Feb. 14, 1933. I. C. HARRIS 1,897,121

DRILLING MACHINE

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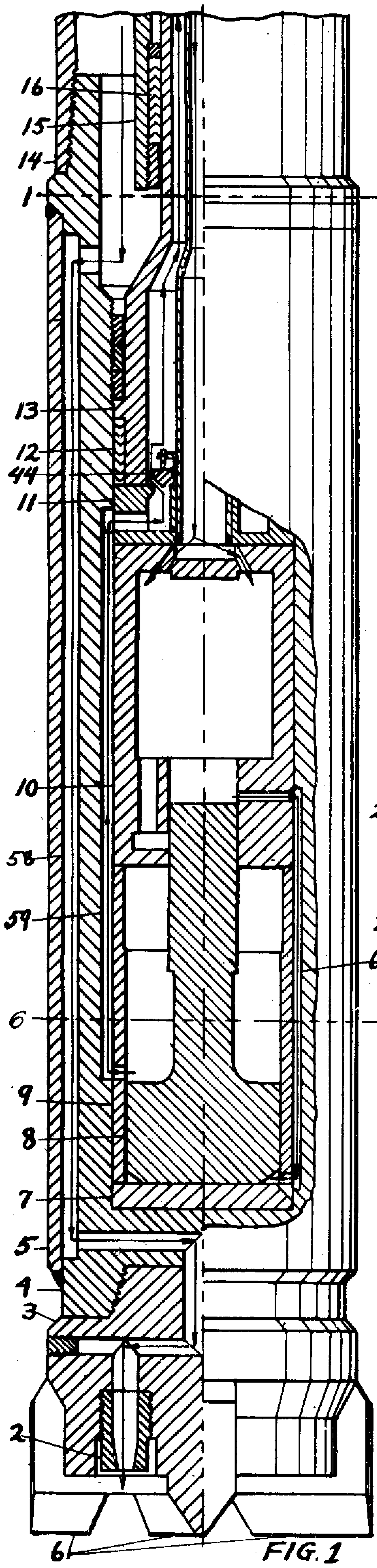

FIG. 1

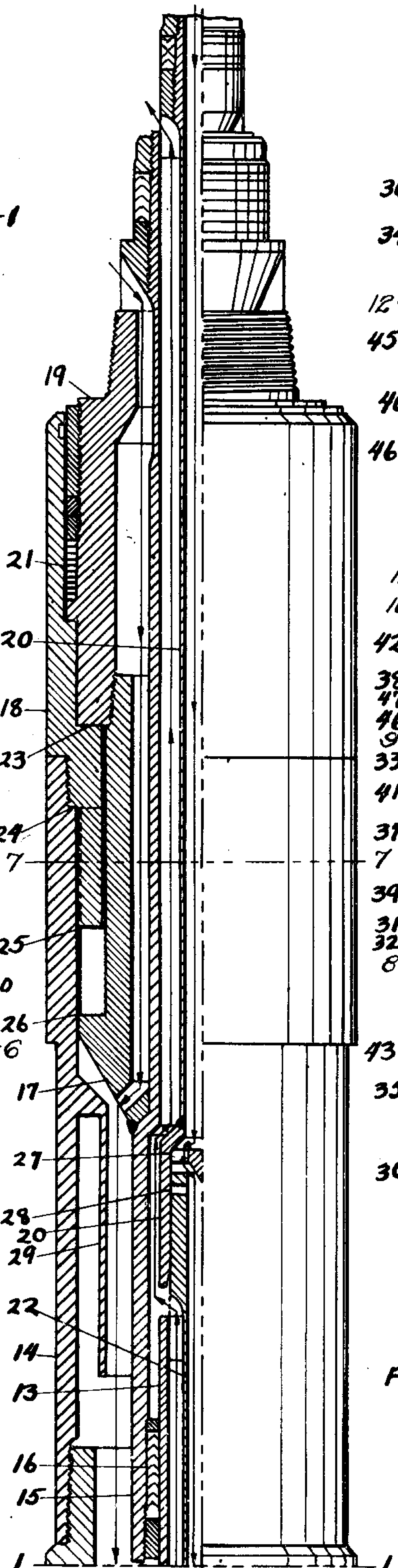

FIG. 2

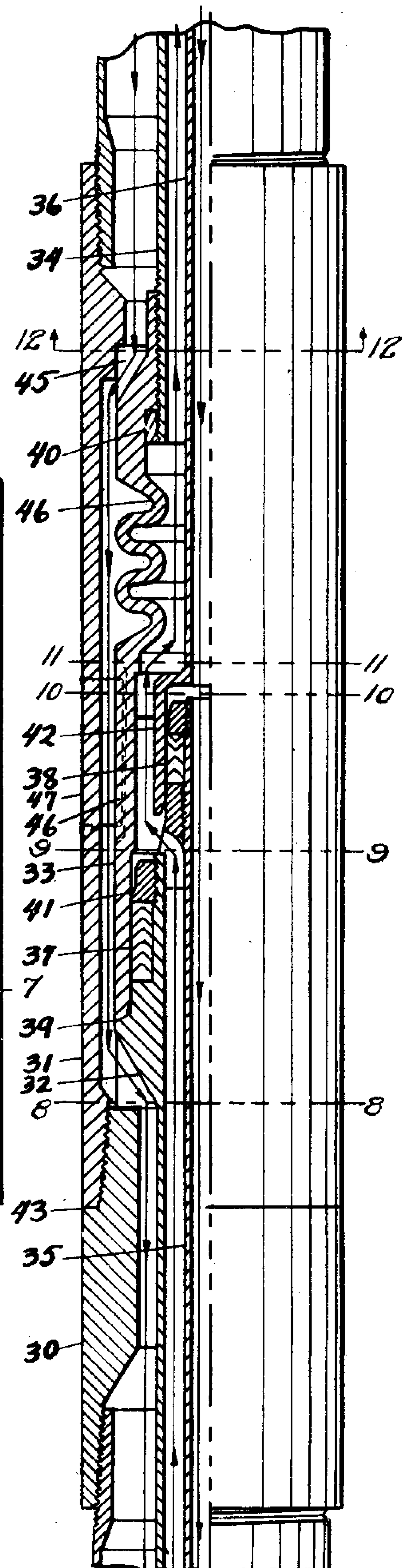

FIG. 3

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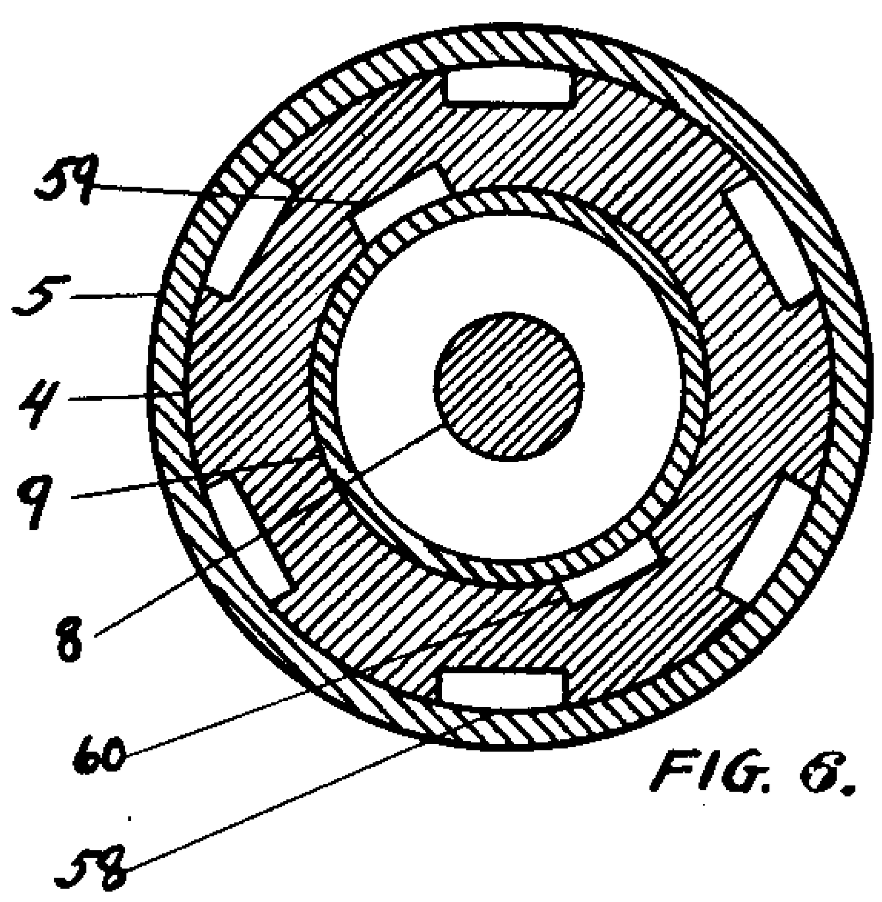

FIG. 6.

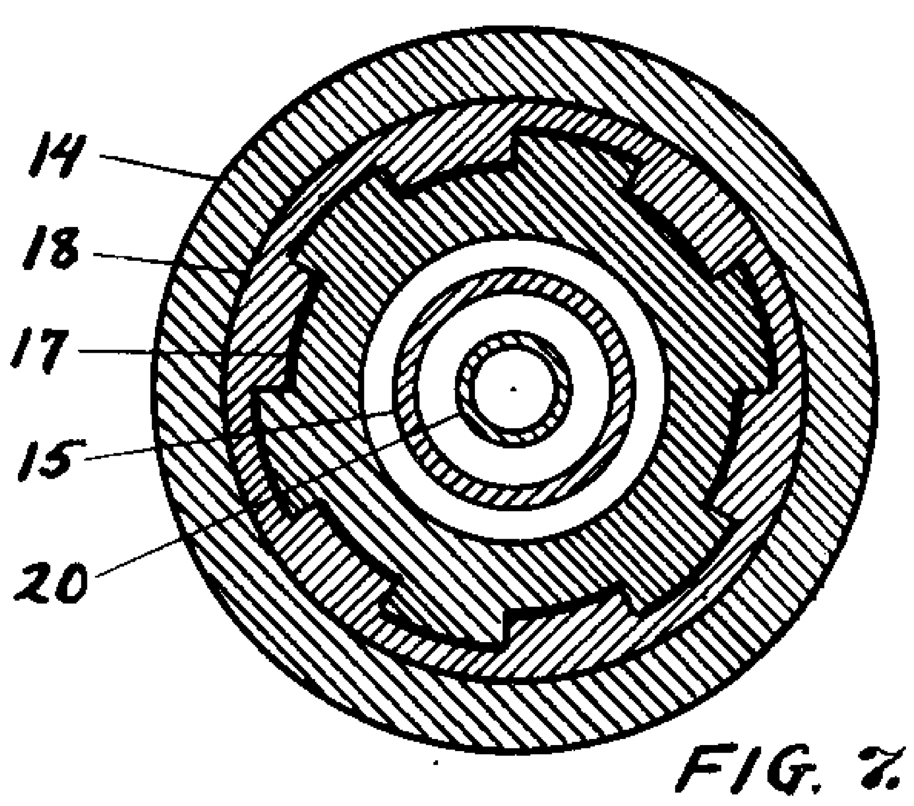

FIG. 7.

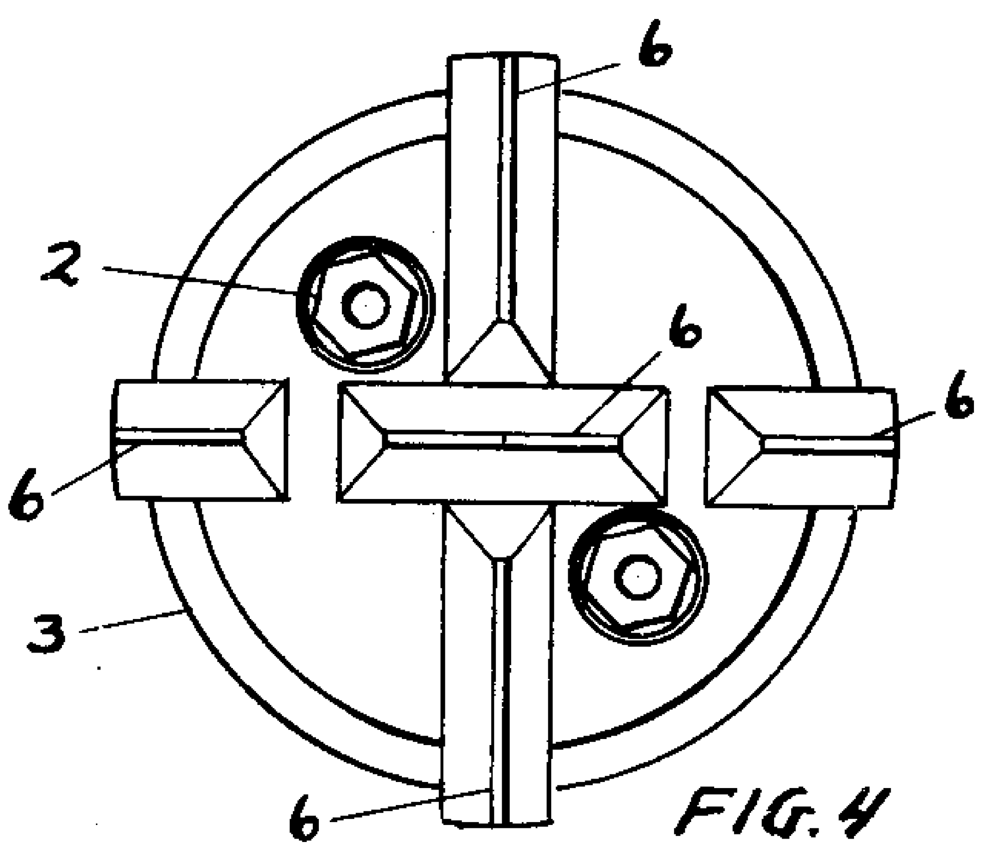

FIG. 4

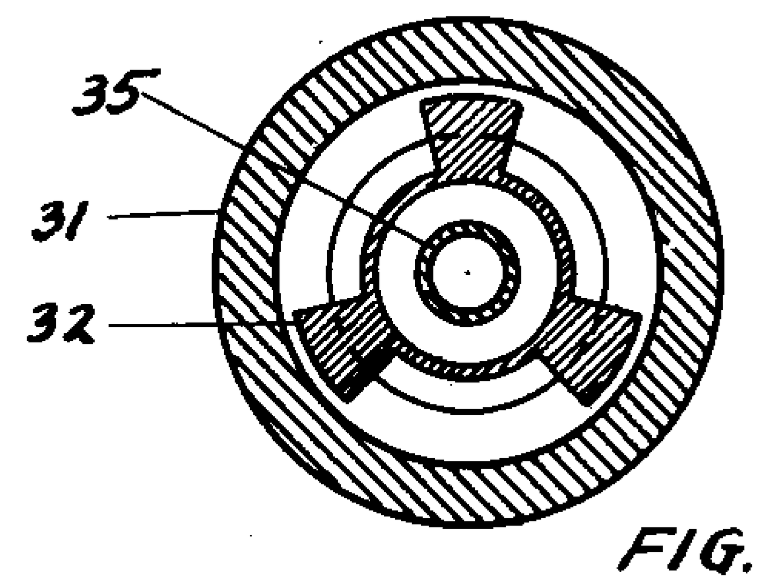

FIG. 8.

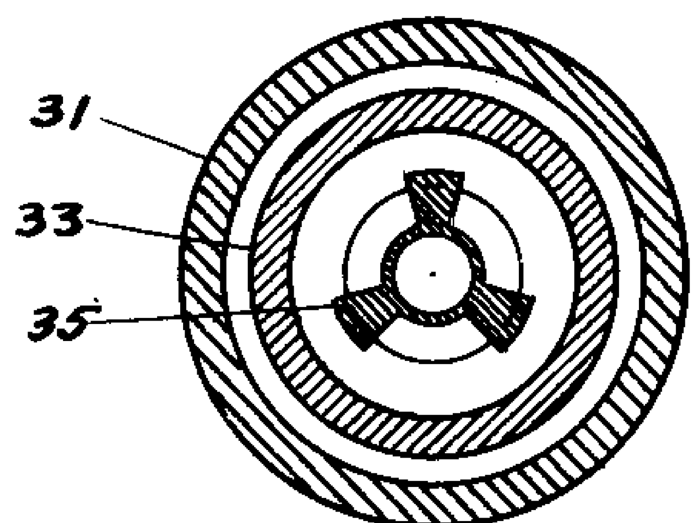

FIG. 9.

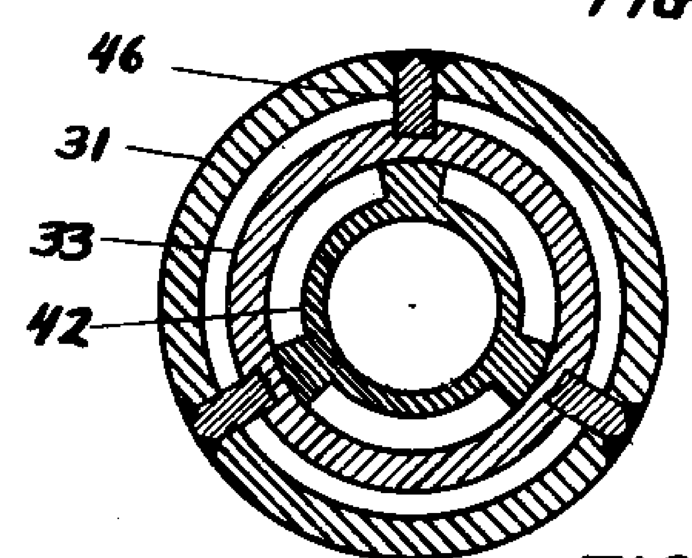

FIG. 10.

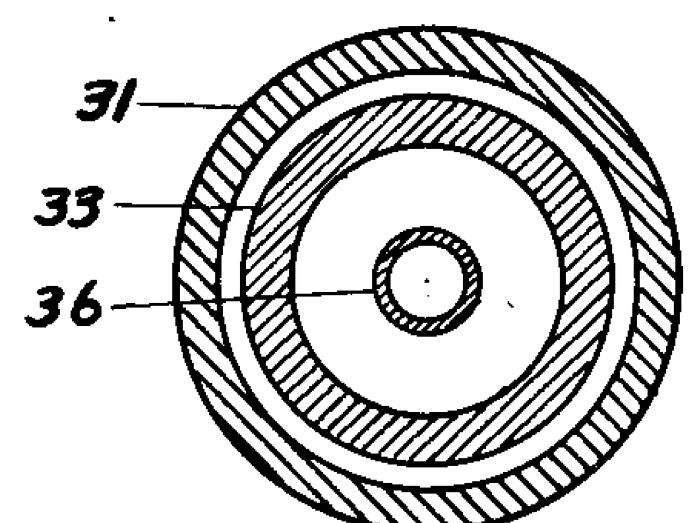

FIG. 11.

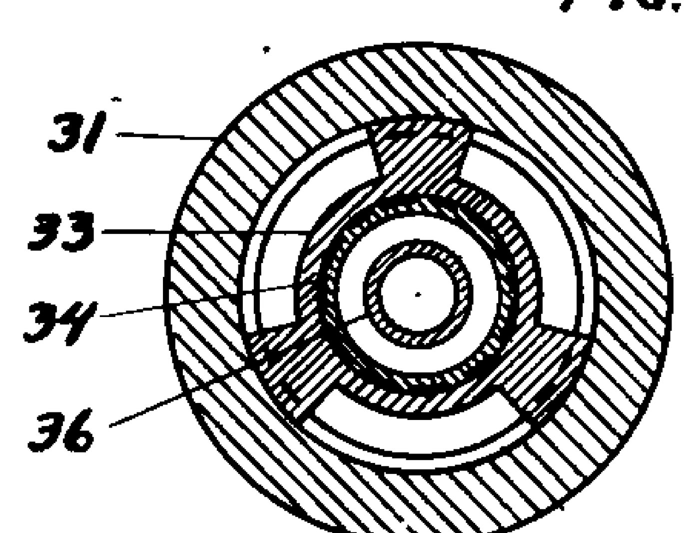

FIG. 12.

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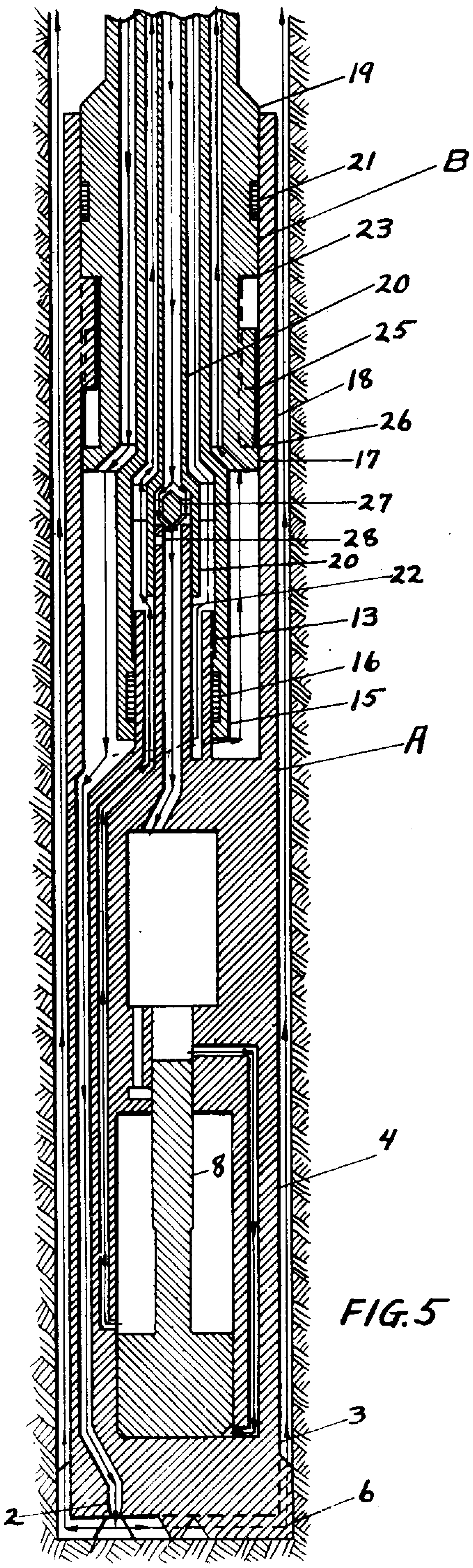

FIG. 5

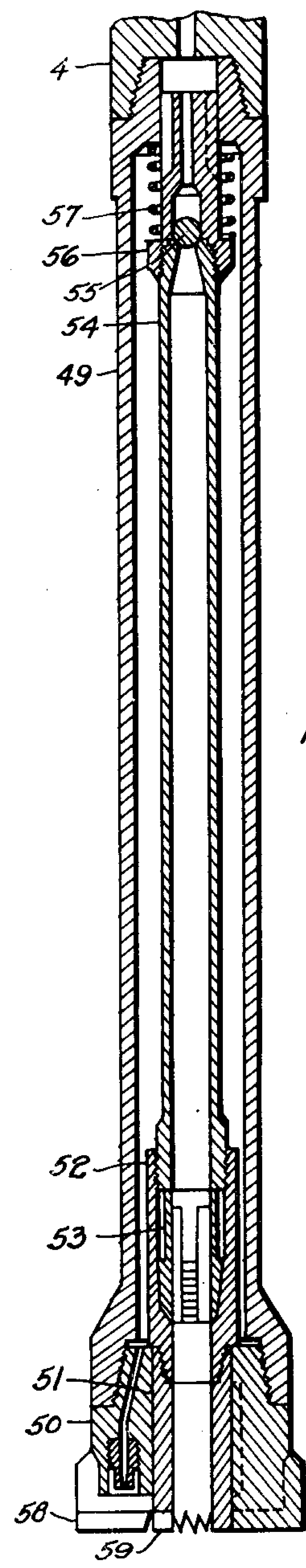

FIG. 13

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Patented Feb. 14, 1933 1,897,121

UNITED STATES PATENT OFFICE

IRVING C. HARRIS, OF LOS ANGELES, CALIFORNIA

DRILLING MACHINE

Application filed April 7, 1930. Serial No. 442,289.

This invention specifically relates to a mechanism for drilling holes in the earth, as for oil, gas, or water, forming bore holes in search for minerals, or to ascertain the nature of the underlying strata, etc.

The present invention will generally be used in connection with devices disclosed in my companion application Serial Number 381,328.

An object of this invention is to provide a drilling mechanism of superior effectiveness and efficiency in forming holes of large diameter to great depths, such for example as holes six inches to two feet in diameter and several thousand feet in depth.

Another object of this invention is to provide a drilling machine which is so constructed and may be so operated as to insure the drilling of hard, soft, and variable formations rapidly and with a minimum of "drift" or departure of the bore from a straight line.

Another object is to provide a mechanism that is so constructed that it may be operated with a minimum of mechanical torque and axial pressure transmitted through the drill-stem, or drill-pipe, from the turn-table at the surface of the ground to the cutting tools at the bottom of the hole, in order to eliminate, or greatly reduce, the number of occasions when drilling tools have to be "fished" out of the hole because of the twisting off of the drill-pipe, or drill-stem, by the application of excessive torque and pressure.

Another object is to provide a mechanism so constructed that cutting tools may be operated by the pressure and flow of compressed air, compressed gas, or any other fluid conveyed to and from the drilling mechanism at the bottom of the hole without mingling with or being affected by the fluid filling the hole being bored, which latter fluid may be, also, used for scavenging, or removing the cuttings made by the drilling operation by circulating it through a conduit for the purpose in the drill-pipe and upward outside of the same.

Another object is to provide a mechanism so constructed that the cutting tools and their actuating mechanism may be operated in a fluid-filled hole under great hydrostatic pressure and be fully protected from loss of efficiency or stoppage by leakage of the said fluid into the mechanism and the conduits conveying the actuating fluid to and from the mechanism at the bottom of the hole.

Another object is to provide a mechanism so constructed that the cutting tools and their actuating mechanisms may be relieved of the great weight of the drill-pipe, or drill-stem, in deep holes, and the pressure of the cutting tools on the bottom of the hole and the feeding of the said tools forward as drilling progresses may be accurately regulated by means independent of the weight and downward pressure of the drill-pipe, or drill stem.

Another object is to provide a mechanism in which the hydrostatic pressure of the fluid filling the bore may be balanced, or overbalanced, as desired, by the pressure of the scavenging fluid within the mechanism in order that, when the cutting edges of the drill are pressed upon the bottom of the hole by the weight of the mechanism and any downward thrust of the scavenging fluid within the mechanism, the maximum force of the hammer blows struck by the fluid-pressure actuated mechanism may be delivered upon the virgin material to be broken from the bottom of the hole.

Another object is to provide a mechanism of the maximum simplicity and a minimum of parts, accomplished by causing certain parts to perform dual functions.

Another object is to provide a means for controlling the pressure of the cutting tools on the bottom of the bore and feeding them downward by means of a hydraulic balance mechanism incorporated in a telescopic joint, which mechanism will have a minimum of parts and be of maximum simplicity of operation.

Another object is to provide a mechanism so constructed that indicating signals may be automatically transmitted from the drilling mechanism at the bottom of the hole to the operator at the surface of the ground, which signals will indicate the position and progress of the cutting tools and enable the operator to properly regulate the pressure on the cutting tools and the feeding of the same downward.

Another object is to provide a drilling mechanism possessing certain rugged details in the cutting tools and their mountings, in combination with other advantages set forth herein, which will enable them to withstand the heavy stresses imposed both in normal operation and by accident or errors of operation, to the end that withdrawals for sharpening, replacement, or repair may be made a minimum.

Another object is to provide a drilling mechanism of the above character which possesses the following parts and features, to wit:

First.—A tubular, revolvable stem, in common usage and hereinafter called a drill-pipe, which drill-pipe has a plurality of conduits, ducts, or passageways, throughout its length, through which fluids may be passed, and which drill-pipe is adapted to be lowered into the bore being formed and be rotated about its axis, carrying the drilling mechanism attached at its lower end.

Second.—A telescopic pressure control mechanism, attached to the lower end of the drill-pipe, and incorporating within it means for providing a limited, axial, telescopic movement, and, at the same time, means of insuring the simultaneous rotation of all of its parts on the axis of the unit regardless of their relative axial position, means of preventing the intermingling of the fluids in the several conduits in passage through the unit, means of utilizing the relative pressures of the fluids in the several conduits in controlling the axial movement of the telescopic joint, and means of transmitting signals through the fluids along the length of the drill-pipe, which signals will indicate to the operator the position and movement of the pressure control mechanism.

Third.—A drilling unit connected below and, through the pressure control mechanism, to the drill-pipe, and consisting of a cutting tool, or cutting tools, actuated by a hammer mechanism operated by fluid, as compressed air, gas, or any other compressed fluid.

A further object is to provide a construction whereby the parts may be readily assembled and disassociated.

With the foregoing objects in view, together with such other objects and advantages as may subsequently appear, the invention resides in parts, and in the construction, combination and arrangement of parts and their equivalents, hereinafter described and claimed and illustrated by way of example in the accompanying drawings, in which:

Fig. 1 is a view as seen in side elevation and axial section, showing the drilling unit and a small part of the pressure control unit.

Fig. 2 is a view as seen in side elevation and axial section, showing the pressure control unit. The two units join on line 1—1 indicated in both figures.

Fig. 3 is a view as seen in side elevation and axial section, showing a tool-joint used for connecting together the sections of the drill-pipe.

Fig. 4 is a view as seen in end elevation, showing the drilling unit as it appears when viewed from the bottom looking upward.

Fig. 5 is a diagrammatic representation of a drilling machine of the character described, including the drilling and pressure control units as they appear when drilling.

Fig. 6 is a view of the drilling unit, as seen in cross section at right angles to its axis, at the elevation indicated by the section line 6—6 in Fig. 1.

Fig. 7 is a view of the pressure control unit, as seen in cross section at right angles to its axis and at the elevation indicated by the section line 7—7 in Fig. 2.

Figures 8, 9, 10, 11, and 12 are views of the tool-joint, shown in Fig. 3, and are cross-sectional views taken in planes at right angles to the axis of the tool-joint and at the elevations and in the directions indicated by the section lines 8—8, 9—9, 10—10, 11—11, and 12—12, respectively, in Fig. 3. All of the parts shown in cross section are indicated by the same numerals as in Fig. 3; and the construction of the tool-joint may be readily understood from the Figs. 3 and 8 to 12 both inclusive.

Fig. 13 is a view in axial section of an elongated form of drill-head used in the place of the one shown as part 3, in Fig. 1, and enclosing a core-bit and core-barrel assembly for the purpose of taking cores of the material being drilled.

The principles of operation are illustrated by the diagrammatic representation in Fig. 5, in which the numbers indicate the position of the parts of the same number in the other figures; and they are described as follows:

The members of the combined assembly of the drilling unit and the pressure control unit, and the connecting drill-pipe above, are divided into two groups which have a limited, relative, telescopic movement in an axial direction with respect to each other, the movement taking place in a telescopic joint. The telescopic joint has interlocking members which cause both groups of members to rotate on their common axis together regardless of the relative axial position of its members. The two groups are indicated in the diagram by cross-hatching, group A, which is the lower group and includes the drilling unit and a part of the pressure control unit, being hatched in one direction, and group B, which is the upper group and includes the balance of the pressure control unit and the drill-pipe extending to the ground surface, being hatched in the reverse direction.

In operation, the entire mechanism is rotated in the hole being bored, by the drill-pipe, which is connected to and rotated by a mechanism, not shown, at the surface of the ground. A fluid, consisting of water and clay and fine detrital material, is pumped down through the drill-pipe and the pressure control and drilling units, through the nozzles, part 2, and back to the surface in the space between the mechanism and the wall of the hole, as indicated by the arrows in the conduits through which this fluid, herein designated scavenging fluid, circulates.

A fluid used in actuating the drilling mechanism passes through the mechanism as indicated by the arrows in the other ducts.

There is a drop of pressure of the scavenging fluid in passing through the nozzles, 2, at the bottom of the drilling unit, and the passageway above them, which may by varied by interchange of parts; and this causes the pressure of the scavenging fluid within the pressure control unit to be greater than the pressure of the fluid in the hole outside at the same elevation. Packing 21 is to prevent the escape of the fluid within to the outside and, also, to form, with associated parts, a plunger upon which may act the pressures of the fluid within and without. The effective area of this plunger is the cross-sectional area of the bore of part 18 in which packing 21 slides.

Packing 16 prevents the pressure of the scavenging fluid from entering the conduits in which the actuating fluid is conveyed to and from the actuating mechanism. Packing 16 slides upon sleeve 13, and forms a plunger, the effective area of which is the cross-sectional area of the outside of sleeve 13 where packing 16 slides upon it.

Sleeve 22 slides in sleeve 20 where they are telescoped together; and there is a plunger formed here, the effective area of which is the cross-sectional area of the bore of sleeve 20 in which sleeve 22 slides.

The three plungers thus described are acted upon by thrusts due to the pressure of the several fluids as described as follows: The scavenging fluid filling the well has a buoyant effect upon all of the equipment in proportion to the fluid displaced. The drill-pipe and the other parts that are included in group B above, have a weight far beyond the buoyant effect; and the drill-pipe is raised or lowered only by manipulation of the mechanism at the surface of the ground by the operator; hence the group B may be considered as fixed in considering these forces. The parts designated as group A are free to move on the telescopic joint in response to the resultant of the several thrusts. The buoyant effect of the scavenging fluid in the well acts upon group A as a thrust upwards and is effective upon the entire effective area of the plunger formed where packing 21 slides within the bore of part 18, as described above.

The pressure of the scavenging fluid within the pressure control unit exerts a thrust in a downward direction upon the same area, minus the area of the plunger formed where packing 16 slides upon sleeve 13, as described above; because the pressure of the scavenging fluid within can not act on this area in a downward direction, while scavenging fluid outside does act upward on the projection of this area at the bottom of the drilling unit.

The pressure of the exhaust actuating fluid produces a thrust downward on the effective area of the latter plunger, minus the effective area of the plunger formed where sleeve 22 slides in sleeve 20, as described above. Also, the pressure of the compressed actuating fluid exerts a downward thrust upon the area of the plunger last named. The thrusts of the actuating fluid pressures are generally small in proportion to the other thrusts, because of lower pressures and smaller areas.

Summarizing these forces tending to cause movement upon the telescopic joint, the buoyant effect of the scavenging fluid in the hole outside of the mechanism, tending to move the parts represented by group A, in Fig. 5, upward, is opposed by all of the other thrusts, as described, plus the force of gravity upon all of the parts represented by group A, in Fig. 5. By a suitable proportioning of the areas of the various plungers and the pressures of the fluids acting upon them, and the weight of the parts represented by group A, the resultant effect can be made to vary from a thrust tending to move group A upward to a thrust tending to move group A downward, or to exert a downward pressure of the cutting tools, 6, on the bottom of the hole when they are in contact with it.

The pressure of the scavenging fluid being pumped down to the drilling mechanism through the drill-pipe is the factor having the greatest effect and most readily controllable in operation; hence the pressure of the cutting tools on the bottom of the hole can be regulated by varying the pressure of the scavenging fluid being pumped while the other pressures are regulated to suit other requirements.

In operation, the pressure on the cutting tools is regulated for proper value by selection of the correct size of nozzle 2 and maintenance of the correct pressure of the scavenging fluid; and, as the entire mechanism is slowly rotated in the hole, the hammer, part 8, is rapidly reciprocated by the actuating fluid, striking very heavy percussive blows on the anvil block, 7 in Fig. 1, which are transmitted through the drill-casing to the cutting edges, 6, to the rock, crushing it. The scavenging fluid, from the nozzles 2 wash the crushed material away and out of the hole. On its return stroke, the hammer, 8, is cushioned by compression of the actuating fluid; and the recoil, in an upward direction, tends to lift group A slightly; but the downward pressure is controlled so as to a little more than balance the recoil. The telescopic joint provides for all relative movement axially between the parts A and B, in Fig. 5, whether required by the regulatory functions of the pressure control mechanism or by the reciprocation of the drilling mechanism, thus performing a dual function and dispensing with many parts used in other designs. This is one of the important advantages claimed for this invention and distinguishes it from the prior art.

The reciprocating movement produced by the hammer mechanism is very slight, being only the penetration per blow and of the order of a few hundredths of an inch at most. This is cushioned and absorbed by the telescopic joint of the pressure control mechanism; and the factors involved are the balance between two columns of fluid reaching to the surface of the ground and connected together at the bottom through a nozzle which introduces some resistance, the elasticity of the walls of the ducts in the drill-pipe and the mechanism, and the compressibility of water,—small as it is,—which is increased to a greater or less extent by being generally somewhat impregnated with gas or air. To this may be added air chambers in or near the telescopic joint which may retain some of the gas or air that may be in the water or may be intentionally introduced for the purpose. The slow movements of the telescopic joint required by its regulatory functions involve only the slow adjustment of the balance between the two columns of scavenging fluid.

Attention is called to an important feature of this invention which is the fact that the entire mechanism below ground level contains but one moving packing which is subject to the full pressure of the high pressure scavenging fluid; and that packing is a small one, viz: packing 16. Packing 21 is subject to the difference in the pressures of the scavenging fluid within the mechanism and without the same, the difference being but a few hundred pounds per square inch at most; and a slight leakage through this packing would not be serious. All other joints are subject to static pressures only. The construction of a complete drilling mechanism, including a pressure control device, with but one sliding joint which must be packed against the maximum hydrostatic pressure and with that sliding joint performing functions previously requiring two or more sliding joints, is one of the important advantages of this invention and distinguishes it from the prior art.

A specific embodiment of the invention illustrated by the diagrammatic representation in Fig. 5 is shown in Figs. 1, 2, 4, 6, and 7, in which details are given which may be readily understood from the numbers which indicate the position of the various parts in the various figures. Particular attention is called to Fig. 7, which shows by a cross-section how the parts 17 and 18 interlock by means of splines in a manner such that the two parts must rotate on their common axis together regardless of their relative axial position.

Fig. 4 shows how the cutting tools appear when viewed from the bottom, the cutting edges being indicated by the number 6. The nozzles that direct the scavenging fluid upon the bottom to wash away the cuttings are designated by the number 2.

In Fig. 1, part 4 is the main part of the drill-casing to which the sleeve 5 is welded, forming in connection with channels, cut in the outside of part 4 before the sleeve 5 is put in place, a system of ducts through which the scavenging fluid is conveyed from the pressure control unit to the drill-head, 3, and to the nozzles, 2, as indicated by the arrows. The drill-head is rigidly attached to the drill-casing by means of the threaded, tapered joint and abutting shoulders, as shown. The hammer, 8, delivers its blows upon anvil block, 7; and the impulse is transmitted through the metal to the cutting edges, 6, without there being any sliding member at the lower end of the drilling mechanism that must be packed against the high pressure scavenging fluid. All reciprocating movement occasioned by the blows of the hammer upon the drill casing and the drill-head is compensated by the telescopic joint in the pressure control unit.

Parts 9 and 10 are sleeves pressed in the drill-casing, 4; and they, in connection with channels cut in casing 4, form the ducts through which the actuating fluid flows, as indicated by the arrows, in causing the reciprocating movements of the hammer, 8. In the illustration used, a so-called valveless type of hammer mechanism is shown, in which the hammer itself performs functions as a valve and is the only reciprocating part.

In Fig. 2, part 14 is a part of the enclosing casing of the pressure control mechanism which is connected to the drill-casing 4, of Fig. 1, and to part 18 by threaded joints. In the lower part of 18, is formed the outside interlocking member of the telescopic joint which interlocks with a matching construction in part 17. In the upper part of 18 is formed the bore in which packing 21 slides. An annular chamber is formed in 14 by a sleeve, 29, in which air or gas may accumulate.

In Fig. 1, part 11 is a member in which passages for conveying actuating fluid from the hammer mechanism, as indicated by the arrows, are formed and in which is a seat for valve 44, which valve prevents the reversal of the flow of the actuating fluid. This valve prevents fluid from flowing back into the actuating mechanism in case of accidental flooding of the exhaust actuating fluid conduit with scavenging fluid; and this is a very important feature claimed for this invention, distinguishing it from prior art. The sleeve 22, in Figs. 1 and 2, is welded to part 11; and these parts provide the passageway for the actuating fluid to flow to the hammer mechanism, as indicated by the arrows.

In Fig. 1, part 13 is connected with drill-casing 4 by a threaded joint and lock rings holding it against the shoulder of part 11; and packing 12 seals the scavenging fluid from entry into the hammer mechanism at this junction. The upper portion of 13, as shown in Figs. 1 and 2, is in the form of a sleeve upon which packing 16 slides. Packing 16, seals the scavenging fluid from entry into the hammer mechanism at this junction, and is the only packing exposed to the full difference in pressure of the scavenging fluid and the exhaust actuating fluid which has any movement between the packing and the sleeve during operation of the mechanism.

The parts designated 13, 14, 18, 22, and 29, in Fig. 2, are the only parts rigidly connected to the hammer mechanism; and they move together with respect to the telescopic joint. All other parts shown in Fig. 2 are rigidly connected to the drill-pipe and move together with respect to the telescopic joint.

In Fig. 2, part 15 is a sleeve carrying packing 16, which slides on sleeve 13, and forming the wall of the pressure control mechanism that separates the outside conduit carrying the scavenging fluid downward, as indicated by the arrows, from the intermediate conduit carrying the exhaust actuating fluid upward, as indicated by arrows. Attached by welding to 16, is part 17 in which is formed the inside interlocking member of the telescopic joint. Part 17 is connected to part 19 by a threaded joint; and the shoulder 23 of part 19 and the shoulder 26 of part 17 provide with the companion shoulders 23 and 25 of part 18 the means of limiting the axial travel of the telescopic joint.

In Fig. 2, part 20 is a tubular member carrying a sleeve at its lower end which telescopes outside of sleeve 22; and the two form, within the pressure control mechanism, the conduit for conveying the actuating fluid downward to the hammer mechanism, as indicated by the arrows, and separate it from the exhaust actuating fluid moving upward, as indicated by the arrows. The two telescoping sleeves 20 and 22 form a sleeve valve mechanism, so constructed that when the telescopic joint approaches its extended position, as when shoulders 25 and 26 come together and the shoulders at 23 separate, sleeve 20 uncovers port 28, allowing the actuating fluid flowing downward to discharge directly into the exhaust actuating fluid conduit and upward to the exhaust outlet without going through the hammer mechanism. This path gives less resistance to the flow of the actuating fluid, and, consequently, causes an increase in the flow of scavenging fluid in both conduits that may be observed by the operator.

A conical plug, 27, supported within sleeve 20, forms, in connection with a seat in the end of sleeve 22, a means of throttling or cutting off entirely, as desired and provided by adjustment, the flow of the actuating fluid downward to the hammer mechanism when the telescopic joint is in its closed position. This causes a reduction, or stoppage, of flow of the actuating fluid in both conduits which may be observed by the operator. When the telescopic joint is between these two extreme positions, the actuating fluid flows to and from the hammer mechanism normally.

The upper ends of parts 15, 19, and 20 are formed, with associated auxiliary parts, into the lower part of a tool-joint to mate with the upper part of a tool-joint such as is used in connecting together the sections of drill-pipe.

Attention is called to the fact that, by using an elongated cutting-tool head with a hollow center and with cutting edges so placed as to detach all of the material from the bottom of the hole excepting a core in the center, together with an assembly of core-barrel parts, of usual construction, for receiving, detaching and retaining the core material, this drilling machine may be used for taking cores or samples of the formations being drilled.

An axial section of such a combination is shown in Fig. 13, in which 49 is an elongated, tubular, separable extension of drill-head 50, which is similar to drill-head 3 shown in Fig. 1, by means of which, drill-head 50 is connected to the drill-body 4 in Fig. 1 in the place of drill-head 3.

Parts 51 to 56 inclusive represent the principal members of a core-bit and core-barrel assembly, of construction commonly used in rotary drilling, in which 51 is the core-bit, 52 the core-catcher housing, 53 the core-catcher slips, 54 the core-barrel, 55 a valve, and 56 the valve housing. Part 57 is a retaining spring. Core-bit 51 is keyed to drill-head 50 and rotates with it. Cutting edges 58 of drill-head 50 excavate the material from the bottom by percussion; and the cutting edges 59 of the core-bit trim off material not removed by the cutting edges 58, the remaining core being received into the interior of the core-barrel as it works downward. When the assembly is lifted, in removing from the hole, the core-catcher slips grip the core, breaking it off and bringing it out with the core-barrel.

The features and advantages distinguishing this invention from the prior art lie in the combination of core-bit and core-barrel assemblies of the ordinary rotary type with a pneumatic, percussion hammer drill of a novel type, in which the combined assembly is held in close contact with the material at the bottom of the hole by a hydraulic control and percussively operated with a very limited reciprocatory travel of the percussion bit, making it possible to take core samples while drilling with a percussion bit and thereby combining the superior advantages of the rotary core drilling method and the superior advantages of the percussion bit as an excavator.

Having described the detail construction of this specific embodiment of the invention, it is pointed out that the essential characteristics of its operation will be the same as previously described for the diagrammatic representation, the important elements bearing the same numbers in both.

Having described the invention, attention is called to the manner in which it fulfills the objects set forth herein. When operated substantially as described, viz: with the hammer mechanism being actuated while it is being slowly rotated by the drill-pipe, with the pressures governing the pressure control mechanism adjusted so that the drill-head, drill-casing, and all parts rigidly attached to the lower part of the telescopic joint, are pressed downward with a pressure sufficient to overcome the recoil due to the return of the hammer and to insure the cutting edges being in contact with the virgin rock, and with the scavenging fluid washing the cuttings away from the cutting edges as fast as made, effective drilling will be accomplished with only a slight steady pressure of the tools on the bottom and a slight torque, transmitted through the drill-pipe, to rotate the drilling mechanism and traverse the cutting edges over the bottom of the hole.

By the means described, it will be seen that the cutting edges will be kept in close contact with the virgin rock on the bottom of the well, but without excessive steady pressure; and the full energy of the percussive blows of the hammer will be delivered to the virgin rock without being dissipated by intervening loose material, as is the case with percussion drills of the usual type used in well drilling.

The slight reciprocatory movement of the drill-casing and the parts rigidly attached to it, will be compensated in the telescopic joint of the pressure control; and this movement will tend to make the pressure control mechanism more "lively", responsive, and sensitive in respect to its functions in regulating the pressure of the cutting edges on the bottom and the feeding of the same downward.

The entire mechanism will be immersed in scavenging fluid, the pressure of which in deep drilling will be measured in thousands of pounds per square inch. The keeping of this pressure out of the drilling mechanism and the actuating fluid conduits is one of the greatest problems; and it is pointed out that, in this invention, there is but one joint that moves during operation that has to be packed against the full pressure of the scavenging fluid. All others are under static pressures only. This one moving joint is small, readily maintained in good condition or renewed, and performs a dual function.

It is pointed out that the apparatus described is of rugged, simple construction for the purpose, with very few parts, readily assembled and disassembled, with few joints in the mechanisms exposed to high fluid pressures, and that it is capable of being operated in a fluid-filled hole under high pressures.

Particular attention is called to the fact that, in any apparatus of the type described immersed in fluid under high pressure, the hydrostatic pressure outside opposes any outward movement of a plunger, such as a drill-stem which must reciprocate through a packing, as in other designs of fluid-pressure-operated drilling machines, the opposition being calculable from the area of the drill-stem where it slides through the packing and the difference between the pressure of the fluid in the well and the pressure within the mechanism. In other types of drilling machines of this general character, such for instance as multiple hammer drills, where several cutting tools are independently actuated and must reciprocate independently, and single hammer types without hydraulic balance pressure control, the opposition of the fluid pressure in the well, as described, absorbs much of the energy of the blows of the hammers. An important feature of this invention lies in the fact that, by means of the pressure control mechanism described, this opposition may be balanced, or overbalanced, as desired, giving a corresponding increase in the effectiveness of the blows of the hammer.

To those familiar with the drilling of deep wells in rock formations, it is known that heavy downward pressure on the drill-pipe and cutting tools and heavy rotative torque transmitted through the drill-pipe to the cutting tools, especially when drilling variable formations with strata dipping from the horizontal, produce reactions that are causes of "drift" or the departure of the hole from a straight line, and, also, causes of the twisting-off of drill-pipe. It is pointed out that this invention provides for effective drilling without using heavy, steady downward pressure and heavy rotative torque, and that, consequently, "drift" and the twisting-off of drill-pipe will be reduced toward a minimum. The signals transmitted to the operator by means of the variations in flow of the actuating fluid, as described, that are produced by the pressure control mechanism, enable the operator to accurately control these forces.

While I have shown and described a specific embodiment of the invention, I do not limit myself to the exact details in construction disclosed, but may employ such changes in construction and arrangements of parts, and such modifications and equivalents as come within the scope of the appended claims.

I claim:

1. In a drilling machine of the character described, a rotatable drill-pipe; a fluid-pressure-actuated drilling mechanism connected to the drill-pipe and rotatable with the same; a fluid-pressure-actuated hammer mechanism comprising the lower part and a control mechanism comprising the upper part of the drilling mechanism, the two said mechanisms being slidably connected with each other to permit relative movement between the two in an axial direction; a drill-head rigidly connected to the lower end of the cylinder of the hammer mechanism and adapted to be percussively actuated by blows of the hammer transmitted through the end of the cylinder and the rigid connection between the cylinder and the drill-head; means of actuating the control mechanism to cause movement of the slidable connection aforesaid necessary to regulate the feeding of the hammer mechanism and the drill-head downward; means of conveying the scavenging fluid to and from the drilling mechanism; means of conveying the actuating fluid to and from the drilling mechanism, in which a valve is placed in the discharge conduit near the exhaust of the hammer mechanism and so constructed as to prevent a flow of fluid in a reverse direction back into the hammer mechanism; a chamber, in communication with the scavenging fluid and near the control mechanism, in which gas may be trapped and stored to provide a cushion of compressible fluid in communication with the scavenging fluid.

2. In a drilling machine of the character described, a rotatable drill-pipe; a fluid-pressure-operated drilling mechanism connected to the drill-pipe and rotatable with the same; a fluid-pressure-actuated hammer mechanism comprising the lower part and a control mechanism comprising the upper part of the drilling mechanism, the two mechanisms being slidably connected with each other in a manner to permit relative movement between the two in an axial direction; a drill-head rigidly connected to the lower end of the cylinder of the hammer mechanism and adapted to be percussively actuated by blows of the hammer transmitted through the end of the cylinder and the rigid connection between the cylinder and the drill-head; means of actuating the control mechanism to cause movement of the slidable connection necessary to regulate the feeding of the hammer mechanism and the drill-head downward; means of conveying the scavenging fluid to and from the drilling mechanism; means of conveying the actuating fluid to and from the drilling mechanism, in which a valve is placed in the discharge conduit near the exhaust of the hammer mechanism and so constructed as to prevent a flow of fluid in a reverse direction back into the hammer mechanism.

3. In a drilling machine of the character described, a rotatable drill-pipe; a fluid-pressure-operated drilling mechanism connected to the drill-pipe and rotatable with the same; a fluid-pressure-actuated hammer mechanism comprising the lower part and a control mechanism comprising the upper part of the drilling mechanism, the two said mechanisms being slidably connected with each other to permit relative movement between the two in an axial direction; a drill-head connected to the lower end of the hammer mechanism and adapted to be actuated by percussive blows of the hammer transmitted through the end of the cylinder of the hammer mechanism to which the drill-head is rigidly attached; means of actuating the control mechanism to cause movement of the slidable connection aforesaid necessary to regulate the pressure of the hammer mechanism and the drill-head on the bottom and feeding the same downward; means of conveying the scavenging fluid to and from the drilling mechanism, in which a chamber opening at its lower end into a conduit conveying the scavenging fluid is so constructed and disposed as to trap and store gas in manner to act as a cushion of compressible fluid in communication with the scavenging fluid.

4. In a drilling machine of the character described, a rotatable drill-pipe; a fluid-pressure-operated drilling mechanism connected to the drill-pipe and rotatable with the same; a fluid-pressure-actuated hammer mechanism comprising the lower part and a control mechanism comprising the upper part of the drilling mechanism, the two said mechanisms being slidably connected to each other in a manner to permit relative movement axially between the two; a drill-head rigidly connected to the lower end of the cylinder of the hammer mechanism and adapted to be actuated by percussive blows of the hammer transmitted through the end of the cylinder and the rigid connection between the cylinder and the drill-head; means of actuating the control mechanism to cause movement of the slidable connection aforesaid necessary to regulate the pressure of the drill-head on the bottom of the hole and the feeding of the same downward; means of conveying to and

from the drilling mechanism the fluids required in its operation.

5. In a drilling machine of the character described, a rotatable drill-pipe; a fluid-pressure-operated drilling mechanism connected to the drill-pipe and rotatable with the same; a fluid-pressure-actuated hammer mechanism comprising the lower part and a control mechanism comprising the upper part of the drilling mechanism, the two said mechanisms being slidably connected with each other in a manner to permit relative movement between the two in an axial direction; a drill-head rigidly connected to the lower end of the cylinder of the hammer mechanism and adapted to be percussively actuated by blows of the hammer transmitted through the end of the said cylinder and the rigid connection between the cylinder and the drill-head, the said drill-head comprising a cutter-head and a tubular means of connecting it to the cylinder aforesaid, the two enclosing a core-bit and core-barrel assembly, the cutter head being adapted to excavate the material from the bottom of the hole excepting a core in the center, and the core-bit and core-barrel assembly being adapted to trim, receive, detach, and retain the said core; means of actuating the control mechanism to cause movement of the slidable connection aforesaid necessary to regulate the feeding of the hammer mechanism and the drill-head downward; means of conveying the scavenging fluid to and from the drill-head; means of conveying the actuating fluid to and from the drilling mechanism, in which a valve is placed in the discharge conduit near the exhaust of the hammer mechanism and so constructed as to prevent a flow of fluid in a reverse direction into the hammer mechanism; a chamber, in communication with the scavenging fluid and near the control mechanism, in which gas may be trapped and stored to provide a cushion of compressible fluid in communication with the scavenging fluid.

6. In a drilling machine of the character described, a rotatable drill-pipe; a fluid-pressure-operated drilling mechanism connected to the drill-pipe and rotatable with the same; a fluid-pressure-actuated hammer mechanism comprising the lower part and a control mechanism comprising the upper part of the drilling mechanism, the two said mechanisms being slidably connected to each other to permit relative movement between the two in an axial direction; a drill-head assembly rigidly connected to the lower end of the cylinder of the hammer mechanism and adapted to be actuated by percussive blows of the hammer transmitted through the end of the said cylinder and the rigid connection between the cylinder and the drill-head assembly, the said drill-head assembly comprising a drill-head and a tubular means of connecting the same to the cylinder aforesaid, the two enclosing a core-bit and core-barrel assembly, the drill-head being adapted to excavate the material from the bottom of the hole excepting a core in the center, and the core-bit and core-barrel assembly being adapted to trim, receive, detach, and retain the said core; means of actuating the control mechanism to cause movement of the slidable connection aforesaid necessary to regulate the pressure of the drill-head on the bottom of the hole and the feeding of the same downward; means of conveying the scavenging fluid to and from the drill-head; means of conveying the actuating fluid to and from the drilling mechanism, in which a valve is placed in the discharge conduit near the exhaust of the hammer mechanism and so constructed as to prevent a flow of fluid in a reverse direction into the hammer mechanism.

7. In a drilling machine of the character described, a rotatable drill-pipe; a fluid-pressure-operated drilling mechanism connected to the drill-pipe and rotatable with the same; a fluid-pressure-actuated hammer mechanism comprising the lower part and a control mechanism comprising the upper part of the drilling mechanism, the two said mechanisms being slidably connected to each other to permit relative movement between the two in an axial direction; a drill-head assembly rigidly connected to the lower end of the cylinder of the hammer mechanism and adapted to be actuated by percussive blows of the hammer transmitted through the end of the said cylinder and the rigid connection between the cylinder and the drill-head assembly, the said drill-head assembly comprising a drill-head and a tubular means of connecting the same to the cylinder aforesaid, the two enclosing a core-bit and core-barrel assembly, the drill-head being adapted to excavate the material from the bottom of the hole excepting a core in the center, and the core-bit and core-barrel assembly being adapted to trim, receive, detach, and retain said core; means of actuating the control mechanism to cause movement of the slidable connection aforesaid necessary to regulate the pressure of the drill-head on the bottom of the hole and the feeding of the same downward; means of conveying the actuating fluid to and from the drilling mechanism; means of conveying the scavenging fluid to and from the drilling mechanism, in which a chamber opening at its lower end into a conduit conveying scavenging fluid is so constructed and disposed as to trap and store gas in a manner to act as a cushion of compressible fluid in communication with the scavenging fluid.

8. In a drilling machine of the character described, a rotatable drill-pipe; a fluid-pressure-operated drilling mechanism connected to the drill-pipe and rotatable with the same; a fluid-pressure-actuated hammer mechanism comprising the lower part and a

control mechanism comprising the upper part of the drilling mechanism, the two said mechanisms being slidably connected to each other in a manner to permit relative movement axially between the two; a drill-head assembly connected to the lower end of the cylinder of the hammer mechanism and adapted to be actuated by percussive blows of the hammer transmitted through the end of the cylinder and the connection between the said cylinder and the drill-head assembly, the said connection being rigid and non-slidable, the said drill-head assembly comprising a drill-head and tubular means of connecting to the casing aforesaid, the two enclosing a core-bit and core-barrel assembly, the drill-head being adapted to excavate the material from the bottom of the hole excepting a core in the center, and the core-bit and core-barrel assembly being adapted to trim, receive, detach and retain the said core; means of actuating the control mechanism to cause movement of the slidable connection aforesaid necessary to regulate the pressure of the drill-head on the bottom of the hole and the feeding of the same downward; means of conveying to and from the drilling mechanism the fluids required in its operation.

9. In a drilling machine of the character described the combination of a rotatable, multi-duct drill-pipe; a fluid operated drilling mechanism connected to the drill-pipe and rotatable with the same, the said drilling mechanism comprising a series of superimposed and telescopic sections joined together generally by threaded joints, the lower section being a drill-head connected to the lower end of the second section, the latter being a long, tubular section, closed at the lower end and enclosing cylinder liner, hammer, anvil-block, and valve parts of a hammer mechanism for operating the drill-head attached, the wall of the second section being provided with a system of passageways for conveying fluid downward to the drill-head and between the enclosed cylinder of the hammer mechanism and the valve controlling it, the third section being an assembly of tubular members, concentrically disposed, forming three concentric passageways for fluid, the said tubular members being connected with the section below by threaded joints and forming mating connections between the respective passageways for fluid in the two sections and connected with the fourth section by means of a telescopic intermeshing of the third section with companion, tubular members of the fourth section, the intermeshing including interlocking splines and limiting collars, all in a manner such that the third and fourth sections may have a limited movement axially between them but must rotate on their axis together regardless of their relative axial position, the fourth section being adapted for connection to the drill-pipe, and the intermeshed third and fourth sections having between the pairs of tubular members means of preventing leakage of fluid through the slidable joints between the three passageways formed by the three pairs of telescopically intermeshed members.

10. In a drilling machine of the character described, the combination of a rotatable, multi-duct drill-pipe, a fluid operated drilling mechanism connected to the drill-pipe and rotatable with the same, the said drilling mechanism comprising a series of superimposed and telescopic sections joined together generally by threaded joints, the lower section being an assembly of parts comprising a hollow-center drill-head and a long, tubular member connecting it to the second section, the two enclosing a core-bit, core-barrel, core catcher, and auxiliary parts, the second section being a long, tubular section, closed at the lower end and enclosing cylinder liner, hammer, anvil-block, and valve parts of a hammer mechanism for operating the drill head and the lower section attached the wall of the second section being provided with a system of passageways for conveying fluid downward to the lower section and between the enclosed cylinder of the hammer mechanism and the valve controlling it, the third section being an assembly of tubular members, concentrically disposed, forming three concentric passageways for fluid, the said tubular members being connected with the section below by threaded joints and forming mating connections between the respective passageways for fluid in the two sections and connected to the fourth section by means of a telescopic intermeshing of the third section with companion, tubular members off the fourth section, the intermeshing including interlocking splines and limiting collars, all in a manner such that the third and fourth sections may have a limited movement axially between them but must rotate together on their axis regardless of their relative axial position, the fourth section being adapted for connection to the drill-pipe, and the intermeshed third and fourth sections having between the pairs of tubular members means of preventing leakage of fluid through the slidable joints between the three passageways formed by the three pairs of telescopically intermeshed members.

11. In a drilling machine of the character described, the combination of a rotatable, multi-duct drill-pipe; a fluid operated drilling mechanism connected to the drill-pipe and rotatable with the same, the said drilling mechanism comprising a series of superimposed and telescopic sections joined together generally by threaded joints, the lower section being a drill-head connected to the lower end of the second section, the latter being a long, tubular section, closed at the lower end and enclosing cylinder liner, hammer,

anvil-block, and valve parts of a hammer mechanism for operating the drill-head attached. the wall of the second section being provided with a system of passageways for conveying fluid downward to the drill-head and between the enclosed cylinder of the hammer mechanism and the valve controlling it, the third section being as assembly of tubular members, concentrically disposed, forming three concentric passageways for fluid, one of the said passageways being obstructed by a valve placed between the two tubular members forming the passageway near the connection with the second section, the said valve permitting flow of fluid in one direction and preventing flow in the opposite direction, the said tubular members being connected with the section below by threaded joints and forming mating connections between the respective passageways for fluid in the two sections and connected with the fourth section by means of a telescopic intermeshing of the third section with companion, tubular members of the fourth section, the intermeshing including interlocking splines and limiting collars, all in a manner such that the third and fourth sections may have a limited movement axially between them but must rotate on their axis together regardless of their relative axial position, the fourth section being adapted for connection to the drill-pipe, and the intermeshed third and fourth sections having between the pairs of tubular members means of preventing leakage of fluid through the slidable joints between the three passageways formed by the three pairs of telescopically intermeshed members.

12. In a drilling machine of the character described, the combination of a rotatable drill-pipe; a fluid-pressure-operated drilling mechanism connected to the drill-pipe and rotatable with the same; means of conveying to and from the drilling mechanism the fluids required in its operation; a hammer mechanism forming a part of the drilling mechanism and adapted to actuate by percussive blows struck in an axial direction a tubular drill-head assembly having cutting edges adapted to excavate all of the material from the bottom of the hole being drilled except a core in the center; a core-barrel assembly contained within the tubular drill-head assembly and adapted to receive, detach, and retain the said core; means within the drilling mechanism, operable by adjustment of the pressures of the fluids used in operating the drilling mechanism, by which the tubular drill-head assembly and the core-barrel assembly contained therein may be maintained in close contact with the bottom of the hole, the reciprocation of the drill-head and core-barrel assemblies limited, and the feeding of the same downward as drilling progresses regulated.

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