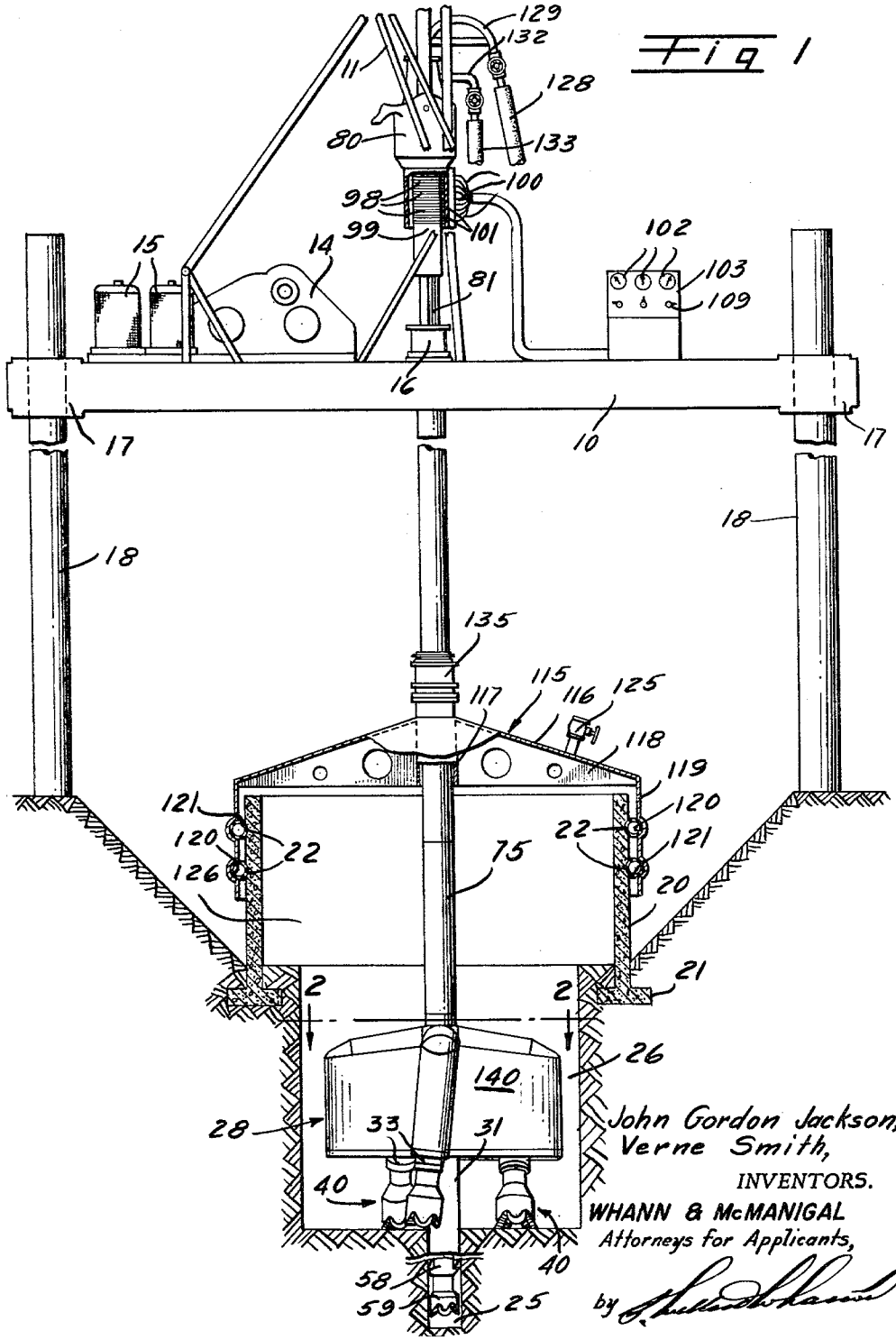
July 20, 1965 J. G. JACKSON ETAL 3,195,661

LARGE BORE HOLE DRILLING APPARATUS

Filed Oct. 15, 1959 3 Sheets-Sheet 1

Fig 1



John Gordon Jackson,
Verne Smith,
INVENTORS.

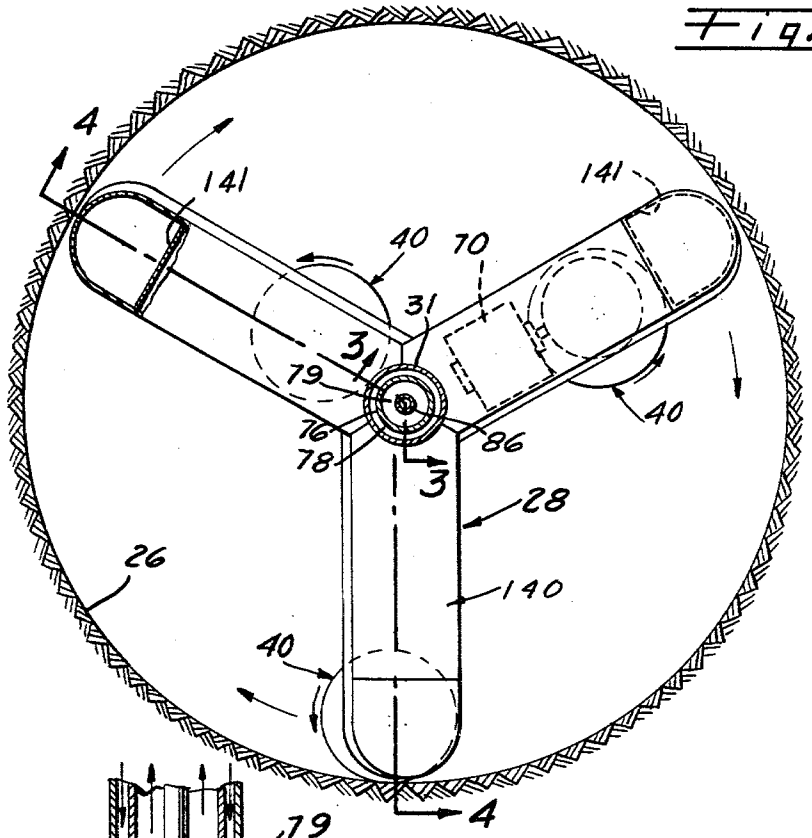
WHANN & McMANIGAL
Attorneys for Applicants,
by

July 20, 1965 J. G. JACKSON ETAL 3,195,661

LARGE BORE HOLE DRILLING APPARATUS

Filed Oct. 15, 1959 3 Sheets-Sheet 2

Fig. 2.



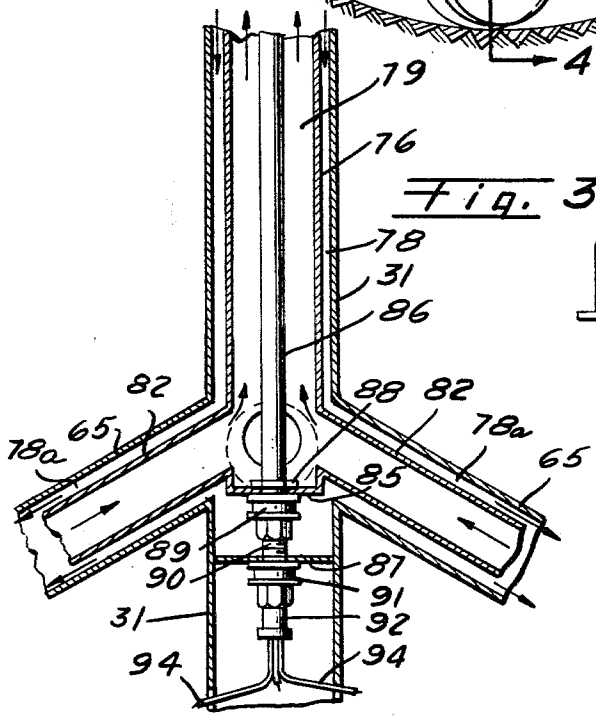


Fig. 3.

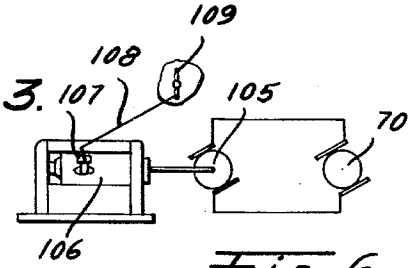


Fig. 6.

John Gordon Jackson,
Verne Smith,
INVENTORS.

WHANN & McMANIGAL
Attorneys for Applicants,

by

July 20, 1965 J. G. JACKSON ETAL 3,195,661

LARGE BORE HOLE DRILLING APPARATUS

Filed Oct. 15, 1959 3 Sheets-Sheet 3

Fig. 4.

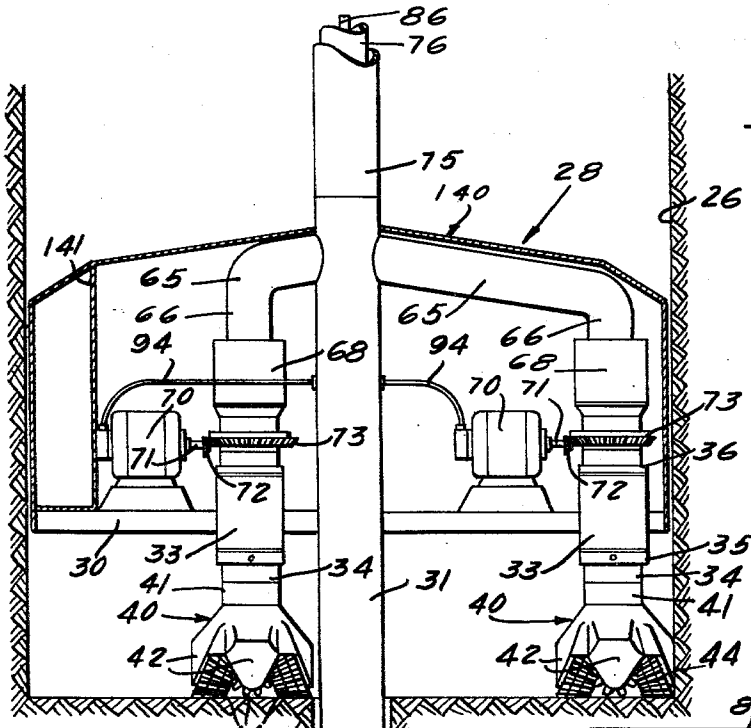
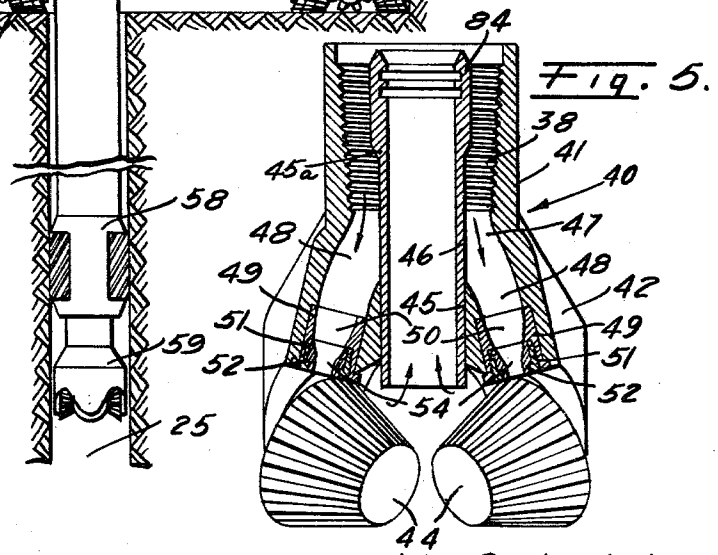


Fig. 5.



John Gordon Jackson,
Verne Smith,
INVENTORS

WHANN & McMANIGAL
Attorneys for Applicants,

by

United States Patent Office 3,195,661 Patented July 20, 1965

3,195,661

LARGE BORE HOLE DRILLING APPARATUS

John Gordon Jackson, Denver, Colo., and Verne Smith, Corona Del Mar, Calif., assignors to Gas Drilling Services Co., Denver, Colo., a co-partnership

Filed Oct. 15, 1959, Ser. No. 846,718
10 Claims. (Cl. 175—95)

This invention relates to the art of drilling bore holes into the earth and relates more particularly to apparatus for drilling such bore holes.

There is an increasing demand for large bore holes to provide large diameter wells or large diameter pits which may be used for underground storage, such as for silage, or pits that may be used as cyclone cellars. The diameter of such bore holes may be as great as 20 feet or even greater.

The drilling or boring of such large diameter bore holes into the earth presents numerous problems and difficulties. For example, removal of cuttings from said bore holes as drilling operations proceed presents an extremely difficult problem.

It is therefore an object of the present invention to provide apparatus for drilling large bore holes into the earth which will solve the problems encountered.

It is another object of the invention to provide apparatus of this character having a plurality of independently rotatable drilling bits having annular paths which overlap each other to cut the desired large diameter bore hole.

It is still another object of the invention to provide apparatus of this character wherein the drilling bits have a milling action and can be moved in circular paths while cutting downward.

A still further object of the invention is to provide apparatus of this character for effecting uniform action of the various bits.

Another object of the invention is to provide means whereby there is extremely high lifting efficiency for carrying away the cuttings in the drilling of large bore holes and the like.

Still another object of the invention is to provide means for carrying the cuttings away without their escaping past the bits into the outer annulus.

A further object of the invention is to provide apparatus for pressurizing the bore hole.

A still further object of the invention is to provide means whereby the bits may be raised for replacement, repair, or the like.

Another object of the invention is to provide apparatus of this character adapted to prevent clogging or sticking of the drilling bits.

Still another object of the invention is to provide apparatus of this character for guiding the rotating parts of the equipment, including the drilling bits.

It is a further object of the invention to provide apparatus of this character by means of which large diameter holes may be rapidly and economically bored into the earth.

A still further object of the invention is to provide apparatus of this character that may be readily transported to a drilling site and capable of ready assembly at said site.

The characteristics and advantages of the invention are further sufficiently referred to in connection with the following detailed description of the accompanying drawings which represent one arrangement. After considering this example, skilled persons will understand that variations may be made without departing from the principles disclosed, and we contemplate the employment of any steps, structures, arrangements, or modes of operation that are properly within the scope of the appended claims.

Referring to the drawings:

FIG. 1 is a side elevational view partly in section of apparatus embodying the present invention;

FIG. 2 is an enlarged sectional view of the drilling unit taken on line 2—2 of FIG. 1, providing a plane view of said unit, there being a portion broken away to show one of the ballast tanks;

FIG. 3 is an enlarged section view taken on line 3—3 of FIG. 2;

FIG. 4 is a sectional view taken on line 4—4 of FIG. 2;

FIG. 5 is an enlarged longitudinal section through one of the drilling bits of the dralling unit; and

FIG. 6 is a diagrammatic view of the power and control system of the motor of one of the drilling bits of the drilling unit.

Referring more particularly to FIG. 1, there is diagrammatically shown a platform 10 comprising the rig floor, on which a derrick 11 is mounted, said derrick being of any well known suitable type. The other equipment required in the drilling of wells is mounted on the platform of rig floor 10. This equipment is of well known character and includes a drawworks 14 with its engines 15. There is also a rotary table 16 of the usual well known character.

At the corners of the platform 10 are pneumatic jacking units 17 of well known character, said jacking units having vertical openings therethrough for slidable reception of support columns 18, which are of steel and are of well known character, said columns extending in the usual manner into the formation to be thereby supported.

Below the platform 10 and in axial alignment with the opening through the rotary table 16, there is a conductor pipe 20 of larger diameter than the diameter of the bore hole to be drilled. Conductor pipe 20 may be of any suitable material, but is shown as being of reinforced concrete, said pipe being cylindrical in shape and being provided at the bottom with an annular footing 21 of sufficient width to properly support said conductor pipe, the footing being disposed beneath the surface of the formation, as best shown in FIG. 1. It is to be understood, of course, that the footing may be disposed in any suitable manner to provide proper support for the conductor pipe. The upper portion of the conductor pipe is provided with a pair of annular recesses 22, which extend about said pipe, and which are arcuate in cross-section. Any suitable number of such grooves may be provided, the purpose of said grooves being described hereinafter.

A pilot hole 25 is then drilled into the formation to the desired depth, which would be somewhat deeper than the depth to which the large diameter bore hole is to be drilled. By way of example, the pilot hole 25 may be 2½ feet in diameter, and is drilled with the usual well known drilling equipment for drilling holes of such size, a single bit being used.

The large diameter bore hole 26 is drilled with a multiple bit drilling unit, indicated generally at 28. This large diameter hole may be twenty (20) feet or more in diameter.

Unit 28 may have any suitable number of bits but the arrangement shown has three. There is, therefore, a three-armed base plate 30, although the plate 30 may be of other character. The arms of said plate meet at the center and there is an axial opening for reception of an axial pipe 31 to which said arms are suitably secured, as by welding, or the like. Pipe 31 is coaxial with the pilot hole 25 and in alignment with the opening in the rotary table 16.

Each arm of the plate 30 is provided with an opening in which is secured, by welding or the like, a thrust bearing 33. The bearings 33 are spaced at different distances from the axial center of the plate 30, and in each bearing is operably mounted a hollow shaft 34 adapted to

rotate within said bearing. Collars 35 and 36 are disposed on and secured to the shaft 34 at the lower and upper ends of the respective bearing 33 and said shaft is provided with external threads at the lower end for threadable reception in the internally threaded box 38 of a bit, indicated generally at 40.

The body 41 of the bit 40 has the usual arms 42 at the lower end thereof operably carrying the rotatable cutters 44. The lower end of the body 41 is provided with an axial opening 45 therein in which is secured, by welding, or the like, an axially arranged tubular member 46, which extends upwardly and has its upper end terminating adjacent the upper end of the bit body, the upper end of said member 46 being disposed within the box 38. As the outside diameter of the member 46 is substantially less than the diameter of the box 38, there is defined between said member and the interior of the box 38 an annular passage or annulus, which extends downwardly from the lower end of said box, as indicated at 47. From the lower end of the annulus 47 there is a passage 48 which extends downwardly through each of the respective arms 42, or the body. Within each of the passages 48 there is secured by press fitting, welding, brazing, or the like, an insert 49 having a passage 50 therethrough which is counterbored at the lower end, as indicated at 51. The counterbore 51 opens downwardly and a nozzle 52 is screwed thereinto, said nozzle having a passage 54 communicating at its upper end with the passage 50 of the insert 49 and discharging downwardly toward the respective cutting member 44.

The lower end of pipe 31 extends downwardly below the bits 40 and into the pilot hole 25, and at the lower end of said pipe 31 there is secured by the usual pin and box arrangement a reamer 58. A bit 59 of any well known construction is attached, by any well known means such as the well known pin and box arrangement, to the lower end of the reamer 58.

Spaced upwardly of the plate 30 there are three branch pipes 65 having their inner ends connected to the pipe 31. The outer end of each pipe 65 has downturned portion 66 which extends into a swivel joint 68 secured to the upper end of the shaft 34. The swivel connection 68 provides means whereby the shaft 34 may rotate and there is packing means in said swivel connection to provide a fluid-tight connection between said swivel and the downturned end portion 66 of the branch pipe 65. Connections of this character are well known and it is believed to be unnecessary to show or describe same in detail.

Power means is provided for operating or rotating the bits 40. As shown there is secured an electric motor 70 on each arm of the plate 30. At one end of the shaft 71 of the motor there is secured a bevel gear 72 which meshes with a large bevel gear 73 secured to an adjacent portion of the shaft 34, it being understood, of course, that other means may be provided between the motor and the shaft 71 for effecting rotation thereof.

It is also to be understood that other power means may be employed to operate the bits 40. For example, hydraulic or air motor means may be used or mechanical power may be provided and transmitted from the surface to the bits.

The upper end of the pipe 31 is secured to the lower end of a drill string 75 by any usual well known means such as the pin and box arrangement commonly employed.

Within the pipe 31 and drill string 75 there is another pipe, indicated at 76, which is of smaller external diameter than the internal diameter of the pipe 31 and said pipe 76 is connected to the lower end of a string of pipes of corresponding size which extends upwardly within the drill string 75 to provide a double, concentric drill string. The purpose of this arrangement is to provide a flow passage 78 between the inner and outer strings of pipe for the flow of drilling fluid, and a second flow passage 79 within the pipe 76 for flow of fluid in the opposite direction. In the arrangement herein disclosed, drilling fluid flows downwardly in the annular passage 78 and upwardly in the passage 79.

In the Grable Patent No. 2,701,122, for Method and Apparatus Employing Compressed Gas for Drilling Wells, there is disclosed apparatus for providing similar circulation of drilling fluid. The arrangement includes a swivel 80 which is connected to the drill string and interior string as shown in said Grable patent, and the mechanism also includes a kelly 81 arranged similarly to the kelly of the apparatus of said Grable patent.

The lower end of the pipe 76 is provided with three branches 82 which extend within the branch pipes 65. Each of the pipes 82 have a swivel connection with the upper end portion 84 of a respective bit member 45a. The connection includes packing and is of known character.

At the lower end of the pipe 76 there is a wall 85 having an axial opening therein for reception of the lower end of a conduit 86 of substantially smaller outside diameter than the inside diameter of the pipe 76, said conduit extending upwardly to the upper end of the pipe strings. Spaced downwardly of the wall 85 is a partition 87 in the pipe 31 which also has an axial opening therethrough. The lower end of conduit 86 is provided with a collar 88 which rests on the upper side of the wall 85 and below said wall there is a stationary packing gland 89.

The lower end of said gland 89 is connected by a short pipe 90 with a second stationary packing gland indicated at 91, from the lower end of which there extends a short conduit 92 open at the bottom for reception of electric cables 94, each of which is provided with the wires which extend from a source of electric current to a motor 70. The cables 94 also include the wires for direct current electric tachometers, which are known in the art. The cables 94 extend upwardly through the conduit 86 and the respective wires of such cables are connected to annular rings 98, which are mounted on but insulated from a pipe portion 99 just below the swivel 80. This is a convenient location for mounting these rings. The rings 98 are connected with respective wires 100 by means of respective brushes 101. This arrangement is diagrammatically shown, as devices for providing electrical connections between rotating and stationary parts are well known.

Certain of the wires 100 are connected with tachometers 102 which may be suitably mounted in a support 103 on the platform 10. The other wires 100 are connected to respective generators 105, FIG. 6, driven by any suitable variable speed means, such as a gas engine 106 or a diesel engine, or the like. The engine 106 is provided with a carburetor 107 which is connected by an actuating member 108 with a control lever, or the like, 109, so that actuation of the lever 109 functions to vary the opening of the carburetor throttle valve and hence vary the speed of the engine 106.

The motors 70 are direct current motors and the generators 105 are direct current generators. Each motor 70 is provided with its own generator and each generator is provided with its own engine 106. By varying the speed of the engine and hence of the generator 105, the speed of the motor 70 is correspondingly varied, and hence each motor 70 is provided with its own generator and engine, each motor is independently operable and its speed is variable independently of the speed of the other motors. The speed of each motor 70 is indicated by its respective tachometer 102.

Although the motors 70 for driving the bits 40 are disclosed herein as being direct current motors, it is to be understood that other types of electric motors may be used as well as other types of power means for operation of the bits. It is desirable to have the motors of the variable speed type, and while a single motor is shown for each bit it is to be understood that there may be additional motors for the respective bits, or the motors may

be otherwise arranged. The important factor is the provision of means for driving the bits and operating them at various speeds in accordance with the requirements of particular drilling operations.

It is to be noted that the bits are inclined, as best shown in FIG. 1, so that the planes of the cutting surfaces of the cutters are inclined upwardly towards or in the direction of rotation of the unit 28. In other words, the leading part of each cutter is higher than the trailing part, so that when the unit 28 is rotated the cutters have a milling action relative to the surface of the formation being cut and do not have to force themselves sideways into the formation.

Other types of bits may be used, such as diamond bits or the like, and under some operating conditions and with such bits it may not be necessary to incline the bits in the manner above pointed out. It is to be understood, too, that bits of different sizes and of different tooth design may be used. It is important, however, that the bottom of the hole be acted upon by the bits and it is to be noted that the bits 40 as they operate are so arranged that as the unit 28 rotates on its axis said bits cut paths in the formation at the lower end of the bore hole 26, and these paths overlap so that with each revolution of the unit 28 the entire area of the bottom of the bore hole 26 is worked upon by said bits.

The usual means, not shown, for rotating the table 16 is provided on the platform 10 to effect rotation of the drill string and hence the unit 28, the inner and outer strings of pipes rotating together. The lower end of the pipe 31, which carries the reamer 58 and bit 59, passes downwardly in the pilot hole 25 as the drilling unit 28 moves downwardly as the bottom of the bore hole 26 is cut away. The reamer 58 and bit 59 keep the pilot hole 25 open sufficiently so that there will be no sticking of the equipment during the drilling operation.

The conductor pipe 20 is provided with a cover, indicated generally at 115, and said cover includes a top 116 having an axial opening therein in which is disposed a depending pipe 117 suitably secured at its upper end to said cover 116 by welding or other means. The top 116 is reinforced by reinforcing members 118 which extend radially of the pipe 117 to the periphery of said cover 116 and at said periphery there is a depending flange 119 which has internal recesses 120 corresponding to the recesses or grooves 22 in the conductor pipe. The cover is sealed on the conductor pipe by means of hollow resilient tubes, which may be of rubber or other suitable material, and which are received in the grooves 22 and 120, which are in opposition to each other when the cover 115 is in proper position. Said tubes 121 are inflatable so as to provide a secure seal between the flange 119 and the conductor pipe 20. There is a valve 125 secured to the top 116 and communicating with the interior of the cover, said valve adapted to be connected to a suitable source of air pressure or other fluid under pressure for pressurizing the interior 126 of the conductor pipe and the bore 26.

Drilling fluid of suitable character, such as air or other gas, for example, is introduced into the annular passage 78 through a conduit 128 connected with an inlet pipe 129 of the swivel 80, as disclosed in the above referred to Grable Patent No. 2,701,122. This gaseous drilling fluid passes downwardly through the annular passage 78*a* between the branch pipes 82 and the branch pipes 65 and thence through the swivel connections 68 and into the passages 47, 48 and 50, and nozzle discharge passage 54 of the respective bits. This fluid is directed onto the respective cutters 44 of said bits and flows upwardly into the pipes 46 and thence into the branch pipes 82 and into the interior passage of the pipe 76 and the corresponding pipes to which said pipe 76 is connected. The fluid passing through the bits picks up the cuttings and carries same upwardly into the swivel 80 from which said fluid and cuttings pass into the pipe 132 and hose 133 which carries same to a suitable disposal point.

In order to maintain fluid pressure in the interior 126 of the conductor pipe and in the bore 26, a rotary sealing device or head 135 is provided and is secured to the pipe 117, the drill string 75 extending through said head 135. Any suitable type of rotating sealing means may be used and such means or devices are well known in the art. These devices maintain the proper seal around the drill string and prevent escape of pressure while permitting the drill string to move upwardly and downwardly therethrough, as well as to rotate.

By pressurizing the bore 26 the cuttings are prevented from escaping outwardly from the bits and are kept within the effective flow paths of the drilling so that said cuttings will be carried upwardly through the pipes 46 and thence carried to the surface through the branch pipes and drill string.

Should it be desired to raise the unit 28 to replace bits or to otherwise service the unit, the pressure within the conductor pipe 20 and bore 26 may be released by means of the valve 125 and the fluid pressure within each pipe 129 is released. The cover and unit 28 may be raised to a point where said unit is readily accessible for servicing, or the like.

There is a cover 140 for the unit 28 and said cover is three-armed so as to enclose the parts of the unit 28 between the plate 30 and the upper side of the branches 65. This cover is adapted to be readily removed and also encloses ballast tanks 141 in which is suitable ballast, such as water or the like, which is used to provide ballasting means for the lower end of the drill string to minimize or eliminate any tendency of the equipment to deviate from the vertical during drilling operations.

Generally the drilling equipment is transported to the drill site on trucks, disassambled in component groups typical of oil field practices. The rig equipment can be transported in loads to conform with road and State highway limits.

Assembly and rig-up of a rig will conform essentially to common oil field practices. After assembly of the drilling rig the pilot hole is drilled to a point below the depth to which the large bore hole is to be drilled.

After drilling the pilot hole this smaller equipment is disassembled. A larger diameter drill stem, which is concentric, as above described, is assembled and attached to a multiple drilling head through a solid cover plate and rotating packer assembly.

The drilling head or unt 28 is slowly rotated on their respective axes. Air or other drilling fluid is supplied by pumps or compressors and circulated down the outer annulus 78 of the dual concentric drill string. Cuttings are picked up by this fluid as the cutters of the bit cut same from the bottom of the bore hole and these cuttings are entrained in the drilling fluid which is returned to the surface upwardly through the central annulus 79 of the drill string. At the surface the air stream discharge line 133 is connected to a separator which causes the cuttings to drop out of said stream. These cuttings may be transported easily and economically away from the drill site if desired.

It is believed that the invention and many of its attendant advantages will be understood from the foregoing description and it is believed that it will be apparent various changes may be made in the process or method and the form, construction and arrangement of the parts of the apparatus of the invention without departing from the spirit and scope thereof or sacrificing all of its material advantages, the form hereinbefore described being merely by way of example.

We claim:

1. Apparatus for drilling large bore holes adapted to be lowered and raised by a drill string, comprising: an axial member having its axis substantially vertical; a supporting member axially secored to said axial member intermediate

the ends thereof and rotatable therewith; a plurality of rotary drilling bits operably carried by said supporting member, said bits being inclined upwardly in the direction of rotation of said axial member and being variously spaced from said axial member so that when the axial member and supporting member are rotated said bits travel in annular concentric paths with edge portions of adjacent paths overlapping; and motor means for each bit for independently rotating same, said motor means being carried by said support member.

2. An apparatus for drilling large bore holes: bit supporting means adapted to be supported on a substantially vertical axis; a plurality of rotary drilling bits carried by said bit supporting means and having cutter elements, said bits being inclined upwardly relative to said vertical axis and to the direction of rotation, said bits being variously spaced radially from the axis of said supporting means so that when said means is rotated said bits travel in annular concentric paths with edge portions of adjacent paths at least meeting; power means for independently rotating each rotary bit; and support means for supporting said bit supporting means for vertical movement and for rotation on said substantially vertical axis.

3. An apparatus for drilling large bore holes; an axial member, bit supporting means carried by said axial member; a plurality of rotary drilling bits carried by said bit supporting means and having cutter elements, said bits being variously spaced from the axis of said means so that when said means is rotated said bits travel in annular concentric paths with edge portions of adjacent paths at least meeting; and ballast means on said bit supporting means for applying downward pressure on the supporting means.

4. An apparatus for drilling large bore holes: a rotatable bit supporting means adapted to be supported on a substantially vertical axis; a plurality of rotary drilling bits carried by said bit supporting means and having cutter elements, said bits being variously spaced from the axis of said means so that when said means is rotated said bits travel in annular concentric paths with edge portions of adjacent paths at least meeting, the bottom plane of the cutter element being inclined upwardly in the direction of rotation of the supporting means to provide a milling action as the bits are moved in circular paths while cutting; means for rotating said bits; and means for supporting and rotating the entire mechanism on said vertical axis.

5. In apparatus for drilling large bore holes and the like: bit supporting means adapted to be supported on a substantially vertical axis; a rotary drilling bit spaced from the vertical axis and carried by said bit supporting means and having cutter elements, the bottom plane of the cutter elements being inclined upwardly in the direction of rotation of the supporting means, means for rotating said drilling bit; and means rotatably supporting said bit supporting means for rotation on said vertical axis.

6. Apparatus for drilling large bore holes, comprising: an axial member; a supporting member axially secured to said axial member intermediate the ends thereof; a plurality of rotary drilling bits having cutter elements carried by said supporting member, said drilling bits having their axes of rotation somewhat inclined from the vertical so that the leading sides of said bits are higher than the trailing sides, said bits being variously spaced radially from said axial member so that when the axial member and supporting member are rotated said bits travel in annular concentric paths with edge portions of adjacent paths overlapping; motor means for each bit for independently rotating same, said motor means being carried by said support member; means for controlling the speed of each motor means independently of the other motor means; a first drill pipe string connected to the axial member; a second pipe string of smaller outside diameter than the inside diameter of the first drill pipe string disposed within the first drill pipe string in concentrically spaced relationship thereto, the inner drill pipe string defining an inner passage and the annulus between the inner and outer drill pipe string defining an outer passage, fluid being adapted to flow downwardly in one passage and upwardly in the other passage; respective conduit means for conducting downwardly flowing fluid in one of said passages to the drilling bits and discharging same against the cutters of the drilling bits; conduit means for conveying fluid from said drilling bits to the other passage for upward flowing fluid; a conductor pipe at the upper end of the bore hole, said pipe being open at the upper end; a removable cover for the upper end of said conductor pipe, said cover having an axial opening therein for reception of the drill string, means releasably sealing said cover to said conductor pipe; and a rotary sealing device secured to said cover in axial alignment with said opening, said drill string being operably received in said rotary drilling head.

7. Apparatus for drilling large bore holes, comprising: an axial member; a supporting member axially secured to said axial member intermediate the ends thereof; a plurality of rotary drilling bits having cutter elements carried for rotation on substantially vertical axes by said supporting member, said drilling bits having their axes of rotation inclined from the vertical in a direction to position the leading sides of said bits higher than the trailing sides, said bits being variously spaced from said axial member so that when the axial member and supporting member are rotated said bits travel in annular concentric paths with edge portions of adjacent paths overlapping; motor means for each bit for independently rotating same, said motor means being carried by said support member; means for controlling the speed of each motor means independently of the other motor means; a first drill pipe string connected to the axial member; a second pipe string of smaller outside diameter than the inside diameter of the first drill pipe string disposed within the first drill pipe string in concentrically spaced relationship thereto, the inner drill pipe string defining an inner passage and the annulus between the inner and outer drill pipe string defining an outer passage, fluid being adapted to flow downwardly in one passage and upwardly in the other passage; respective conduit means for conducting said downwardly flowing fluid to the drilling bits and discharging same against the cutters of said drilling bits; and conduit means for conveying said fluid after same has been discharged against said drilling bits to the passage for upward flowing fluid.

8. Apparatus for drilling large bore holes, comprising: an axial member having its axis substantially vertical; a supporting member axially secured to said axial member intermediate the ends thereof and rotatable thereby; a plurality of rotary drilling bits having cutter elements operably carried by said supporting member, the axes of said bits being inclined upwardly in the direction of rotation of the axial member so that the leading sides of said bits are higher than the trailing sides thereof, said bits being variously spaced from said axial member so that when the axial member and supporting member are rotated said bits travel in annular, concentric paths with edge portions of adjacent paths overlapping; motor means for each bit for independently rotating same, said motor means being carried by said supporting member; means for controlling the speed of each motor means independently of the other motor means; and a drill string connected to the axial member for lowering, raising and positioning the apparatus to thereby control the pressure of the bits on the formation at the bottom of the hole.

9. Apparatus for drilling large bore holes adapted to be lowered and raised by a drill string, comprising: a supporting member adapted to be secured to said drill stem; a plurality of rotary drilling bits operably carried by said supporting member, said bits being inclined upwardly in the direction of rotation of said supporting member and being variously spaced from the axis of ro-

tation of said supporting member so that when the supporting member is rotated said bits travel in annular concentric paths; and means for rotating said bits on their respective axes.

10. Apparatus for drilling large bore holes adapted to be lowered and raised by a drill string, comprising: a supporting member adapted to be secured to said drill stem; a plurality of rotary drilling bits operably carried by said supporting member, said bits being inclined so that the trailing edges of said bits first engage the formation being cut and being variously spaced from the axis of rotation of said supporting member so that when the supporting member is rotated said bits travel in annular concentric paths; and means for rotating said bits on their respective axes.

References Cited by the Examiner

UNITED STATES PATENTS

1,292,159	1/19	Trumpour.	
2,074,951	3/37	Zublin	175—397
2,466,709	4/49	Karr.	

2,701,122	2/55	Grable	175—69
2,703,698	3/55	Westerman	255—306
2,758,825	8/56	Wohlmeyer.	
2,887,301	5/59	Day	175—334
2,890,022	6/59	Brown	175—334
2,930,586	3/60	Long	175—71

FOREIGN PATENTS

17,985	5/04	Austria.
197,767	5/58	Austria.

OTHER REFERENCES

"Drilling With Gas Promises Lower Costs," Oil and Gas Journal, pages 104–105, 147, August 25, 1952.

"Aerated Mud Drilling," The Petroleum Engineer, page B–46, November 1955.

BENJAMIN HERSH, *Primary Examiner.*

CHARLES E. O'CONNELL, BENJAMIN BENDETT, *Examiners.*