may proceed to drill sites in a different and distant area if desired.

Referring now to Figs. 8–10 a functional description of the air motor and drill bit may be seen. The air motor 38 consists basically of a cylindrical tube 100 enclosing a longitudinal rotor 101 of a substantial length supported within the tube by upper and lower bearings 102 and 103 respectively; upper and lower ends of tube 100 terminate at tubular boxes 104 and 105 which connect to the drill pipe 20. Cavity 106 is connected to an arcuate slot 107 in bearing mount 108 through holes 109 and circular passage 110 which slot delivers pressurized air to annular intake chamber 111. Bearing mount 108 includes threads 117 which engage threads 118 of box 104 which are tightened to compress fabric shim 119 to provide an air seal between the mount and box at engagement. A generally cylindrical shell 112 extends longitudinally but not concentrically through the tube 100 beyond the active length of rotor 101. Intermediate its length shell 112 includes a circumferential projection 113 including a groove 114 for reception of an O ring 115. It should be noted that shell 112 is offset from the center of rotor 101 to provide an eccentric rotor chamber 116 and offset from tube 100 so as to provide a relatively large annular section for intake chamber 111 on one side of tube 100, and a very small annular section at the opposite side. Similarly projection 113 is offset relative to shell 110 so that it completely fills the annular chamber 111 and O ring 115 and seals the lower end of the intake chamber 111 and provides a second longitudinal annular chamber which becomes the exhaust chamber 120. Adjacent the large section of the intake chamber 111, shell 112 is drilled with a series of holes or ports 121. Rotor 101, being offset radially in shell 112, touches the shell at point 125 just to one side of ports 121. Blades 122 are spring loaded within slots 123 by compression springs 124 so that they expand from their minimum volume position at the point 125 of rotor and shell contact to their maximum volume position at point 126. When pressurized air enters ports 121 it expands and forces blade 122 and rotor 101 in a clockwise direction until the blade 122 passes point 126, after which blade 122 forces the air ahead out exhaust ports 127 and through exhaust slot 128 in bearing mount 129 at the

lower end of air motor 38. The upper end of a rotor 101 is formed as a neck 130 which serves as a mounting for the inner race 131 of bearing 102. The outer race 132 is mounted in annular shaped mount 108. The lower end 133 of box 104 retains the outer race 132 in place by compressing the opposite end of the outer races 132, against a shoulder 134 near the lower end of mount 108. Nut 135 engaging the threaded end 136 of neck 130 together with washer 137 act to retain the inner race 131 of bearings 102 by binding the same again against a shoulder 138 on neck 130. Bearing mount 108 is secured to tube 100 by means of taper head screws 139 and to shell 112 by taper head screws 140, all screws being countersunk in their attaching parts. Washer 137 is a lock type device which prevents nut 135 from working loose and permits the nut and rotor 101 to rotate simultaneously with inner bearing race 131. The top bearing 102–A is exposed to the incoming blast of air from cavity 106 and consequently permits passage of air vertically down through all the top bearings 102 and through radial passages 145 to intake chamber 111 thereby providing a means for cooling the bearings. The lower bearings are cooled similarly by a jet of air entering through radial passage 146 in shell 112 and mount 129. The lower end of bearings 103 is open to channel 147 and these bearings are held in place by retaining ring 148. Neck 150 projecting from the lower end of rotor 101 is splined as at 151 and engages matching spline 152 in lower box 105 to impart rotary motion to box 105 and attached drill bit 39. A pin 153 passes through aligned holes 154 and 155 in the neck 150 and box 105 respectively to secure the drill motor 38 and drill bit 39 against relative axial movement. Longitudinal passages 156 connect channel 147 to cavity 157 which opens directly into the central opening 158 of drill bit 39. The lower rim 159 of tube 100 overlaps undercut 160 of box 105 to provide a relatively air tight rotary seal between tube 100 and box 105.

Referring to Fig. 10 the construction and operation of the drill bit per se may be observed. The complete bit 39 is seen to consist basically of a shank 170 including a tapered threaded pin 171 and three forks 172 each including a spindle 173 which is welded thereto as at 174, and a cutter cone 175 journalled thereto. Tines 172–A and 172–B of forks 172 are connected by a flat land 176 and together therewith form a cavity 178 for reception of lip 177 of spindle 173. Spindle shaft 179 includes a race 180 which together with cooperating race 181 defines a raceway 182 for reception of balls 183 which are loaded at assembly through loading track 184. Since this is an air course bit, certain channels are necessary therethrough to introduce air to raceway 182; a channel 185 is drilled in shank 170 and at an angle to central opening 158 and in alignment with channel 186 in spindle 173 which leads to raceway 182. In order to prevent leakage of air between surfaces 176 and 177, a hollow insert 187 having shoulder 188 is placed at assembly in the space 189 between said surfaces. The partially expended air from drill motor 38 after entering cavity 157 enters central opening 158 as indicated at arrow 80. As the air stream passes channel 185 a portion of the air (arrow 85) enters the channel and passes through insert 187 and channel 186 to raceway 182, and after passing around the raceway and balls 183 it passes through clearance 194 between the spindle 173 and cutter 175 to rejoin the air stream 81 going back up the hole 76 to carry the cuttings to the surface. A particular advantage in using the partially expanded exhaust air 80 of air motor 38 to cool air motor bearings 103 and drill bit bearings 183 is that compressed air cools rapidly upon expansion and is much cooler than ambient air and therefore capable of carrying away more heat from the bearings than would be possible using atmospheric air or compressed air.

In Fig. 14 a detailed schematic sequence of cable operation may be observed. Drill pipe 20 and consequently drill cage 18 are shown in a horizontal position, and ordinarily the tension on cable 55 is sufficient to keep the pipe in this position. However, if horizontal drilling, as required in some excavation operations, is anticipated, a separate latch 200 is required to maintain this position during drilling. Latch 200 is seen in Fig. 13 to pivot and automatically latch about pin 24 of plate 14, and remain latched under the action of spring 202 until released by a pull on wire 203. Stop 199, acting against the lower arm 204, prevents latch 200 from pivoting about pin 24 and permitting rage 18 to lower accidentally. With latch 200 in place, the drill pipe 20 in Fig. 14 will be moved horizontally forward as shown by arrow 205 upon clockwise rotation (arrow 206) of winch 57, and upon counterclockwise rotation (arrow 207) the drill pipe 20 through its cable reeving will be retracted as shown by arrow 208. Upon release of latch 200, and the engagement of latch 30, the pipe 20 and its cage may be lowered from the horizontal position of Fig. 14 to a vertical position through the arc shown by arrows 209 by a clockwise rotation of winch 57 to the vertical position of Fig. 15. With latch 30 still engaged the pipe 20 may be raised back to its horizontal position through the arc shown by arrows 210 of Fig. 15 upon counterclockwise rotation of winch 57 as represented by arrow 207–A. With latch 30 released and latch 68 engaged the pipe 20 may be raised or lowered relative to its vertical axis by the operation shown diagrammatically in Fig. 15. When winch 57 is rotated clockwise (arrow 206–A) cable 56 is reeled in, and through upper anchor 42 causes pipe 20 to move down (into hole 76) as indicated by arrow 205–A; when winch 57 is rotated counterclockwise (arrow 207–A) cable 55 is reeled in, and through lower anchor 43 raises pipe 20 up (out of hole 76) as indicated by arrow 208–A.

A cab-over type truck shown in Figs. 16 and 17 may be used in place of the conventional truck (Figs. 1 and 2) for further improved operation. The truck chassis represented by numeral 220 includes a special cab 221 with an inwardly inclined windshield 222 and a downwardly tapered front panel 223. A separate upper section 224 of the windshield is tinted to permit increased vision without glare. Winch 57–A is driven by means of gear box 225 which in turn is driven by a power take-off shaft 226 extending forward from engine 227. Gear box 225 is supported by cross piece 228 which is attached to longitudinal runners 229 to become part of the frame 4–A. The cage 18–A is virtually identical to that shown in Fig. 3, and the shield 82–A is shown attached to cage 18–A by means of brackets 230 and capscrews 231. Vertical members 11–A upstand from runners 229 and are reinforced by braces 12–A to form a frame to pivotally support the cage 18–A and drill stem 85–A. Winch 57–A is set as far rearward as possible to provide a clear field of vision as represented by line 232 between the operator and the drill bit 39–A so that the hole 233 to be drilled may be accurately located. The remaining structure of the rig in Figs. 16 and 17 corresponds to that previously described. By using a cab-over type truck and rig it is possible for the operator to drill a series of shallow shot holes in a predetermined pattern for seismic operations without ever having to get out of the cab. This feature is especially advantageous when operating in cold or inclement weather, not only from the standpoint of comfort to the operator but also from the standpoint of increased speed and efficiency of operation.

From the foregoing description it will be readily seen that there has been produced a device and process as substantially fulfills the objects of the invention as set forth herein.

While this specification sets forth in detail the present and preferred construction of this invention, still in practice such deviations from such detail may be resorted

to as do not form a departure from the spirit of the invention as defined in the appended claims.

Having thus described the invention, what is claimed as new and useful and is desired to be secured by Letters Patent is:

A drilling unit comprising: a drill stem, means to support said drill stem for longitudinal movement, a source of pressurized air; said drill stem including a non-rotary drill pipe, a rotary air motor, and a drill bit in close proximity to said motor; a central bore through said drill pipe, means to introduce pressurized air into said bore, an air intake side and air exhaust side on said drill motor, said intake air side adapted to receive pressurized air, said exhaust side adapted to exhaust expanded and cooled air, a vane type rotor extending axially in said air motor attaching to said drill pipe, a stationary upper box on said motor connecting said bore and intake side, a stationary shell extending longitudinally but non-concentrically in surrounding relation to said rotor to form an air chamber therebetween, said vanes cooperating with said shell to form an air tight sliding fit with said shell when moving through said air chamber, a stationary tube extending from said upper box in longitudinal and concentric relation to said rotor, a lower box attached to said rotor for rotation therewith, said stationary tube engaging said lower box in a close sliding fit, a drill bit including bearings attached to said box, cutter cones on said bearings, a central opening extending through said bit to the vicinity of said cutter cones, an air passage longitudinally through said box and connecting said central opening, an air path connecting said central opening and said bearings whereby air is adapted to enter said intake side, rotate said rotor, pass through said air passage and central opening to said cutter cones as expanded and cooled air, a portion of the air passing through said air path to cool said bearings.

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