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2,072,470

DRILLING TOOL

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Fig. 1.

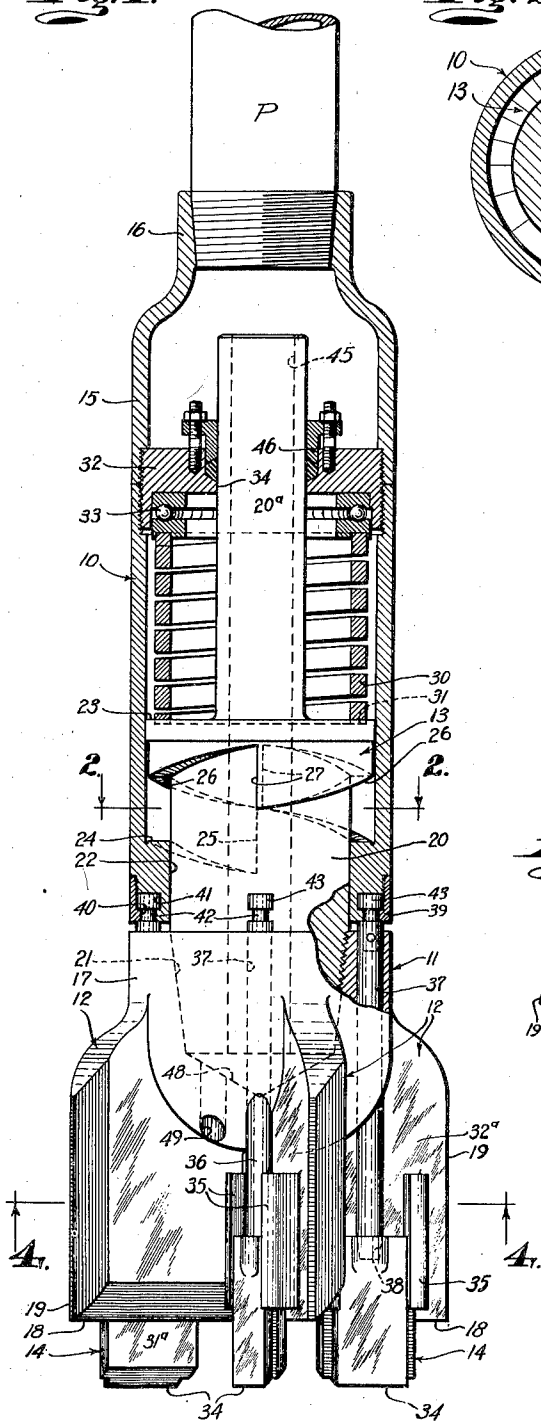


Fig. 2.

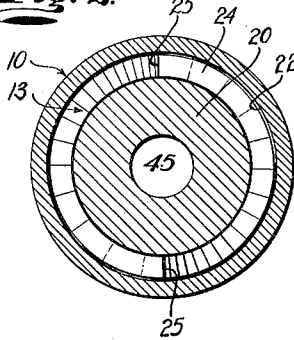


Fig. 3.

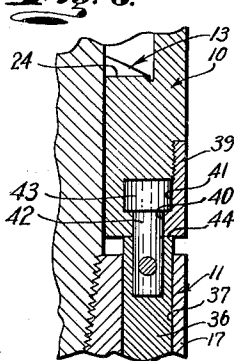


Fig. 4.

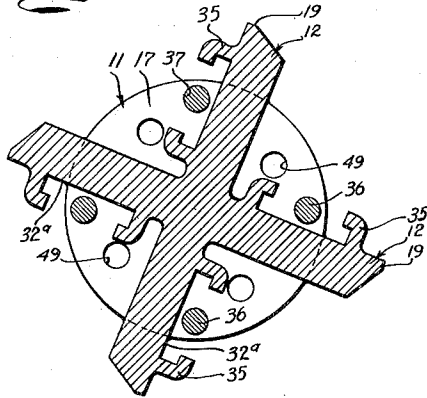
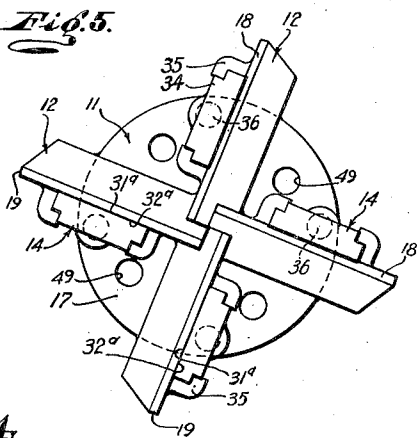


Fig. 5.



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DRILLING TOOL

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12 Claims. (Cl. 255—61)

This invention relates to a well drilling tool and relates more particularly to a drilling tool or drill for use in the rotary method of well drilling. A general object of the invention is to provide a practical effective well drilling tool that is very rapid and efficient in operation.

Another object of the invention is to provide a rotary well drilling tool in the form of a drill bit or core drill embodying cutting parts that cut into the formation by a percussive or chipping action.

Another object of the invention is to provide a rotary well drilling bit or drilling tool that penetrates or cuts into the formation by the combined action of shearing or dragging cutting parts and chipping parts that are cooperatively related to produce a rapid penetration of the formation.

Another object of this invention is to provide a rotary well drilling tool embodying cutting parts that operate as drag type blades when the tool is penetrating certain earth formations and that operate to pound and chip away the formation as well as shear the formation by dragging when the drill encounters an earth formation that offers greater resistance to turning of the cutting blades whereby the drill is automatically adaptable to and is effective in penetrating earth formations of various characters.

Another object of the invention is to provide a rotary well drilling tool that embodies a cutting head that automatically retracts when the cutting parts encounter high resistance to their rotary movement and is then suddenly driven downwardly under spring pressure to chip away the formation, the sequence of dragging and chipping continuing as long as the high resistance to rotation of the head is present.

Another object of the invention is to provide a rotary drilling tool of the character mentioned that includes cutting parts that are associated with the head to turn therewith and that are held against vertical movement with respect to the barrel or shank to remain in engagement with the formation during retraction of the head and thus insure the effective chipping action of the cutting parts of the head.

A further object of this invention is to provide a drilling tool of the character mentioned in which the parts are simple and inexpensive of manufacture and are readily replaceable when worn.

The various objects and features of my invention will be fully understood from the following detailed description of a typical preferred

form and application of the invention, throughout which description reference is made to the accompanying drawing, in which:

Fig. 1 is a side elevation of the tool provided by this invention showing the cutting head in its up or retracted position and illustrating the body and certain other parts in central vertical cross section. Fig. 2 is a transverse, detailed sectional view taken as indicated by line 2—2 on Fig. 1. Fig. 3 is an enlarged fragmentary vertical detailed sectional view illustrating the connection between one of the cutter stems and the body. Fig. 4 is a transverse detailed sectional view taken substantially as indicated by line 4—4 on Fig. 1 and Fig. 5 is a bottom elevation of the tool.

The improved cutting means or drilling means provided by this invention is adapted for embodiment in well drilling tools of various types, for example, it is adapted for embodiment in rotary well drills, rotary core drills, etc. In the following detailed disclosure I will describe the invention embodied in a rotary well drilling bit, it being understood that the invention is not to be restricted to this class of well tool but is to be taken as also contemplating rotary core drills.

The embodiment of the present invention illustrated in the drawing includes, generally, a shank or body 10, a head 11 having cutting parts 12, means 13 for imparting downward blows or a percussive action to the head 11 when the cutting parts 12 encounter high resistance to their rotation and cutting parts 14 rotatable with the head 11 and connected with the body 10 to move longitudinally therewith.

The shank or body 10 may be varied considerably without departing from the spirit of the invention and may be varied in different applications of the invention. In the form and application of the invention illustrated in the drawing the body 10 is an elongate tubular structure. A cap or head section 15 is provided at the upper end of the body 10 and has a reduced upper portion 16. The reduced upper portion 16 of the head section 15 may be internally threaded to facilitate the connection of the body with the drilling string P. In the preferred construction the wall of the body 10 is internally thickened at its lower end portion.

The cutting head 11 is disposed or arranged at the lower end of the body 10 and includes a body or shoe 17 which may be of substantially the same external diameter as the body 10. The upper end of the shoe 17 may be flat and normal to oppose the lower end of the body 10 and the lower end

of the shoe may be tapered or rounded downwardly and inwardly. The cutting parts 12 project downwardly and outwardly from the lower end of the shoe 17 to have active engagement with the earth formation at the bottom of the well bore. The cutting parts 12 are in the nature of blades and may be separable parts or parts that are integral with the shoe 17. The cutting blades or cutting parts 12 may be vertical and may be disposed in planes that are substantially radial with respect to the longitudinal axis of the tool. The lower cutting edges 18 of the cutting parts 12 are bevelled or sharpened to cut into the formation by a shearing or dragging action as well as by a percussive or chipping action. The lower cutting edges 18 may be straight and may be substantially horizontal as illustrated in the drawing. The reaming or outer cutting edges 19 of the cutting parts 12 are operable to ream or cut the well bore to gauge and are preferably comparatively long and substantially vertical. The upper ends of the cutting parts 12 may be bevelled or rounded upwardly and inwardly as illustrated. In accordance with the broader principles of the invention there may be any desired or practical number of circumferentially spaced cutting parts 12. In the particular form of the invention disclosed there are four equally spaced blades or cutting parts 12 on the shoe 17.

The means 13 connects or associates the cutting head 11 with the body 10 to turn therewith when there is little resistance to rotation of the cutting parts 12 and operates to impart a percussive or hammering action to the head 11 when there is an increased resistance to turning movement of the cutting parts 12 and 14 so that the cutting parts 12 cut or dig into the formation by a chipping action. The means 13 includes a stem 20 projecting from the upper end of the shoe 17 to enter the lower end of the tubular body 10. In the preferred arrangement illustrated in the drawing the lower end of the stem 20 is threaded into a socket 21 in the upper end of the shoe 17. The lower portion of the stem 20 is slidably guided in the lower portion of the body opening 22. The upper end portion 20^a of the stem 20 is preferably reduced in diameter, thus providing the stem with an upwardly facing annular shoulder 23.

The means 13 includes cam parts or ratchet parts on the body 10 and stem 20 for imparting the hammering action to the cutting head 11. The thickened lower wall portion of the body 10 presents an upwardly facing internal shoulder which has a plurality of inclined or spiralled faces 24. In the particular case illustrated there are two faces 24 each extending for substantially 180°, it being understood that there may be a greater number of these faces if desired. The inclined or spiralled faces 24 of the body 10 terminate at their opposite ends in abrupt or vertical shoulders 25. The shoulders 25 face rearwardly relative to the direction of rotation of the drill. The stem 20 has two downwardly facing inclined or spiralled faces 26 that are complementary to the body faces 24. The spiralled faces 26 of the stem 20 terminate at their opposite ends in abrupt or vertical shoulders 27 which face forwardly relative to the direction of rotation of the tool.

When the cutting head 11 is in its lowermost position relative to the body 10 the spiralled faces 26 are in cooperation with the faces 24 throughout their longitudinal extents and the shoulders 25 and 27 may be in abutment or cooperation. When the engagement of the cutting parts 12 and 14 with the earth formation causes the head 11 to

lag with respect to the rotating body 10 the spiralled faces 24 of the body ride along the faces 26 of the stem 20 causing the head 11 to retract or move upwardly with respect to the body 10. The faces 24 ride or move along the faces 26 until the shoulders 25 pass the shoulders 27 whereupon the head 11 is suddenly released to move downwardly relative to the body 10.

The means 13 includes a spring 30 for urging the cutting head 11 downwardly relative to the body 10 to provide the desired frictional contact between the faces 24 and 26 and to move the head 11 downwardly with considerable force when the shoulders 25 pass the shoulders 27, as above described, so that the cutting parts 12 strike the formation to chip or break it away. The spring 30 is in the nature of a heavy spiralled or helical spring surrounding the reduced upper portion 20^a of the stem 20. The lower end of the spring 30 may bear in an annular groove 31 in the shoulder 23. A ring 32 is provided on the interior of the body 10 to form an abutment for the upper end of the spring 30. The ring 32 may have threaded engagement with the adjacent end portions of the body 10 and cap 15 to form a connector or coupling between the body and cap. An anti-friction bearing 33 is arranged between the upper end of the spring 30 and the ring 32 so that the spring 30 is subjected to a minimum amount of torque or turning forces. The opening 34 of the ring 32 may slidably guide the reduced upper portion 20^a of the stem 30 and means is provided for sealing between the ring and stem as will be hereinafter described. The spring 30 acting downwardly on the stem 20 causes the spiralled faces 26 to bear on the faces 24 with considerable force so that substantial resistance to rotation of the head 11 is required to overcome the friction between the cooperating faces 26 and 24 and to cause slippage between them. The spring 30 is sufficiently strong to move the head 11 downwardly with great force when the shoulders 25 move past the shoulders 27 to suddenly free the head 11 for downward movement relative to the body. The resulting downward movement of the head 11 brings the cutting parts 12 into hammering and chipping engagement with the formation at the bottom of the well bore.

The cutting parts 14 are associated with the head 11 to turn therewith and are connected to the body 10 in a manner so that they are made to move longitudinally therewith. The cutting parts 14 are in the form of elongate blades positioned in front of and backed up by the forward faces of the cutting parts 12. There may be one cutting part 14 at each blade or cutting part 12. The rear surfaces 31^a of the cutting parts 14 may have sliding engagement with the forward faces 32^a of the cutting parts 12. The cutting parts 14 are spaced inwardly some distance from the outer edges 19 of the cutting parts 12 and are spaced outwardly from the central longitudinal axis of the drill. The lower cutting edges 34 of the cutting parts 14 are sharpened and bevelled to have effective cutting engagement with the formation at the bottom of the well bore. The edges 34 may be straight and substantially horizontal. It is to be noted that the cutting edges 34 of the cutting parts 14 are considerably shorter than the lower cutting edges 18 of the cutting parts 12. Flanges or guides 35 on the forward faces 32^a of the cutting parts 12 have guiding engagement with the vertical edge portions of the cutting parts 14.

Stems 36 are connected to the upper ends of the cutting parts 14 and are slidably or shiftably re-

ceived in substantially vertical openings 37 in the shoe 17. The stems 34 are preferably removably threaded in sockets 38 in the upper ends of the cutting parts 14. The lower end portion of the body 10 is externally grooved and a collar 39 is threaded on its periphery to close the outer sides of the grooves. There is thus provided an annular groove 40 open at the lower end of the body 10 and an annular groove 41 of greater radial width at the upper end of the groove 40. The stems 36 have reduced portions 42 which extend through the groove 40 with suitable working clearance and heads 43 are provided on the upper ends of the stems to move or operate in the groove 41. The portions 42 may be welded, pinned or otherwise secured to the bodies of the stems 36. The lower end of the body 10 is adapted to bear downwardly on annular shoulders 44 on the stems 36. The cutting parts 14 assembled or arranged as just described are positively urged downwardly by the body 10 and are held against upward movement with respect to the body. The cutting parts 14 in being connected with the head 11 to turn therewith may lag or remain substantially stationary with the head.

Means is provided for handling the rotary mud or circulation fluid. The upper end of the body opening 22 is open to receive the circulation fluid conducted downwardly by the drilling string P. The stem 20 has a central longitudinal fluid passage 45 whose upper end receives fluid from the upper portion of the body opening 22. A packing gland 46 is provided on the ring 32 to prevent the leakage of fluid around the stem portion 20^a. The fluid passage 45 conducts the fluid downwardly to a main passage 48 in the shoe 17. The shoe 17 has suitable ports 49 for carrying the fluid from the main passage 48 and for discharging it at or adjacent the cutting parts 12 and 14 to flush them and to provide for the desired discharge of fluid into the lower portion of the well bore.

In operation the cap section 15 of the body 10 is connected to the lower end of the drilling string P or with the drill collar on the lower end of such a string. The tool is operated by rotating the drilling string and feeding it downwardly in the usual manner. During operation of the tool the cutting parts 12 and the cutting parts 14 are adapted to engage and cut away the formation at the bottom of the well bore. The principal blades 12 are also operable to cut the bore to gauge. Under certain operating conditions the spring 30 may exert a sufficient downward force on the stem 20 so that the frictional cooperation between the faces 24 and 26 cause the head 11 to rotate with the body 10. In other words, under certain conditions the resistance to movement of the cutting parts 12 and 14 may not be sufficient to overcome the frictional engagement between the faces 24 and 26 and the head 11 moves with the body 10. Under such conditions the cutting parts 12 act as drag type blades to shear or cut away the earth formation at the bottom of the bore. The parts are related and proportioned so that the cutting edges 18 are in substantially the same horizontal plane as the cutting edges 34 when the head 11 is in its down or lowest position. Accordingly, under the conditions just described the bit or tool operates in substantially the same manner as the drag type cutting tools.

When the drill encounters an earth formation that offers greater resistance to forward movement or turning of the cutting parts 12 and 14, the engagement of the cutting parts with the formation causes the cutting head 11 to lag

with respect to the rotating body 10. Such lagging of the head 11 results in movement of the faces 24 along the spiralled faces 26. The cooperation of the spiralled faces 24 and 26 moves the head 11 upwardly thus retracting its cutting parts 12 out of active biting engagement with the formation at the bottom of the well bore. The cutting parts 14 remain in engagement with the formation at the bottom of the bore and the drag or resistance to their rotary movement causes the head 11 to continue to lag relative to the rotating body 10. The spiralled faces 24 of the body 10 eventually move over the faces 26 to the position where the shoulders 25 pass the shoulders 27. When this occurs the head 11 is suddenly released for free downward movement with respect to the body 10. During the upward movement or retraction of the head 11 the cutting parts 14 in being connected with the body 10 by the stems 36 remain in active engagement with the formation at the bottom of the bore to cause the head 11 to continue to lag and to prevent bodily downward movement of the drill. The spring 30 is further compressed during the upward movement or retraction of the head 11 and upon the shoulders 25 passing the shoulders 27 the spring moves the head 11 downwardly with great force. This brings the lower edges 18 of the cutting parts 12 into pounding or chipping engagement with the formation at the bottom of the bore. The cutting parts 12 may then have dragging or shearing engagement with the formation at the bottom of the bore until the resistance to forward or rotary movement of the cutting parts again causes retraction of the head 11. In some instances the head 11 may be made to continue to reciprocate, in which case the cutting parts 12 cut by a percussive action and have little or no dragging-cutting action. In this manner the cutting parts 12 act to cut away the formation by a shearing or dragging action and by a pounding or chipping action. The drill is thus adapted for operation in formations that are not readily penetrated by the usual drag type bits. The combined dragging and chipping action of the principal cutting parts makes the tool particularly rapid and efficient in operation. The head 11 and the cutting parts 14 may be readily removed for repair or replacement.

Having described only a typical preferred form and application of my invention, I do not wish to be limited or restricted to the specific details herein set forth, but wish to reserve to myself any variations or modifications that may appear to those skilled in the art or may fall within the scope of the following claims:

Having described my invention, I claim:

1. A rotary well drilling tool including a body, a cutting head at the lower end of the body, a stem on the head telescopically assembled with the body whereby the head is reciprocable and turnable relative to the body, cutting blades on the head operable to act on the major portion of the bottom of the well bore, means operable by virtue of the rotary drag on the blades to reciprocate the head whereby the blades have a chipping action on the formation, and a cutting part connected with the body to move vertically therewith and to turn relative thereto and engaging the head to turn with the head.

2. A rotary well drilling tool including a body, a cutting head, a stem on the head telescopically assembled with the body whereby the head is rotatable and reciprocable relative to the body, a cutting part associated with the head to turn

therewith having relative rotary engagement with the body and being immovable vertically with respect to the body to remain in cutting engagement with the formation during reciprocation of the head, cutting blades on the head operable to act on the earth formation at the bottom of the well bore, and means on the stem and body operable by virtue of the rotary drag on the cutting blades and the cutting part to reciprocate the head whereby the blades have a percussive cutting action.

3. A rotary well drilling tool including a body, a cutting head, a stem on the head telescopically assembled with the body whereby the head is turnable and reciprocable relative to the body, a cutting part associated with the head to lag and turn therewith and having relative rotary engagement with the body and being immovable vertically with respect to the body to remain in cutting engagement with the formation during reciprocation of the head, cutting blades on the head operable to act on the earth formation at the bottom of the well bore, and means on the stem and body operable by virtue of the rotary drag on the cutting part to reciprocate the head whereby the blades have a percussive cutting action.

4. A rotary well drilling tool including a body to be connected with a rotary drilling string, a cutting head at the lower end of the body reciprocable with respect thereto, cutting blades on the head for acting on the formation at the bottom of the well bore, means for causing reciprocation of the head by virtue of rotation of the body relative to the head, a cutting part for acting on the formation at the bottom of the well bore, means connecting the cutting part and the head for relative vertical movement and for simultaneous rotation, and means connecting the cutting part with the body for vertical movement therewith and for relative rotation whereby the cutting part turns with the head and remains in engagement with the formation during reciprocation of the head.

5. A rotary well drilling tool including a body to be connected with a rotary drilling string, a cutting head at the lower end of the body reciprocable with respect thereto, cutting blades on the head for acting on the formation at the bottom of the well bore, means for causing reciprocation of the head by virtue of rotation of the body relative to the head, a plurality of separate cutting parts for acting on the formation at the bottom of the well bore and each shiftably bearing on the forward face of a blade, whereby their engagement with the formation may cause the head to lag relative to the rotating body, and independent connections between the body and the cutting parts whereby the cutting parts are carried by the body to remain in engagement with the formation during reciprocation of the head.

6. A rotary well drilling tool including a body to be connected with a rotary drilling string, a cutting head at the lower end of the body reciprocable with respect thereto, cutting blades on the head for acting on the formation at the bottom of the well bore, means for causing reciprocation of the head by virtue of rotation of the body relative to the head, cutting parts for acting on the formation at the bottom of the well bore shiftably bearing on the blades whereby their engagement with the formation may cause the head to lag relative to the rotating body, and means rotatably connecting the said cutting

parts with the body and holding them against vertical movement with respect to the body to remain in engagement with the formation during reciprocation of the head.

7. A rotary well drilling tool including a body having an opening in its lower end, a cutting head at the lower end of the body, cutting blades on the head for acting on the formation at the bottom of the well bore, a stem on the head entering the opening, cam parts on the body and stem for causing reciprocation of the head by virtue of rotation of the body relative to the head, a cutting part bearing on and rotatable with the head, and a rotatable connection between the cutting part and body holding the cutting part against vertical movement with respect to the body to remain in engagement with the formation and cause the head to lag relative to the rotating body.

8. A rotary well drilling tool including a body having an opening in its lower end, a cutting head at the lower end of the body, cutting blades on the head for acting on the formation at the bottom of the well bore, a stem on the head entering the opening, a spring in the opening acting on the stem to urge the head downwardly, cam parts on the body and stem for causing reciprocation of the head by virtue of lagging of the head relative to the body, a cutting part rotatable with the head and associated with the head for relative vertical movement, and a rotatable connection between the cutting part and the body holding the cutting part against vertical movement with respect to the body to remain in engagement with the formation during reciprocation of the head whereby its engagement with the formation may cause the head to lag relative to the rotating body.

9. A rotary well drilling tool including a body having an opening in its lower end, a cutting head at the lower end of the body, cutting blades on the head for acting on the formation at the bottom of the well bore, a stem on the head entering the opening, means for causing reciprocation of the head by virtue of turning movement of the body relative to the head comprising cooperating ratchet parts on the body and stem, and a spring in the opening urging the head downwardly, cutting parts rotatable with the head and associated with the head for relative vertical movement and means rotatably connecting the cutting parts with the body and holding the cutting parts against vertical movement with respect to the body to remain in engagement with the formation during reciprocation of the head whereby their engagement with the formation may cause the head to lag relative to the rotating body.

10. A rotary well drilling tool including a body to be connected with a rotary drilling string, a cutting head at the lower end of the body reciprocable with respect thereto, cutting blades on the head for acting on the formation at the bottom of the well bore, means for causing reciprocation of the head by virtue of rotation of the body relative to the head when the head lags, the head having a vertical opening, a cutting part associated with the head to turn therewith, a stem on the cutting part shiftably passing through the opening in the head, and a connection between the last mentioned stem holding the cutting part against vertical movement and allowing it to turn with the head whereby the engagement of the cutting part with the formation may cause the head to lag.

11. A rotary well drilling tool including a body to be connected with a rotary drilling string, a cutting head at the lower end of the body reciprocable with respect thereto, cutting blades on the head for acting on the formation at the bottom of the well bore, means for causing reciprocation of the head by virtue of rotation of the body relative to the head when the head lags, there being an annular groove in the lower end of the body and a vertical opening in the head, cutting parts associated with the head to turn therewith, rods on the cutting parts movably received in the openings, and heads on the rods movable through the groove whereby the cutting parts may cause the head to lag through their engagement with the formation, the rods cooperating with the head whereby the cutting parts remain in cooperation with the formation during reciprocation of the head.
12. A rotary well drilling tool including a body having an opening in its lower end, a cutting head at the lower end of the body, cutting blades on the head for acting on the formation at the bottom of the well bore, a stem on the head entering the opening, means for causing reciprocation of the head by virtue of turning movement of the body relative to the head when the head lags comprising cooperating ratchet parts on the body and stem, and a spring in the opening urging the head downwardly, there being an annular groove in the lower end of the body and substantially vertical openings in the head, rods shiftably received in the openings and cooperating with the body to be held against vertical movement, heads on the rods movable through the groove, and cutting parts on the rods bearing on the head whereby their engagement with the formation may cause the head to lag.

WALTER N. THOMPSON. 20