Jan. 4, 1927. 1,612,889

E. SMITH

METHOD AND APPARATUS FOR DRILLING WELLS

Filed May 9. 1923

Fig. 1.

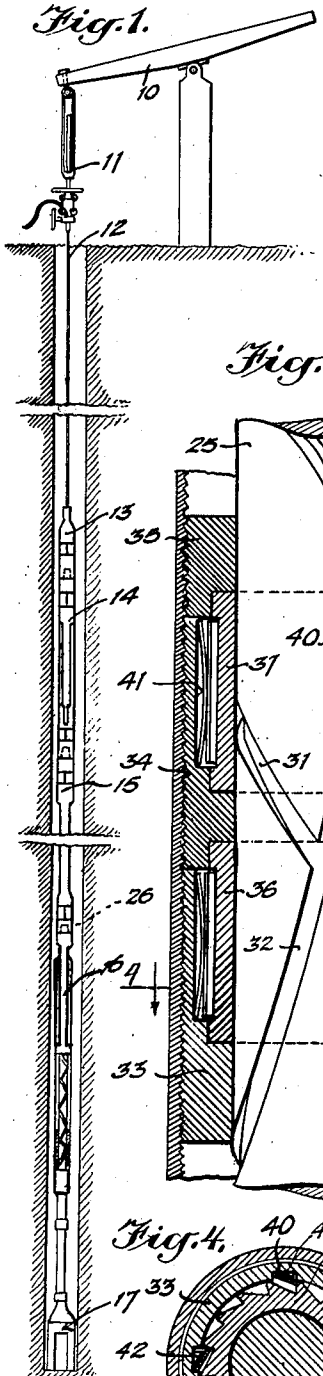


Fig. 2.

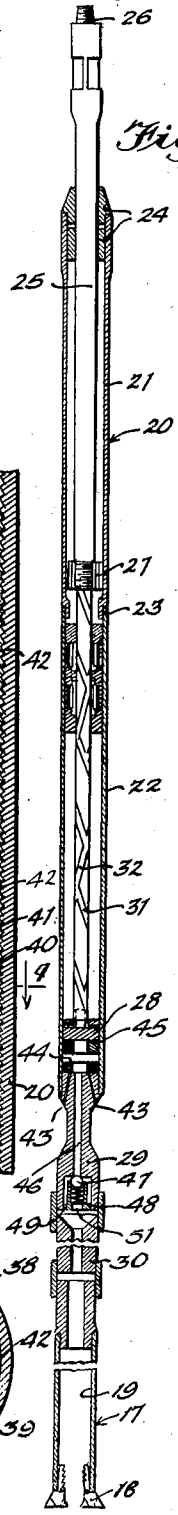


Fig. 3.

Fig. 4.

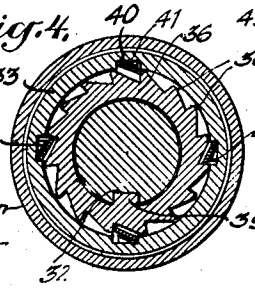


Fig. 5.

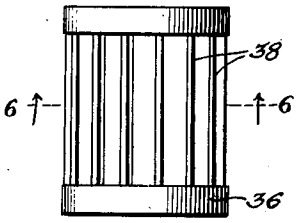


Fig. 6.

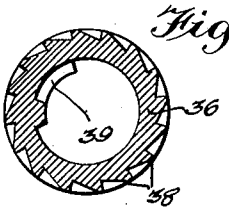


Fig. 7.

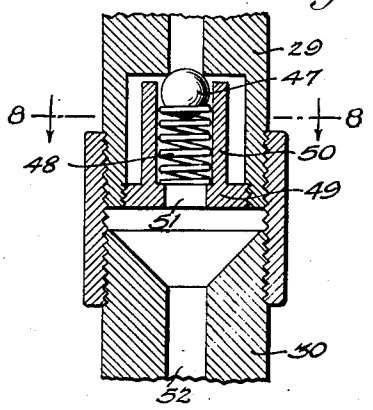
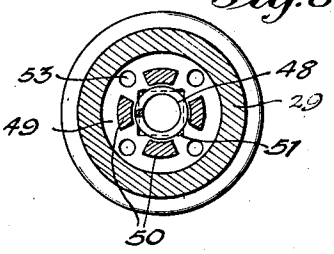


Fig. 8.



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UNITED STATES PATENT OFFICE.

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METHOD AND APPARATUS FOR DRILLING WELLS.

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This invention relates to improvements in a method and apparatus for drilling, reaming, cleaning and boring holes for oil, gas, water or minerals; for prospecting for the same; and for obtaining cores of the rocks drilled through for purposes of determining their dip, composition, porosity, oil or mineral content, correlation and other information of valve.

In well drilling, as at present practiced, two systems are employed, namely, the percussion and the rotary, distinguishable from each other by the kind of motion employed to produce the cutting of the rock or other material being drilled through. The percussion system produces the cutting by a vertical reciprocating motion of a cutting tool suspended from an actuating member extending to the surface of the ground and includes such methods of drilling as the Pennsylvanian (cable), the Canadian, or the Galician (rods). The rotary system produces the cutting by a rotary movement of the cutting tool driven by a rigid connection to a rotating member located at the surface end of the hole, and includes such methods of drilling as are known in practice as the rotary, the calyx, the diamond, the adamantine and other core forming methods.

The percussion system produces the cutting by a hammering action which breaks up or shatters the rock ahead of the tool, downwardly and outwardly at the sides of the hole, and frequently for a considerable distance. The center of this shattered zone is eventually crushed by the impact of the tools and reduced to powder or relatively small fragments which, upon mixing with the drilling water, are removed by bailing. The remainder of the rock in the shattered zone has a tendency to slump or cave into the hole causing considerable trouble in drilling, such as the wedging of tools, the freezing of the casing and frequently the abandoning of the hole. In certain industries, the percussion system has two distinct advantages, namely:—(*a*) nearly universal use so that everything that is needed for the working of the system, including labor, is abundant and easily obtainable; and (*b*) the hole can usually be drilled with very little water so that in the special case of drilling for oil or gas there is little chance of passing through productive beds without discovery. This system, however, has the following disadvantages:—(*a*) the crushing of the rock makes the samples removed much harder to identify than they would be if the rock were not crushed; (*b*) the cavings from above so mix with the rock being actually drilled as to make a correct determination of the latter frequently impossible; and (*c*) the cavings from the shattered zone cause great mechanical difficulties in the operation of drilling and frequently result in the abandoning of the hole.

The rotary system produces the cutting by an auger motion, or by the sawing and chiseling actions of the teeth of a rotating cutter. In order to prevent the cutting tool from heating and to remove the drillings, mud-laden water is forced from the surface down a hollow drill stem to the bottom of the hole and is returned to the surface between the drill stem and the wall of the hole. In this system no zone of shattering is produced and the mud-laden fluid further prevents caving by the hydrostatic pressure it exerts against the wall of the hole. This rotary system has three distinct advantages, namely:—(*a*) the cutting of the rock in such a manner as to obtain a firm wall and to eliminate a zone of shattering; (*b*) the adaptability of the system to the use of core cutting bits which have great economic utility; and (*c*) the wall sustaining action of the mud-laden fluid which makes its use especially valuable in soft rocks and sand which cave too badly to be successfully penetrated by the percussion system. The rotary system, however, has the following disadvantages:—(*a*) its installation is too expensive for drilling shallow wells; (*b*) in practice cores are not frequently taken, especially in drilling for oil or gas, on account of the time lost in running the tools in and out of the hole, and the samples ordinarily obtained and the log of the well have little real economic value; and (*c*) oil or gas bearing horizons are frequently passed unnoticed due to improper handling of the mud-laden fluid.

The main advantages of the two systems, except as applied to rock too soft to stand in an open hole, may be retained and most of the disadvantages of said systems may be

overcome by adapting rotating cutting tools to the percussion system in such a manner as to eliminate the percussion action on the rock. This result is accomplished by means of my improved apparatus which converts the vertical reciprocating motion employed in the percussion system into a rotating motion of the tools, the latter, in themselves, not vertically reciprocating, but resting on the material being cut.

The invention will be better understood by a study of the accompanying drawings, illustrating, by way of example, the preferred embodiment of my invention.

In these drawings—

Figure 1 is a side elevation of the apparatus in operative position and constructed in accordance with the invention;

Figure 2 is a longitudinal sectional view of the portion of the apparatus embodying the features of the present invention;

Figure 3 is an enlarged longitudinal sectional view illustrating the mechanism for imparting rotary movement to the cutting tool;

Figure 4 is a transverse section on the line 4—4 of Figure 3;

Figure 5 is a side elevation of one of the ratchet cylinders utilized in the mechanism shown in Figure 3;

Figure 6 is a transverse section on the line 6—6 of Figure 5;

Figure 7 is an enlarged fragmentary longitudinal section of the pump mechanism employed in connection with the invention; and

Figure 8 is a section on the line 8—8 of Figure 7.

Briefly, the invention contemplates the provision of mechanism for the conversion of a reciprocating movement of a member held against rotation at the surface, such as a drill rod, applied through a flexible sustaining means, such as a cable, rope, etc., or through a rigid sustaining means, such as rods or hollow tubes, into a rotary movement of another member, such as a casing to which a cutting tool is connected, whereby said cutting tool will have imparted thereto only a rotary movement while the same is in operation. Thus, according to my invention the drilling of the hole is accomplished by actuating a rotary cutting tool in contact with the material to be drilled solely by the reciprocatory movement of a member or element extending from the surface of the ground to the drilling apparatus at the bottom of the hole, and utilizing the torsional strength of the actuating member to overcome the force exerted by the material being cut in opposition to the rotation of the tool. As the actuating member, the drive pipe commonly used for rotating the cutting tool in the rotational systems of well drilling may be used, but the actuating member or element preferably employed is one having relatively small torsional rigidity, and the tool is rotated solely by the tensile and torsional strengths of this member, aided, of course, by the action of gravitation, or, in other words, by the weight of the apparatus.

By the term "relatively small torsional rigidity" it is intended to define any member or element for transmitting the driving force from the surface of the ground to the bottom of the hole, the torsional resistance of which is relatively small as compared with that of the drive pipe ordinarily used for rotating the cutting tool in the rotational systems of well drilling. I have discovered that the torsional strength of the cable, rod, or tube commonly used to actuate drilling tools of the percussion type, although having relatively small torsional rigidity, can be employed in an entirely practicable manner to overcome the reaction against the cutting tool of the material being cut, or in other words, the resistance to rotation encountered by the tool, that is, the force which tends to prevent the rotation of the tool. Hence, it is unnecessary to provide the drilling apparatus at the bottom of the hole with means for engaging with the walls of the hole for preventing the rotation of any part of the apparatus.

The conversion of the reciprocating movement into a rotary movement may be accomplished by any suitable means, such as that shown in the accompanying drawing, or by the use of gears and chains, or by hydraulic pressure created by the rise and fall of the reciprocating member, or by the reaction of a lug on one member working in a spiral groove formed in the other member. For convenience in flushing away and thoroughly mixing the drillings with the drilling water and to prevent the bit from heating during drilling, the invention further contemplates the provision of a pumping mechanism actuated under control of the reciprocating member to pump a fluid to the cutting tool while the apparatus is in operation.

The apparatus is shown as including the usual walking beam 10 supporting a temper screw 11 of known construction, to which is connected the cable or rope 12 utilized for lowering the drilling apparatus into a well. Although a flexible element is shown in the accompanying drawing, it is to be expressly understood that a rod, hollow tube, or other means may be utilized instead of said element 12. Rigidly attached to the lower end of the cable 12 is a socket 13 to which is connected what is commonly known as a jar 14 and sinker 15, which are elements usually employed in drilling apparatus of this character. Since these elements form no part of the present invention, they have merely been shown diagrammatically in Fig-

ure 1. Connected to the lower end of the part 15 is a mechanism, generally indicated by the numeral 16, which is a part of the present invention and which is utilized for converting the reciprocating movement of a part of the mechanism into a rotary movement of another part thereof, to which latter part the cutting tool, generally indicated by the numeral 17, is attached. This cutting tool may be of any desired construction, the one shown in the drawings including the drill bit 18 and core barrel 19 in which drillings are collected in the manner well known in the art for the purpose of determining the quality of the material being drilled through.

The mechanism 16 preferably includes the drill casing, generally indicated by the numeral 20, which is preferably made in upper and lower sections 21 and 22 joined at their meeting ends 23. The upper end of the section 21 is provided with bearings 24 in which is slidably mounted the upper portion of the rod 25, the upper extremity of which is provided with a standard tool thread 26 for attachment to the lower end of the part 15. Intermediate the ends of the rod 25 the same is provided with a guide 27, which cooperates with a combined guide and plunger 28 carried by the lower end of said rod for the purpose of retaining the rod 25 in axial alignment with the longitudinal axis of the casing 20 as said rod is reciprocated by the action of the walking beam 10. The length of the reciprocating rod 25 with respect to the length of the stroke of said rod is such that the maximum stroke of said rod will not be sufficient to cause either of the guides 27 or 28 to contact with adjacent parts disposed within the casing 20 and is also such that when the rod is at the extremities of its stroke, no part thereof will engage any element carried by the casing to impart a vertical or reciprocating movement to the latter.

The mechanism for converting the reciprocating movement of the rod 25 into a rotary movement of the casing 20 and consequently of the cutting tool 17, which is connected to said casing through the members 29 and 30, the latter of which is commonly known as a sinker, will now be described. To accomplish this conversion, the portion of the rod 25 between the guides 27 and 28 is provided with two spiral grooves 31 and 32, the former of which has a greater number of turns, and therefore a smaller pitch than the latter, as clearly shown in Figure 3. Adjacent the upper end of the section 22 of the casing 20 the same in internally screw threaded and has mounted therein a plurality of superimposed cylinder supporting members or sleeves 33, 34 and 35 through which the rod 25 extends and through the medium of which a rotary movement is imparted to the casing 20.

Interposed between the lower and intermediate sleeves 33 and 34 and the intermediate sleeve and upper sleeve 35 are the cylinders 36 and 37 of similar construction. Each cylinder is provided upon its outer surface with a plurality of rigid teeth 38 extending longitudinally of the cylinder and terminating short of the ends thereof. The cylinder 36 is provided upon its inner face with a spirally arranged rib 39 engageable in the spiral groove 32 of the rod 25 so that a rotary movement will be imparted to the cylinder 36 as the rod 25 is reciprocated. The cylinder 37 is likewise provided upon its inner surface with a spirally arranged rib (not shown) similar in all respects to the rib 39 except that the same extends in an opposite direction and at a different slope so as to engage in the groove 31 in the rod 25.

Cylinder 36 which engages groove 32 is utilized to impart rotation to the casing 20 during the upward movement of the rod 25 and cylinder 37 coacting with groove 31 imparts rotation to the casing in the same direction upon the downward movement of said rod. During the upward movement of the rod 25 the cylinder 37 idles and, vice versa, the cylinder 36 idles during the downward movement of said rod. In order to accomplish this, means are provided for allowing a clockwise movement of the cylinders 36 and 37 without affecting the movement of the casing 20. This means, as shown in Figure 4, preferably comprises a plurality of pawls 40 each formed of a strip of material of a length substantially the same as that of the teeth 38 and seated in recesses 41 formed in the inner surface of the adjacent cylinder supporting sleeve. Although there are four of these pawls 40 shown in Figure 4, it will be understood that as many of said pawls may be provided as may be found convenient. The pawls 40, which are diagonally disposed in the recesses 41, have interposed between them and the bottom of said recesses the leaf springs 42 which normally have a tendency to force said pawls inwardly toward the teeth 38 of the adjacent cylinder. The position of each pawl with respect to the adjacent cylinder is such that when said cylinder is rotated in a clockwise direction it will idle, but when rotated in the opposite direction it will cause the casing to turn with it.

As the rod 25 is reciprocated the cylinders 36 and 37 alternately will be rotated in the same direction to impart rotational movement to the casing 20 through the intermediary of the sleeves 33 and 34. As previously described the upward movement of the rod 25 imparts rotation to the cylinder 36 through the engagement of the rib 39 in the groove 32, which has a lesser number of turns than the groove 31. The pitch

of said groove 32 is such that as the rod 25 moves upwardly the same will have less tendency to lift the casing 20 and thereby disengage the cutting tool from the material being cut.

The pitch of grooves 31 and 32 may be varied as desired so as to best suit the well drilling apparatus to the existing conditions of operation. In practical operation the tool may occasionally be lifted from contact with the bottom of the hole by the engagement of plunger 28 with lower sleeve 33 at the upper part of the stroke. This might occur by the improper periodical downward feeding of the cable 12 to allow for the advance of the cutting tool, but it is not intended that any drilling of the hole shall be accomplished by the impact of the tool at the bottom of the hole, which would result in such a case. On the other hand, such operation of the apparatus is to be avoided, inasmuch as it has a tendency to damage the cutting tool, this tool being of the rotary type which is intended to produce cutting of the material merely by rotation under a proper, and preferably substantially constant, feeding pressure, rather than by impact.

In operating my improved well drilling apparatus by means of a flexible cable 12, for example, as illustrated in Fig. 1, the first few strokes of the walking beam 10 serve to wind up the cable, that is, during these strokes a sufficient twist, or torsional stress, is accumulated in the cable 12 to bring its torsional resistance up to the point where the reaction of the material being cut against the tool 18 is overcome. When this point is reached the tool begins to rotate, and, therefore, to cut its way through the material being drilled. Thereafter the motion of rod 25 is one of substantially pure reciprocation, and that of casing 20 one of rotation in a single direction. It will be understood that the force acting upon the reciprocating rod 25 during each upstroke is produced by tension in the cable 12 and that during the down stroke of the walking beam the rod 25 is acted upon by its own weight and the weight of the sinker 15 and such other auxiliary apparatus as is desirable to place in the tool string above rod 25. A sufficient number of these auxiliary tools is included to secure the weight required to drive the rod 25 on its downward stroke to cause the rotation of the cutting tool 18, so that drilling is done during both strokes.

The groove 31, cylinder 37, and its cooperating ratchet mechanism, serve not only to rotate the tool on the down stroke of rod 25, under the weight of the parts just mentioned, but also to prevent the twist from coming out of the cable during this stroke. Otherwise rod 25 would merely rotate in one direction on the up stroke and in the opposite direction on the down stroke, and no rotation would be imparted to the casing 20 and cutting tool 18. If it is desired, the apparatus may be so arranged that the cutting tool is rotated during the up stroke only under the tension applied on the cable by the walking beam.

The pressure upon the cutting tool 13 is determined entirely by the weight of the various parts attached to the lower end of cable 12. The feeding pressure is thus substantially independent of the manner in which the drilling apparatus is controlled at the surface. It is, therefore, not under the control of the well driller. During the upward stroke the feeding pressure depends upon the weight of casing 20, and the parts connected to its lower ends less the amount of the tension applied to the cable 12 by the walking beam 10. On the down stroke the pressure is somewhat greater, inasmuch as the weight of the parts above casing 20 is added to the weight of the casing itself, and the parts below it. By suitably proportioning the weights of these various parts to the weight of the drilling tool employed, the most effective pressure with a given tool can be obtained. Furthermore, during the up stroke, if the teeth of the cutter 18 have a tendency to dig into the material being cut, a characteristic of operation which obtains particularly when operating in the softer formations, the operation of the apparatus is such as automatically to withdraw the teeth of the cutter from engagement with the material until the resistance to rotation is sufficiently reduced to allow the tool to proceed.

The pump mechanism, which is utilized for pumping a fluid to the cutting tool, is shown in detail in Figures 7 and 8. The member 29 forming a part of this mechanism is provided in its upper end with inlet ports 43, the inner ends of which are normally closed by a valve 44 movable in the lower end of the casing and limited in such movement by a ring 45 above which the combined guide and plunger 28 is disposed. The member 29 is also provided with a longitudinal passage 46, the lower end of which is normally closed by a ball valve 47 engaged by a spring 48 mounted upon a valve seat 49 and between the guide arms 50 thereof. The base of the valve seat 49 is provided with an opening 51 through which the fluid flows when the valve 47 is opened. In order that the water flowing downwardly through the passage 46 and past the valve 47 may be permitted to flow to the cutting tool the lower member 30 is also provided with the longitudinal passage 52 in alignment with the opening 51 in the valve seat 49. This valve seat may also be provided with a plurality of smaller openings 53 for permitting the water to flow therethrough. The flow of water to the cutting tool is con-

trolled by the reciprocating movement of the guide and plunger 28 which is carried by the rod 25 in such manner that when said plunger 28 moves upwardly a suction is created which will draw the water from the well through the ports 43 against the weight of the valve 44. Upon a downward stroke of the plunger 28 the water drawn into the lower section of the casing 20 is then forced downwardly through the passage 46, thus opening the valve 47 against the tension of the spring 48 to permit said water to flow through the lower member 30 and from thence to the cutting tool.

The improved well drilling apparatus of this invention combines the advantages of the rotary and percussion or reciprocatory systems of well drilling, and eliminates many of the disadvantages of each. Thus, the rigid and relatively expensive drive pipe of the rotary system is replaced by the relatively inexpensive cable of the percussion system, yet the effectiveness and efficiency of the rotary cutter is retained. The material being drilled through is not subjected to the shattering action of percussion tools, thereby reducing the tendency of the walls of the holes to cave and to freeze the tools, or other parts of the apparatus, therein.

Either a core-cutting bit, or a solid bit which cuts a complete circular hole, may be employed with the same apparatus. However, at present, when it is desired to obtain cores, it is necessary to do the entire drilling by the rotary system or change over from the percussion system to the rotary system for drilling the portion of the hole where cores are desired.

When it is desired to obtain a core, the drilling apparatus is merely hoisted to the surface and the core removed from the core barrel 19. The core is thus removed by the same cable that is used to operate the apparatus, and it is not necessary to first hoist the string of drilling tools to the surface and then lower in a bailer or core-catcher to remove the core. Because of the fact that cores may be obtained with such great facility, they are taken much more frequently than with other systems of drilling, so that the samples and the log of the well have a relatively great economic value.

The improved apparatus, moreover, is adapted for use with the apparatus of the percussion system of drilling which is in the most common use because of its relatively low cost. Hence, the apparatus may be adopted without having to discard expensive apparatus which is already in use.

What is claimed is:

1. The method of drilling wells which comprises actuating a rotary drilling tool in contact with the material to be drilled by the reciprocatory movement of an actuating member having relatively small torsional resistance extending from the surface of the ground to the bottom of the well, and utilizing the torsional strength of the actuating member to overcome the force exerted in opposition to the rotation of the tool by the material being removed by the tool.

2. The method of drilling wells which comprises actuating a rotary cutting tool in contact with the material to be drilled by the reciprocatory movement of a flexible cable extending from the surface of the ground to the bottom of the well, and utilizing the torsional strength of the cable to overcome the force exerted in opposition to the rotation of the tool by the material being removed by the tool.

3. The method of drilling wells which comprises supporting a tool in contact with the material to be drilled by means of a member having relatively small torsional rigidity, applying a reciprocating motion to the upper end of said member, causing a torsional stress to be applied to said member during each upward stroke thereof, maintaining said torsional stress during each downward stroke of said member, and utilizing said stress for overcoming the force exerted in opposition to the rotation of the tool by the material being removed by the tool.

4. The method of drilling wells which comprises supporting a tool in contact with the material to be drilled by means of a member having relatively small torsional rigidity, applying a reciprocating motion to the upper end of said member, causing a torsional stress to be applied to said member during each reciprocation thereof, and utilizing said stress for overcoming the force exerted in opposition to the rotation of the tool by the material being removed by the tool.

5. The method of drilling wells which comprises supporting a tool in contact with the material to be drilled by means of a member having relatively small torsional rigidity, applying a reciprocating motion to the upper end of said member, causing a torsional stress to be applied to said member during each upward stroke thereof, accumulating said torsional stress during successive strokes until the tool begins to rotate, and thereafter utilizing the accumulated stress for overcoming the force exerted in opposition to the rotation of the tool by the material being removed by the tool.

6. The method of drilling wells which comprises supporting a tool in contact with the material to be drilled by means of a member having relatively small torsional rigidity, applying a reciprocating motion to the upper end of said member, causing a torsional stress to be applied to said member during each upward stroke thereof and increasing said torsional stress during each

downward stroke thereof until the tool begins to rotate, and thereafter utilizing the accumulated stress for overcoming the force exerted in opposition to the rotation of the tool by the material being removed by the tool.

7. In an apparatus for drilling wells, a mechanism disposed freely in the hole being drilled near the bottom for converting reciprocatory motion into rotary motion in a single direction about the axis of the hole, a cutting tool attached to said mechanism and driven thereby to rotate substantially on the axis of the hole, a reciprocating driving device located at the surface of the ground, and a power transmitting element for connecting said motion-converting mechanism with the driving device, said motion-converting mechanism being operable independently of the walls of the hole and being actuated solely by the power transmitting element to rotate the tool.

8. In an apparatus for drilling wells, a mechanism disposed freely in the hole being drilled for converting reciprocatory motion into rotary motion, a cutting tool attached to said mechanism and rotated thereby, a reciprocating driving device located at the surface of the ground, and a power transmitting element having relatively small torsional resistance for connecting said motion-converting mechanism with the driving device, said motion-converting mechanism being operable independently of the walls of the hole and being actuated solely by the power transmitting element to rotate the tool.

9. In an apparatus for drilling wells, a mechanism disposed freely in the hole being drilled for converting reciprocatory motion into rotary motion, a cutting tool attached to said mechanism and rotated thereby, a reciprocating driving device located at the surface of the ground, and a flexible cable connecting said motion-converting mechanism with the driving device, said motion-converting mechanism being operable independently of the walls of the hole and being actuated solely by the flexible cable to rotate the tool.

10. In an apparatus for drilling wells, a rotary cutting tool, mechanism for converting reciprocatory motion into rotary motion disposed freely in the hole being drilled, a reciprocating driving device located at the surface of the ground, and a power transmitting element having relatively small torsional rigidity for connecting said motion-converting mechanism with the driving device, said motion-converting mechanism being operable independently of the walls of the hole and being actuated solely by the power transmitting element to rotate the tool.

11. In an apparatus for drilling wells, a rotary cutting tool, mechanism for converting reciprocatory motion into rotary motion disposed freely in the hole being drilled, a reciprocating driving device located at the surface of the ground, and a power transmitting element having relatively small torsional rigidity for connecting said motion-converting mechanism with the driving device, the up-stroke of the driving device tending to twist the power transmitting element, and said motion-converting mechanism including means for preventing the untwisting of the power transmitting element during the down-stroke thereof, so as to cause sufficient torsional strength to be built up in the power transmitting element to overcome the force exerted by the material being drilled in opposition to the rotation of the cutting tool.

12. In an apparatus for drilling wells, a rotary cutting tool located at the bottom of the hole being drilled, a reciprocating driving device located at the surface end of the hole, a member having relatively small torsional rigidity connected to the driving device and extending down the hole, means for connecting the lower end of said member to the rotary cutting tool for causing relative rotation between said tool and the lower end during the upward stroke of the driving device, and means for preventing the backward relative rotation of said parts during the downward stroke of the driving device.

13. In an apparatus for drilling wells, a tool-driving casing freely rotatable in the hole being drilled, a driving member reciprocable in the casing for imparting rotation thereto, a drilling tool co-axially attached to the lower end of the casing, a reciprocating driving device at the surface of the ground, and a power transmitting element for connecting said driving device with said driving member.

14. In an apparatus for drilling wells, a tool-driving casing freely rotatable in the hole being drilled, a driving member reciprocable in the casing for imparting rotation thereto, a drilling tool co-axially attached to the lower end of the casing, a reciprocating driving device at the surface of the ground, and a power transmitting element having relatively small torsional rigidity for connecting said driving device with said driving member.

15. In an apparatus for drilling wells, a rotatable tool supporting casing, a reciprocatory rod movable in said casing, and means including a plurality of cylinders alternately rotated by the reciprocation of said rod for imparting a rotary movement to said casing.

16. In an apparatus for drilling wells, a casing freely rotatable in the hole being drilled, a driving member reciprocable within said casing, a ratchet and pawl mechanism

controlled by the reciprocation of said member for imparting a rotary movement to the casing, and a drilling tool co-axially attached to the lower end of the casing and driven thereby in a single direction of rotation.

17. In an apparatus for drilling wells, a reciprocating member having spiral grooves therein, a rotating member suitable for attachment to a cutting tool, and a mechanism including ratchet cylinders having ribs engageable in said grooves, teeth on their outer surfaces, and pawls cooperating therewith for transforming the reciprocating movement of the first named member into a rotating movement of the second named member through the medium of said pawls and ratchet cylinders.

18. In an apparatus for drilling wells, a tubular tool-driving casing, a reciprocatory rod movable therein, said rod having a smooth portion and a spirally grooved portion, a bearing at one end of the casing for said smooth portion, a piston adjacent the grooved end of the rod cooperating with the casing to act as a guide for the rod and to pump water to the cutting tool, and a ratchet and pawl mechanism controlled by the reciprocation of the rod for imparting a rotary movement to the casing.

19. In an apparatus for drilling wells, a tubular tool-driving casing, a reciprocatory rod movable therein and provided with a plurality of grooves at least one of which is of spiral shape, a piston at the lower end of said rod cooperating with the walls of the casing to act as a guide for the rod and to pump water to the cutting surface of the tool, and a mechanism including pawls and ratchet cylinders, the latter having ribs engageable in said grooves, for transforming the reciprocating movement of the rod into a rotating movement of the casing.

20. In an apparatus for drilling wells, a tubular tool-driving casing, a reciprocatory rod movable therein, said rod having a smooth portion and a spirally grooved portion, a bearing at one end of the casing for the smooth portion, a piston at the grooved end of the rod cooperating with the walls of the casing to act as a guide for the rod and to pump water to the cutting surface of the tool, a bearing for the rod intermediate the ends of the casing, and a mechanism including pawls and ratchet cylinders, the latter having ribs engageable in said grooves, for transforming the reciprocating movement of the rod into a rotating movement of the casing.

21. In an apparatus for drilling wells, a tubular tool-driving casing constructed in sections, a reciprocatory spirally grooved rod movable in said casing, and a plurality of pawls and ratchet cylinders disposed adjacent one end of one of said sections and cooperating with the spirally grooved rod to convert the reciprocating movement of the rod into a rotating movement of the casing.

22. In an apparatus for drilling wells, a tubular tool-driving casing, a reciprocatory spirally grooved rod movable therein, a plurality of sleeves secured in the casing and constituting bearings for a plurality of ratchet cylinders, said cylinders cooperating with the spirally grooved rod to convert the reciprocating movement of the rod into a rotating movement of the casing.

23. In an apparatus for drilling wells, a tubular tool-driving casing, a reciprocatory spirally grooved rod movable therein, a plurality of sleeves secured in said casing and constituting bearings for a plurality of ratchet cylinders, a longitudinal recess in each of said sleeves for receiving a pawl for cooperating with the ratchet teeth, said ratchet and pawl mechanism cooperating with the spirally grooved rod to convert the reciprocating movement thereof into a rotating movement of the casing.

24. In an apparatus for drilling wells, a tubular tool-driving casing, a reciprocatory spirally grooved rod movable therein, a plurality of sleeves secured in said casing and constituting bearings for a plurality of ratchet cylinders, a longitudinal recess in each of said sleeves for receiving a pawl for cooperating with the ratchet teeth, a flat spring in each recess urging the pawl against said teeth, said ratchet and pawl mechanism cooperating with the spirally grooved rod to convert the reciprocating movement thereof into a rotating movement of the casing.

25. In an apparatus for drilling wells, a tubular tool-driving casing, a reciprocatory rod movable therein, a ratchet and pawl mechanism controlled by the reciprocation of the rod for imparting a rotary movement to the casing, and a piston at the lower end of the rod cooperating with the walls of the casing to pump water to the cutting surface of the tool.

26. In an apparatus for drilling wells, a tool-driving member, a reciprocating rod movable with respect thereto, a rotary drilling tool operatively connected to the lower end of the driving member to rotate co-axially therewith mechanism associated with said member for converting reciprocatory movement of the rod into a rotary movement of the member, a pump cylinder on said member, a piston therefor on said rod, and an element provided with an inlet passage for taking water from the well, and an outlet passage for delivering said water to the cutting surface of the tool.

27. In an apparatus for drilling wells, a tool-driving member, a reciprocatory rod movable with respect thereto, mechanism associated with said member for converting

the reciprocatory movement of the rod into a rotary movement of the member, a pump cylinder associated with said tool-driving member, a piston therefor on said rod, a part secured to the lower end of said tool-driving member, a rotary cutting tool operatively attached to the lower end of said part, said part having an upwardly directed intake passage for drawing water from the bottom of the well, and a centrally located outlet passage for delivering water to the cutting tool.

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