

Nov. 24, 1953

V. J. DEVINE ET AL

2,660,402

CORE DRILLING APPARATUS

Filed Dec. 19, 1949

3 Sheets-Sheet 1

Fig. 1.

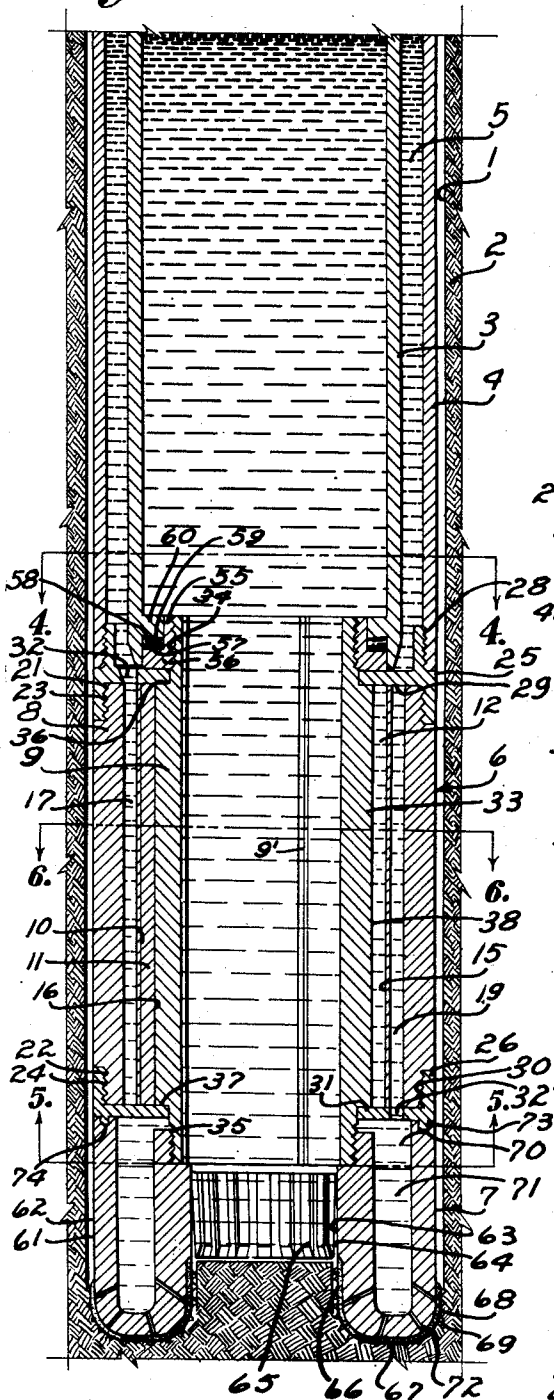
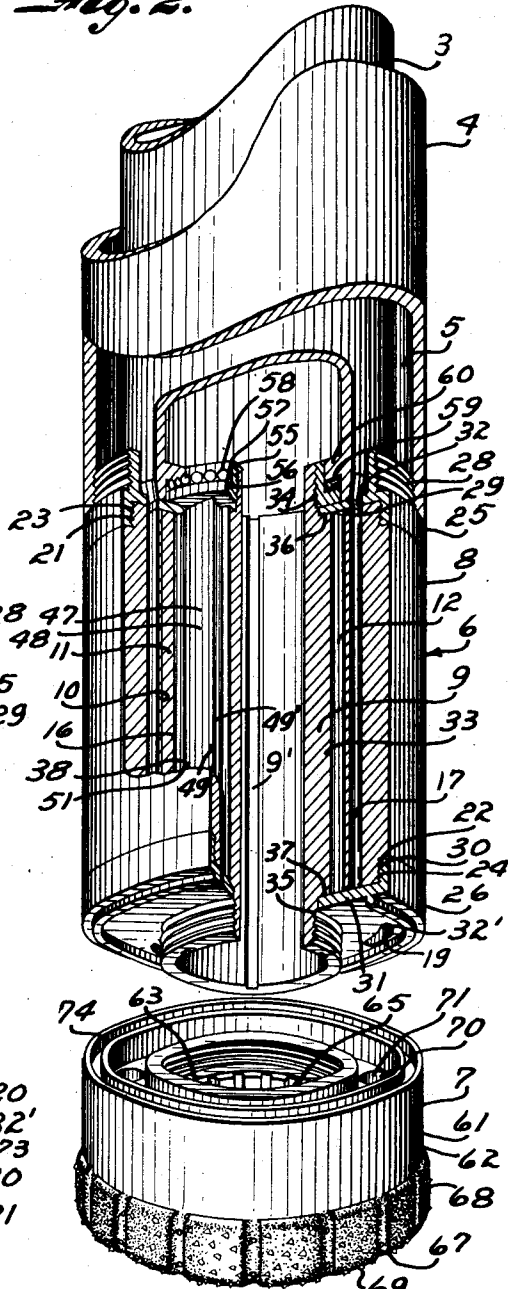


Fig. 2.



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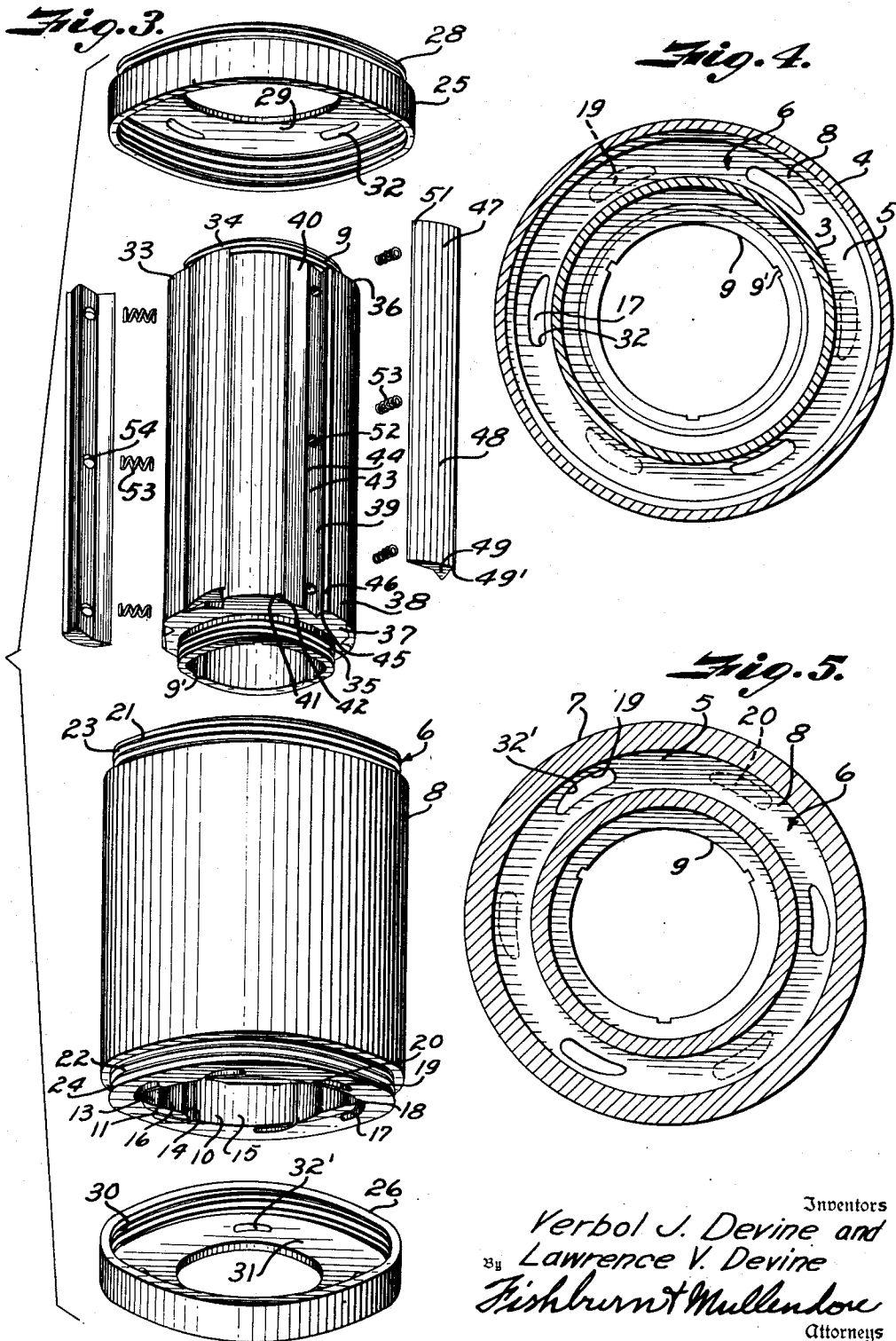
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Fig. 8.

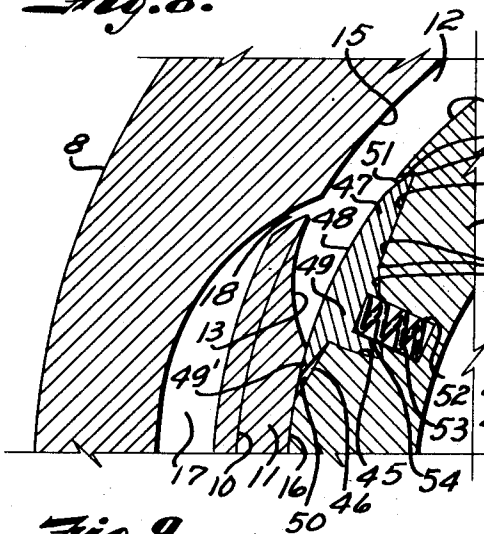


Fig. 6.

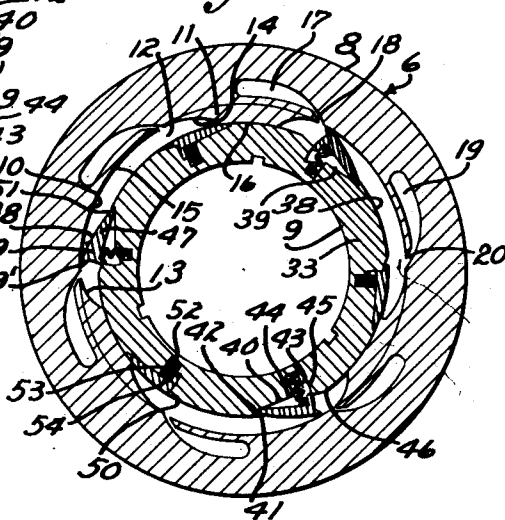


Fig. 9.

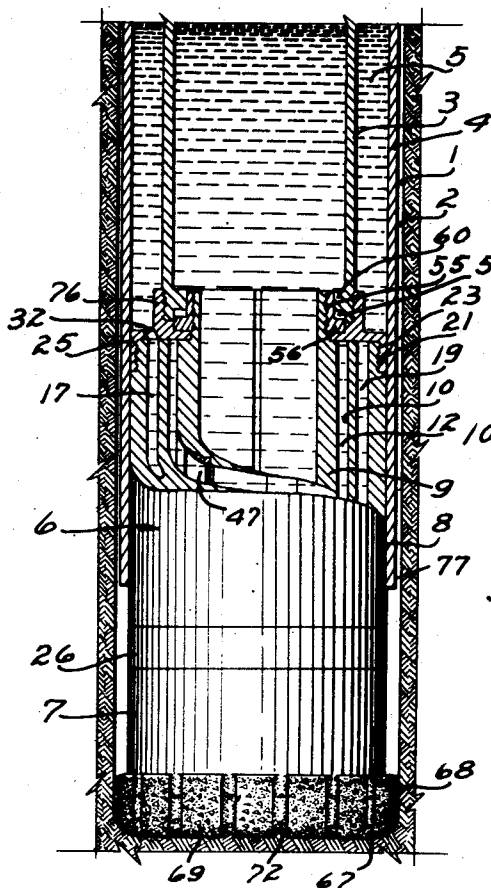
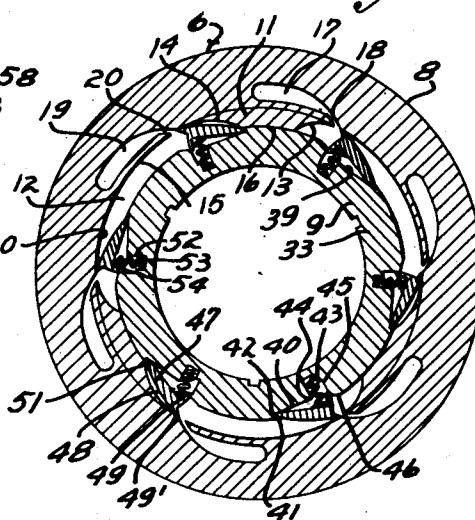


Fig. 7.



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2,660,402

CORE DRILLING APPARATUS

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Application December 19, 1949, Serial No. 133,822

3 Claims. (Cl. 255-4)

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This invention relates to a drilling apparatus such as used in exploration of earth formations at substantial depths and for drilling wells into producing formations. Usually such an apparatus includes a drill bit mounted on the lower end of a string of drill pipe having a Kelly or drive rod on its upper end which is rotated by a power mechanism located above ground to effect turning of the drill bit. Simultaneously a drilling fluid is circulated downwardly through the string of drill pipe to lubricate the drill bit and wash the cuttings to the top of the bore hole. As the hole progresses, additional strings of drill pipe are added as required to maintain connection between the rotating mechanism and the drill bit.

Many difficulties are encountered with such apparatus particularly when drilling at substantial depths due to deflection of the drill bit from a straight course caused by whipping and bending of the drill pipe, difficulty of controlling weight of the drill pipe on the bit in accordance with the drilling speed through the various formations, twisting off of the drill pipe joints and many other reasons well known to those experienced in drilling earth formations. In order to reduce such hazards the equipment is being made heavier and stronger which renders the handling thereof more difficult as well as requiring greater motive power in effecting operation thereof. Prior to the present invention it has been proposed by rotating the drill bit through a motor that is carried by the lower end of the drill pipe for rotating the bit. However, such mechanism precludes the taking of cores of the earth formation progressively with the drilling and interferes with the running in and out of various instruments, tools, and the like through the drill pipe, as when coring a head of the drill bit to test pressures and obtain advance knowledge of the lower formations before penetration thereof by the larger bit.

It is, therefore, the principal object of the present invention to provide a drilling apparatus with a motor unit that is mounted on the lower end of the drilling string and directly connected with the drill bit but which is constructed to provide an axial passageway therethrough of ample size for passing a core and performing other operations that may be required in the drilling of a bore hole.

Other objects of the invention are to provide a motor unit that is of simple construction and which has the working parts thereof located exteriorly of the axial passageway but within the scope of a standard drill bit, and to provide a

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drilling apparatus that permits the use of non-rotating light weight drill pipe.

It is also an object of the invention to provide a drilling apparatus including a bottom hole motor wherein the core may be removed through the inner drill pipe without pulling the drilling string, thereby saving in drilling time and reducing the cost of the operations.

In accomplishing these and other objects of the invention as hereinafter pointed out, we have provided improved structure the preferred forms of which are illustrated in the accompanying drawings wherein:

Fig. 1 is a vertical section through the lower portion of a drilling string showing a core bit actuated by a motor in accordance with the present invention.

Fig. 2 is a perspective view of the motor and core bit in disassembled spaced relation. Parts of the motor being broken away to better illustrate the construction.

Fig. 3 is a perspective view of the motor parts shown in disassembled spaced relation.

Fig. 4 is a cross-section on the line 4-4 of Fig. 1 particularly illustrating the intake channels to the motor.

Fig. 5 is a cross-section on the line 5-5 of Fig. 1 particularly illustrating the exhaust channels.

Fig. 6 is a cross-section through the motor on the line 6-6 of Fig. 1 showing one position of the rotor and its operating vanes.

Fig. 7 is a similar cross-section showing another position of the rotor and operating vanes therefor.

Fig. 8 is an enlarged fragmentary section through the rotor and stator particularly illustrating details of the vanes.

Fig. 9 is a side elevational view of a modified form of the invention a portion of the motor being shown in section.

Referring more in detail to the drawings:

1 designates a bore hole that is being drilled through an earth formation 2 by means of a drilling apparatus constructed in accordance with the present invention and which includes inner and outer strings of pipe 3 and 4 which are usually composed of sections interconnected by conventional tool joints or couplings not shown. The inner pipe 3 is of smaller external diameter than the inner diameter of the outer pipe 4 to provide an annular downflow passageway 5 through which a drilling fluid is circulated from above ground for actuating a drilling motor 6 and to carry cuttings made by a drill bit 7 upwardly through the inner pipe 3 to the top of the ground.

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The motor 6 and drill bit 7 constitute the principal feature of the present invention in that they are constructed to form and pass a core upwardly through the inner pipe 3 and to provide a passageway completely through the drilling string for insertion of various instruments and other devices incidental to drilling and coring of a bore hole.

The motor 6 includes a stator 8 and rotor 9. In the preferred form of the invention illustrated in Figs. 1 to 8 inclusive, the stator is directly connected to the outer pipe 4 and is supported in stationary position therewith. The rotor 9, however, is rotatably mounted with respect to the inner stationary pipe 3 to effect rotation of the drill bit 7, which is directly connected with the rotor. However, the drill bit may be connected with the rotor through one or more joints of drill pipe if desired.

The stator 8 includes a sleeve-like body having an outer diameter substantially conforming to the outer diameter of the bit 7 and having an inner axial bore 10 containing circumferentially spaced inserts 11 which are welded or otherwise secured within the inner bore of the stator to provide pressure chambers 12 therebetween that are of arcuate cross section and have curving sides 13 and 14 joining the outer curved faces 15 of the chambers with the inserts. The curved sides thus provide cam portions for controlling movement of the rotor vanes as later described. The inserts 11 are of such cross-sectional width as to provide arcuate sealing faces 16 for contact with the rotor 9 and prevent leakage of fluid from one of the pressure chambers to the other.

Extending longitudinally of the wall of the stator in parallel relation with the axis of the rotor are pressure fluid intake channels 17 having slot-like outlets 18 opening through the faces 15 of the stator chambers adjacent the juncture of the cam portions 13 with the faces 15 of the chambers 12 as best shown in Figs. 6 and 7. Located intermediate the intake channels 17 are similarly arranged exhaust channels 19 having slot-like ports 20 located adjacent the juncture of the cam surface 14 with the outer surface 15 of the chambers for escape for the pressure fluid.

The ends 21 and 22 of the stator are of reduced diameter and externally threaded as at 23 and 24 to mount couplings rings 25 and 26 respectively. The upper coupling 25 includes an internally threaded depending flange that is engaged with the threads 23 and an upwardly extending externally threaded flange 28 engaged by the internal threads of the outer pipe 4. The coupling also includes an inwardly extending annular plate portion 29 to close the upper ends of the exhaust channels and to engage the rotor as later described. The lower coupling 26 is similarly formed in that it is provided with an upwardly extending internally threaded flange 30 engaged with the threads 24 on the lower end of the stator, and an inwardly extending annular plate portion 31 that closes the lower ends of the intake channels 17. The plate portion 29 is provided with ports 32 in registry with the upper ends of the intake channels to permit entrance of the drilling fluid for operating the motor. The plate portion of the lower coupling is provided with exhaust ports 32' in registry with the exhaust channels 19 for discharge of the drilling fluid through the bit.

The rotor 9 includes an elongated cylindrical body 33 having reduced threaded ends 34 and 35 which form annular shoulders 36 and 37 in

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registry with the ends of the stator, for engagement between plate portions of the coupling rings 25 and 26, whereby the rotor is centered with respect to the stator and retained from axial movement therein. Formed within the outer circumferential outer face 38 of the rotor are a plurality of circumferentially spaced vane receiving pockets 39 that extend longitudinally of the rotor. The pockets 39 are of groove-like character and have substantially shallow bottom portions 40 that extend at an angle from undercut lips 41 to provide bearing sockets 42 for edges of the vanes as later described. The bottom portions 40 cooperate with similar bottom portions 43 that form obtuse angles therewith as at 44 to provide deeper portions for the grooves to accommodate head portions of the vanes. The sides 45 of the pockets opposite the vane sockets are formed on arcs generated from the bearing sockets 42 whereby the heads of the vanes may swing outwardly from the pockets into the pressure chambers 12 of the stator. The arcuate sides 45 terminate short of the circumferential face 38 of the rotor to form recesses 46 to accommodate lip portions on the vanes as later described.

The vanes 47 substantially conform to cross sectional shape with the pockets of the rotor and have arcuate outer faces 48 conforming to the outer curvature of the rotor, and which are adapted to make contact with the cam portions at the sides of the stator chambers. The opposite faces of the vanes are formed on angular planes substantially corresponding with the bottoms of the pockets to provide a relatively thick head portion 49 on the retractive sides thereof and which serve as the effective surfaces against which the drilling fluid acts to effect rotation of the rotor. Head portions of the vanes are also formed on arcs corresponding with the curvature of the side faces 45 of the pockets so that they swing outwardly to bring lip portions 49' thereof into sealing contact with the outer faces of the rotor chambers, the head portions being sufficiently thick to maintain contact with the rotor and prevent leakage under the vanes. The lip portions 49' are shaped to be received within the recesses 46 of the pockets and provide initial entrance spaces 50 for the pressure fluid as the vanes uncover the intake slots 20 of the stator. The opposite edges of the outer surfaces of the vanes may be also relieved as indicated at 51 to permit outward swinging movement thereof under the lip portions 41 of the pockets.

In order to normally urge the vanes outwardly into the contact with the outer surfaces 15 of the stator chambers, the bottom of each pocket at the deeper side thereof is provided with one or more spring sockets 52 for seating springs 53 that bear within spring seats 54 of the respective vanes.

Mounted on the reduced end of the rotor is an internally threaded collar 55 having an outwardly extending annular flange 56 that cooperates with the shouldered end of the rotor in engaging the respective ring-like plate portion of the upper coupling as best shown in Fig. 1. The flange 56 also provides the lower race 57 for anti-friction bearings 58 which roll against an upper race 59 that is provided by an inwardly extending flange 60 attached to and extending inwardly from the inner face of the inner pipe 3 a point above the lower end thereof.

The rotor is thus connected with the inner

pipe in such a manner as to prevent longitudinal movement thereof but to permit free rotation under weight of the inner pipe.

Core bit 7 includes a ringlike body 61 having an outer face 62 substantially conforming to the outer diameter of the stator and an inner face 63 substantially conforming at its upper end with the inner diameter of the rotor but which tapers downwardly and inwardly to provide a seat 64 for a core catcher 65. Below the seat for the core catcher, the inner face of the bit extends downwardly in cylindrical form to provide an inner reaming face 66 joining with an end drilling face 67. The outer circumference of the bit also forms reaming face 68. The reaming and drilling faces are inlaid with cutting elements such as diamonds 69 or other forms of abrasive devices. The upper end of the drill bit has an annular groove 70 in communication with the exhaust ports 19 of the motor, for distributing drilling fluid to channels 71 for supplying the drilling fluid to outlet ports 72 leading through the respective drilling faces of the bit as best shown in Fig. 1.

In order to prevent leakage between the bit 7 and motor 6 the lower coupling 26 carries an annular rib 73 that engages in an annular groove 74 in the bit 7 that is located on the outer side of the distribution groove 70. The inner circumference of the rotor 9 may be provided with longitudinal grooves 9' for receiving keys or splines of various instruments or tools that may be run through the inner pipe 3 and used ahead of the drill bit, for example, a small core barrel (not shown) when taking a core ahead of the bit.

In using the apparatus the outer pipe 4 is connected with the discharge of a pressure pump (not shown) to supply drilling fluid to the down-flow passageway 5 between the pipes 3 and 4. The upper end of the inner pipe 3 is connected with a slush pond where the cuttings and parts of core are separated out and the fluid is returned to the pressure pump.

In starting a bore hole, the inner and outer pipes 3 and 4 are respectively connected with the rotor 9 and stator 8 elements of the motor 6. The bit 7 is connected to the rotor 9 by engaging the internal threads thereof with the lower threaded end 35 of the rotor and to bring the sealing groove 74 into engagement with the annular sealing rib 73. If no core is to be taken, an ordinary drilling bit may be substituted for the core bit shown in the drawings.

When the drilling fluid is forced downwardly through the outer passageway 5, it enters the motor 6 through the intake ports 32 and passes downwardly through the intake channels 17 from where it is discharged through the slot-like ports 18 (Fig. 6) into the pressure chambers 12 of the motor. The vanes 47 enter the pressure chambers 12 and swing outwardly responsive to action of the compression springs 53, supplemented by the pressure fluid acting under the lips 49' which brings the head portions 49 of the vanes into position to be acted upon by the pressure fluid to effect a clockwise rotation of the rotor as illustrated in Figs. 6 and 7. When the vanes 47 pass the ports 20 of the outlets 18, the pressure fluid that becomes trapped thereahead is discharged through the exhaust ports because the preceding vanes have uncovered the exhaust ports to expell the drilling fluid into the exhaust channels 19 to the water courses 71 and 72 in the drill bit. After the vane 47 passes the slot-like exhaust ports 20, the curved rear edge thereof contacts

the curved cam surfaces 14 which press the vanes back into the pockets 39 of the rotor 9 to permit passing thereof under the sealing faces 16 of the stator 8. As soon as the vanes 47 pass the sealing faces 16, they again swing outwardly to be engaged by a second jet of pressure fluid in the next pressure chamber and so on around the circumference of the stator. The pressure fluid is thus applied at a plurality of points on each turn of the rotor to produce the required torque necessary for rotating of the bit.

The pressure fluid exhausted from the rotor chambers passes through the exhaust channel 19 to the annular passageway 71 and is distributed to the ports 70 through the bit for discharge through the branch ports 72 for lubricating the drilling surfaces of the bits and carrying the cuttings inwardly toward the core passageway through the motor 6 and upwardly through the inner pipe 3 to the top of the bore hole.

As the drilling progresses, additional sections of inner and outer pipe 3 and 4 are applied to the sections in the bore hole as in customary practice.

It is obvious that the power is applied substantially directly at the point of the bit 7 as a result that the pipes 3 and 4 need to resist only the reaction pressure of the motor, consequently lighter weight pipe may be used. It is also obvious that since the pressure is applied directly at the bottom of the hole chatter and backlash of the bit is eliminated. Consequently, the drilling life of the bit is prolonged and a straighter hole is effected. It is obvious that as the drilling progresses, sections of the core are propelled upwardly through the central opening of the rotor and are discharged through the inner pipe 3 under the flow pressure of the drilling fluid. In instances, where it is necessary to remove the core, this may be effected by running a socket member into the drill pipe by means of a cable to engage and lift the core out of the bore hole. Therefore, it is not necessary to remove the drill pipe and the drilling need be stopped only while the core is being engaged by the socket. Another feature is that only the body 33 of the rotor 9 and bit 7 are under rotation. All of the parts remain stationary. The vanes of course being carried by the rotor, swing to and from the rotor pockets by their sliding movement over the surfaces 13, 15, 14, and 16 of the inner circumference of the stator.

It is also obvious that a free passageway is provided entirely through the motor and bit which permits running in and out of various instruments and other apparatus used in connection with drilling of a bore hole. When taking a core ahead of the bit, the small core barrel may be driven from the rotor of the motor by providing the barrel with keys that engage the inner longitudinal grooves 9' within the rotor.

It is further obvious that we have provided a motor construction which has a large axial passageway clear of any operating parts and which has a relatively small exterior when compared with the diameter of the passageway. This is made effective through the particular design of the vanes and pressure chambers. Another feature is the power effected by the multiplicity of pressure chambers each being supplied with pressure fluid which acts on all of the vanes as they pass through the respective chambers.

In the form of the invention illustrated in Fig. 9, the inner pipe 3 is connected with a flange 76 on the coupling ring 25 but the stator 8 is con-

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connected with the coupling in the same manner as in the first described form of the invention. The stator is thus supported from rotation by the inner pipe 3. The outer pipe is free of the stator but has the lower end 77 thereof sleeved over the upper end of the stator and may be shifted relatively to the inner pipe otherwise the structure and operation is the same as in the first described form of the invention.

What we claim and desire to secure by Letters Patent:

1. A core drilling apparatus including a core bit having an axial passage for a core and provided with water courses, an inner string of drill pipe through which the core is adapted to be removed, a core barrel forming a downward continuation of the inner drill pipe and having a driving connection with the core bit, an outer pipe coaxial with the inner drill pipe and spaced therefrom to provide a downward flow passage therebetween for pressure fluid, a sleeve-like stator encircling the core barrel and having fixed connection with one of said pipes, said stator having circumferentially spaced elongated pressure chambers on the inner side thereof with the pressure chambers having inlet connections with the down flow passage and exhaust connections with the water courses of the core bit, and vanes on the core barrel and arranged to move in and out of the pressure chambers responsive to flow of pressure fluid for turning the core barrel to rotate said bit.

2. A core drilling apparatus including a core bit having an axial passage for a core and provided with water courses, an inner string of drill pipe through which the core is adapted to be removed, a core barrel forming a downward continuation of the inner drill pipe and having a driving connection with the core bit, an outer pipe coaxial with the inner drill pipe and spaced therefrom to provide a downward flow passage therebetween for pressure fluid, a sleeve-like stator encircling the core barrel, a coupling connecting the stator with the outer pipe and having an inwardly extending annular flange engaging a shoulder on the core barrel and provided with inlet ports, said stator having circumferentially spaced elongated pressure chambers on the inner side thereof with the pressure chambers in connection with the inlet ports in said flange, a collar fixed to the core barrel and engaging said flange, said inner string of pipe having an internal flange cooperating with said collar to provide bearing races, bearings for said races to journal the core barrel relatively to the inner drill pipe, a coupling connected with the lower end of the stator and having an inner flange closing the lower ends of the chambers in encircling relation with the lower end of the core

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barrel at the connection of said core bit and having exhaust ports connected with the water courses of the core bit, and vanes on the core barrel and arranged to move in and out of the pressure chambers responsive to flow of pressure fluid for turning the core barrel to rotate said bit.

3. A drilling apparatus including a bit having an axial passage and provided with water courses, an inner string of drill pipe, a sleeve-like rotor forming a downward continuation of the inner drill pipe and having a driving connection with the bit, an outer pipe coaxial with the inner drill pipe and spaced therefrom to provide a downward flow passage therebetween for pressure fluid, a sleeve-like stator encircling the rotor, a coupling connecting the stator with the outer pipe and having an inwardly extending annular flange engaging a shoulder on the rotor and provided with inlet ports, said stator having circumferentially spaced elongated pressure chambers extending longitudinally on the inner side thereof with the pressure chambers in connection with the inlet ports in said flange, a collar fixed to the rotor and engaging said flange, said inner string of pipe having an internal flange cooperating with said collar to provide bearing races therebetween, bearings for said races to journal the rotor relatively to the inner drill pipe, a coupling connected with the lower end of the stator and having an inner flange closing the lower ends of the chambers in encircling relation with the lower end of the rotor at said connection with the bit and having exhaust ports connected with the water courses of the bit, and vanes on the rotor and arranged to move in and out of the pressure chambers responsive to flow of pressure fluid for turning the rotor to rotate said bit.

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