March 22, 1938. J. H. HOWARD 2,111,781

WELL DRILLING BIT

Filed July 6, 1936

Fig. 1.

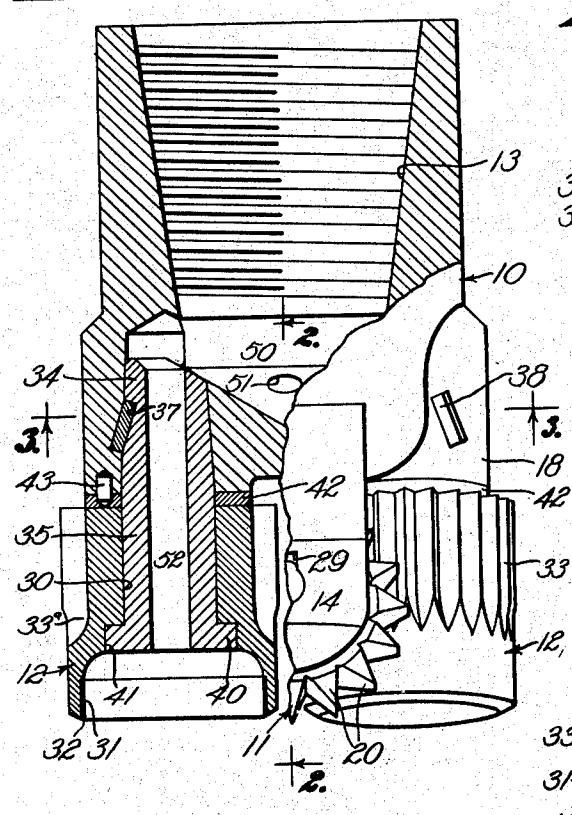


Fig. 3.

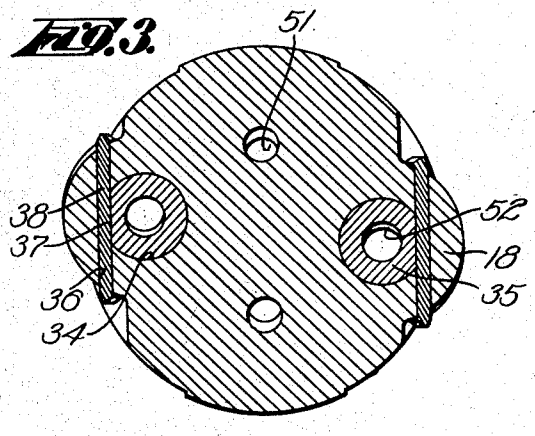


Fig. 4.

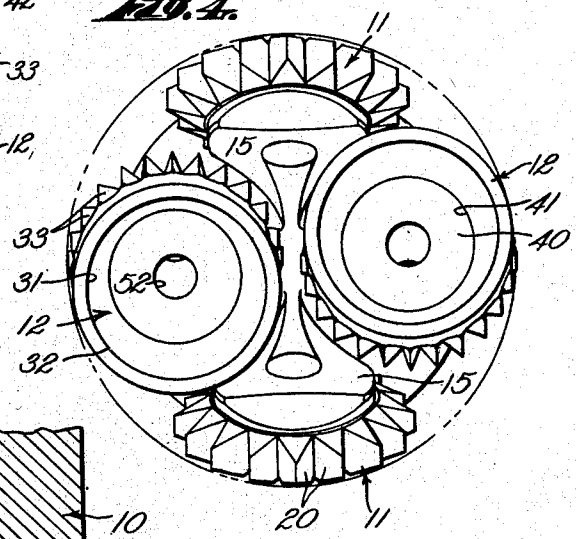
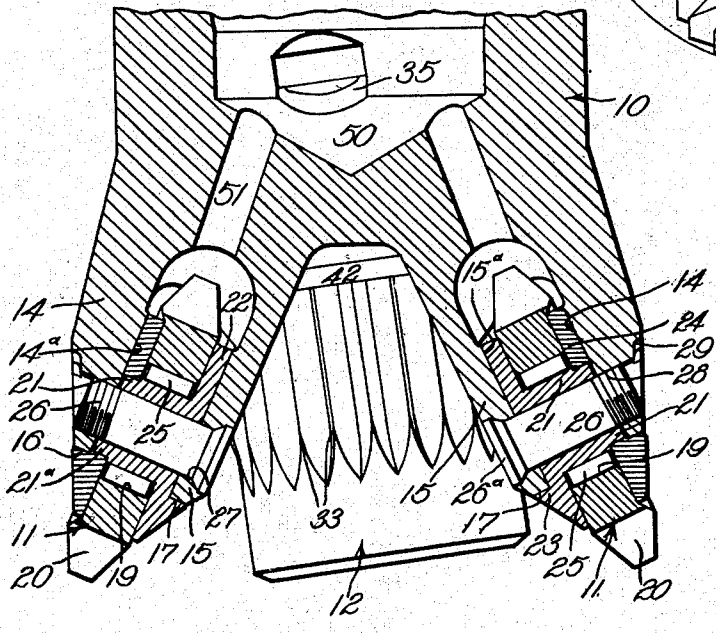


Fig. 2.



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UNITED STATES PATENT OFFICE

2,111,781

WELL DRILLING BIT

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16 Claims. (Cl. 255—71)

This invention relates to a well drilling tool and relates more particularly to a drilling bit for use in the rotary method of well drilling. A general object of the invention is to provide a practical effective well bit embodying an improved and very efficient combination of cutters.

Another object of this invention is to provide a rotary well drilling bit in which the outer or peripheral portion of the well bore is drilled by rotatable cutters of one type and the remaining inner portion of the bore is drilled by rotatable cutters of another type whereby the maximum efficiency of both forms of cutters is obtained.

Another object of this invention is to provide a well bit embodying roller type cutters rotatably supported for rotation about substantially horizontal or only partially inclined axes to cut an annular channel at the periphery of the well bore by a rolling and crushing action, and embodying scraper type cutters supported for rotation about nearly vertical axes to cut away the remaining portion of the bore by a scraping or shearing action.

Another object of this invention is to provide a well bit of the character mentioned in which the slightly tilted or nearly vertical shearing type cutters are self-sharpening through their engagement with the earth formation.

Another object of this invention is to provide a bit of the character mentioned in which the slightly tilted or nearly vertical scraping type cutters are forced to rotate and, therefore, are very efficient and long wearing.

Another object of this invention is to provide a novel and highly efficient form of rotatable cutter for a well drilling bit which cutter is intended to be supported for rotation about a nearly vertical axis and embodies reaming cutting teeth to assure its rotation.

Another object of this invention is to provide a well bit of the character mentioned in which the crushing roller cutters are mounted on pins which are dependably supported at both their inner and outer ends.

Another object of this invention is to provide a well drilling bit of the character mentioned in which the nearly vertical rotatable scraping cutters are devoid of teeth at their lower ends and, therefore, are not as liable to failure as the toothed nearly vertical cutters heretofore introduced.

Another object of this invention is to provide a well drilling bit of the character mentioned in which a stream of circulation fluid is discharged downwardly from within the lower end of each scraper type cutter to clear its cutting edge of mud and cuttings.

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 improved bit provided by this invention with a portion in vertical cross section to illustrate the rotatable mounting of one of the scraper type cutters. Fig. 2 is an enlarged fragmentary vertical detailed sectional view taken substantially as indicated by line 2—2 on Fig. 1. Fig. 3 is a transverse detailed sectional view taken as indicated by line 3—3 on Fig. 1 and Fig. 4 is a bottom elevation of the bit.

The rotary well drilling bit of the present invention includes, generally, a shank or body 10, crushing roller type cutters 11 rotatably supported on the body 10, and shearing or scraping type cutters 12 rotatably supported on the body 10.

The shank or body 10 is adapted to be connected with the lower end of a rotary well drilling string. The body 10 may be integral and may be generally cylindrical. Means is provided at the upper end of the body 10 to facilitate its connection with the well drilling string. In the particular case illustrated a tapered screw threaded socket 13 is provided in the upper end of the body 10 to receive a pin on the lower end of the drilling string. The lower end portion of the body 10 may be enlarged in diameter. The body 10 is provided with pairs of wings or legs 14 and 15 to receive and carry the cutters 11 and their mountings. In the particular embodiment of the invention illustrated there are two diametrically opposite pairs of legs 14 and 15. The legs 14 and 15 are integral with the body 10 and project downwardly and outwardly from its lower end. The legs 14 are the outer legs of the pairs and may be somewhat thicker than the inner legs 15. The legs 14 and 15 of each pair are substantially parallel and are provided at their inner sides with opposing raised bearing surfaces 14^a and 15^a, respectively. The lower outer corners of the outer legs 14 are bevelled to be substantially vertical and flat shoulders 16 are provided on the lower ends of the legs 14 and are substantially normal to the surfaces 14^a. The lower inner corners of the legs 15 may be suitably bevelled away and flat shoulders 17 are provided on the lower ends of these legs.

The body 10 is provided with spaced bosses 18

to carry the means for rotatably supporting the cutters 12. In the embodiment of the invention illustrated there are two substantially diametrically opposite bosses 18 projecting downwardly at the lower end of the body 10. The bosses 18 are partially cylindrical and their longitudinal axes are slightly inclined downwardly and forwardly with respect to the direction of rotation of the bit. Due to the pitch or slight inclination of the bosses 18 they are not directly diametrically opposite but have their axes at opposite sides of a diametrical plane. The lower ends of the bosses 18 are flat and are normal to their longitudinal axes.

The cutters 11 are operable by a crushing action to form an annular cut or channel in the peripheral portion of the well bore. The cutters 11 are in the nature of roller cutters. The roller cutters 11 have central longitudinal openings 19 and flat normal ends. Peripheral cutting teeth 20 are provided on the cutters 11. The teeth 20 preferably overhang or project outwardly beyond the outer ends of the cutters 11. The inner and outer corners of the teeth 20 are preferably bevelled off, as illustrated in the drawing. The teeth 20 may be straight or spiralled, if desired or found practical. The two roller cutters 11 may be identical in size and shape.

The invention provides effective dependable means for rotatably supporting the roller cutters 11 between the spaced legs 14 and 15. The means for rotatably supporting the cutters 11 include bushings 21. The bushings 21 are tubular cylindrical members and are provided at their inner ends with annular thrust flanges 22. The flanges 22 are adapted to bear against the surfaces 15a. Extensions or lugs 23 are provided on the thrust flanges 22 and cooperate with the shoulders 17 to prevent rotation of the bushings 21 and to transmit upward thrusts directly to the legs 15. The outer end portions 21a of the bushings 21 are reduced in diameter and carry thrust washers 24. The washers 24 are adapted to bear outwardly against the thrust surfaces 14a. The cutters 11 are rotatably supported on the bushings 21 between the flanges 22 and the washers 24. In practice the cutters 11 may be rotatably supported on the bushings 21 through roller bearings 25. The flanges 22 and the washers 24 serve to space the cutters 11 from the legs 14 and 15 and to transmit end thrusts to the legs.

Shafts or screws 26 are passed inwardly through openings 27 in the legs 15 and have their outer portions threaded in openings 28 in the legs 14. The openings 27 and 28 are inclined downwardly and inwardly having longitudinal axes normal with the surfaces 14a and 15a. The screws 26 are provided at their inner ends with heads 26a bearing outwardly against the legs 15. The headed and threaded screws 26 serve to tie together the lower portions of the legs 14 and 15. The screws 26 pass through the bushings 21 to support the bushings between the legs 14 and 15. Notches 29 are provided in the outer sides of the legs 14 at the openings 28 and end parts of the screws 26 are peened into these notches 29 to lock the screws against unthreading. The cutters 11 supported as just described are rotatable about downwardly and inwardly inclined axes and project downwardly beyond the lower ends of the legs 14 and 15 to act on the formation at the bottom of the well bore and project slightly beyond the outer sides of the legs 14 to assist in cutting the bore to gauge. It is believed that it will be understood by those skilled in the art how the roller cutters 11 operate to cut an annular groove in the periphery of the well bore by a crushing rolling action.

The cutters 12 are an important feature of the invention being of novel shape and construction. The invention, as illustrated, includes two cutters 12 which may be alike in size and shape. The cutters 12 are generally cylindrical though graduated or varying in external diameter. The cutters 12 are preferably, though not necessarily, tubular. As illustrated in the drawing each cutter 12 has a central longitudinal opening 30. The upper ends of the cutters 12 are flat and normal. In accordance with the invention the cutters 12 are substantially cup-shaped having depressions or central sockets 31 in their lower ends. The sockets 31 are comparatively large in diameter and are provided to form or leave annular cutting edges 32 at the lower ends of the cutters. The cutting edges 32 are the principal cutting edges of the cutters 12 and have shearing or scraping engagement with the earth formation as will be hereinafter described. The extreme lower ends of the cutters 12 are bevelled upwardly and away from the cutting edges 32. The sockets 31 in the lower ends of the cutters 12 provide or leave cylindrical walls at the lower ends of the cutters and the edges 32 occur at the lower ends of these walls.

The walls or surfaces of the sockets 31 are hard faced with tungsten carbide, or the like, to provide the cutters with long wearing cutting edges 32. The sockets 31 are comparatively deep so that the edges 32 are very long wearing. As the edges 32 scrape along the bottom of the well bore the metal behind or surrounding the edges 32 being softer than the hard facing comprising the edges 32, wears away, leaving the edges 32 sharp. Due to the depth of the sockets 31 the edges 32 automatically remain sharp until the tubular lower walls of the cutter 12 are almost entirely worn away.

In addition to the cutting edges 32 the cutters 12 are provided with reaming teeth 33. The upper portions of the cutters 12 are enlarged in external diameter and longitudinally extending grooves 33a are formed in these enlarged portions of the cutters to form or leave the reaming teeth 33. The grooves 33a forming the teeth 33 are preferably of substantial depth to extend into the bodies of the cutters 12. The reaming teeth 33 extend from the upper ends of the cutters 12 to circumferential lines spaced slightly above the upper walls of the sockets 31. In the drawing the teeth 33 are shown as straight or axial, it being understood that the reaming teeth 33 may be pitched or spiralled, if desired. The teeth 33 being formed in the enlarged upper portions of the cutters 12 have active longitudinal edges for contacting and reaming the side wall of the well bore as will be more fully described. The cutters 12 are preferably carburized throughout their various surfaces, with the exception of the side walls of the sockets 31, to have hard internal as well as external surfaces.

Simple, effective means are provided to rotatably support the cutters 12 on the body 10. In accordance with the invention the cutters 12 are rotatably supported for rotation about axes which are slightly inclined downwardly and forwardly relative to the direction of rotation of the bit. Sockets or openings 34, having the desired slight inclination, enter the bosses 18 from their lower ends and extend upwardly into the body 10 proper. The longitudinal axes of the openings

on the tool prevent the cutters 12 from being subjected to excessive feed pressures.

The cutters 11 and the cutters 12 are dependably supported for independent rotation about their individual axes. The cutters are supported so that they may be easily and quickly removed for resharpening or replacement. The body 10 is subjected to little or no wear and the various wear taking parts may be readily replaced. The tool is inexpensive to manufacture and to repair and service.

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 fall within the scope of the following claims:

Having described my invention, I claim:

1. A rotary well drilling bit including, a body, a roller cutter rotatably supported on the body for rotation about a substantially transverse axis and positioned to make an annular cut in the peripheral portion of the well, and a cutter rotatably supported on the body for rotation about an axis inclined downwardly and slightly forwardly relative to the direction of rotation of the bit and having a scraping edge for acting on the inner portion of the well.

2. A rotary well drilling bit including, a body, a roller cutter rotatably supported on the body for rotation about a substantially transverse axis and positioned to make an annular cut in the peripheral portion of the well, and a cutter rotatably supported on the body for rotation about an axis inclined downwardly and forwardly relative to the direction of rotation of the bit, the last mentioned cutter having a continuous scraping edge for acting on the inner portion of the well bore.

3. A rotary well drilling bit including, a body, a roller cutter rotatably supported on the body for rotation about a substantially transverse axis and positioned to make an annular cut in the peripheral portion of the well, and a cutter rotatably supported on the body for rotation about an axis inclined downwardly and forwardly relative to the direction of rotation of the bit, the last mentioned cutter having a continuous scraping edge for acting on the inner portion of the well bore, and reaming teeth for contacting the side wall of the bore to effect its rotation.

4. A rotary well drilling bit including, a body, and a substantially cylindrical cutter supported on the lower end of the body for rotation about an axis inclined downwardly and forwardly relative to the direction of rotation of the bit, there being an opening in the lower end of the cutter leaving a wall of tubular form whose lower end presents an annular scraping edge.

5. A rotary well drilling bit including, a body, and a cutter supported on the lower end of the body for rotation about an axis inclined downwardly and slightly forwardly relative to the direction of rotation of the bit, the cutter including an endless scraping edge on its lower end.

6. A rotary well drilling bit including, a body, and a cutter supported on the lower end of the body for rotation about an axis inclined downwardly and slightly forwardly relative to the direction of rotation of the bit, the cutter including an endless scraping edge on its lower end, and reaming teeth above said edge.

7. A rotary well drilling bit including, a body, and a cutter supported on the lower end of the body for rotation about a nearly vertical axis, there being an opening in the lower end of the cutter leaving a wall of tubular form which presents an annular scraping edge, said cutter including hard facing material lining the said socket whereby said wall wears away through use to maintain said edge sharp.

8. A rotatable cutter for a well drill including, a cutter body intended to be supported for rotation about a generally vertical axis, said body having an opening in its lower end leaving a peripheral tubular body wall, and a tubular lining of hard material on the wall of said opening to provide a cutting edge.

9. A rotatable cutter for a well drill including, a cutter body to be supported for rotation about a nearly vertical axis, said body having an opening in its lower end leaving a tubular body wall, and hard material on the internal surface of said wall to provide a cutting edge at its lower end, and raised reaming teeth on the periphery of the body above said edge.

10. A well bit including, a body to be rotated in a well, a rotatable cutter having a scraping edge at its lower end and axially extending reaming teeth on its external surface, and means rotatably supporting the cutter on the lower end of the body to rotate about a downwardly and forwardly inclined axis to have said edge scrape on the bottom of the bore and to have its outer peripheral surface adjacent and substantially parallel with the side wall of the bore whereby the said teeth engage the side wall to cause rotation of the cutter.

11. A well bit including, a body to be rotated in a well, a rotatable cutter having a scraping edge at its lower end and axially extending reaming teeth on its external surface of greater effective diameter than the lower portion of the cutter, and means rotatably supporting the cutter on the lower end of the body to rotate about a downwardly and forwardly inclined axis to have said edge scrape on the bottom of the bore and to have its outer peripheral surface adjacent and substantially parallel with the side wall of the bore whereby the said teeth engage the side wall to cause rotation of the cutter.

12. A well bit including a body having a fluid opening, a pin carried by the body and projecting from its lower end, and a cutter rotatable on the pin about a downwardly and forwardly inclined axis, said cutter having a socket in its lower end leaving an annular scraping cutting edge for acting on the bottom wall of the bore, said pin having an opening for conducting fluid from the first mentioned opening to said socket.

13. A rotary well drill including, a body having a pair of spaced depending legs, a pin extending between said legs to have its ends supported thereby, a roller cutter on said pin rotatable about a substantially transverse axis to act on the bottom wall of the well, and a scraping cutter rotatably supported by the body to rotate about a slightly downwardly and forwardly inclined axis to act on the bottom wall of the well.

14. A rotary well drill including, a body, substantially diametrically opposite pairs of spaced legs projecting from the lower end of the body, pins supported by said legs, roller cutters supported on said pins for rotation about downwardly and inwardly inclined axes to have rolling contact with the peripheral portion of the bore, and cutters rotatably supported by the body between said pairs of legs to rotate about

34 are normal to the lower ends of the bosses 18 and the openings 34 are tapered being of upwardly diminishing diameters. The means for rotatably carrying the cutters 12 include studs or pins 35 arranged upwardly in the openings 34. The upper portions of the pins 35 are tapered to properly fit the openings 34.

Means are provided for removably locking the pins 35 in the openings 34. Transverse openings 36 are provided in the bosses 18 and intersect or partially join the openings 34 adjacent their outermost wall portions. The openings 36 are elongate in cross section and have their major transverse axes inclined downwardly and outwardly. Notches 37 are provided in the exteriors of the pins 35 to complement or communicate with the openings 36. Wedges 38 are arranged or driven in the openings 36 to cooperate with the notches 37. The end portions or at least the small end portions of the wedges 38 are turned over to prevent accidental displacement of the wedges from the openings 36. The wedges 38 cooperate with the notches 37 to dependably lock the pins 35 against displacement from the openings 34 and serve to hold the pins against rotation. The pins 35 project downwardly from the bosses 18 and the cutters 12 are rotatable on the projecting portions of the pins. The pins 35 project through the openings 30 in the cutters 12 and have annular flanges 40 at their lower ends to prevent displacement of the cutters. The flanges 40 are preferably received in annular recesses 41 in the upper walls of the sockets 31. Hardened thrust washers 42 are preferably interposed between the upper ends of the cutters 12 and the lower ends of the bosses 18. Suitable dowels 43 hold the thrust washers 42 against rotation.

The cutters 12 are rotatably supported on the pins 35 to rotate about approximately vertical axes, the axes of rotation of the cutters being slightly inclined downwardly and forwardly relative to the direct rotation of the bit. Thus the lower ends of the sockets 31 on the cutters 12 are open and trailing portions of the cutting edges 32 have shearing or scraping engagement with the formation at the bottom of the well bore. The active portions of the cutting edges 32 are in substantially the same horizontal plane as the edges of the teeth 20 where they contact the formation. The scraping cutters 12 are positioned and mounted so that their peripheral surfaces are substantially vertical where they are opposed to and adjacent to the side wall of the well bore so that these surfaces move in a circular path larger in diameter than the circular paths of the outermost surfaces of the bosses 18 and legs 14. Owing to this disposition of the cutters 12 the reaming teeth 33 come into positive cooperation with the earth formation and are substantially vertical as they engage the side wall of the well. The engagement of the reaming teeth 33 with the side wall of the well bore reams the bore to gauge and effects the positive rotation of the cutters 12 about their individual axes. This independent rotation of the cutters 12 renders their edges 32 more effective and long wearing.

The invention provides means for flushing the cutters 11 and 12 of cuttings and mud. A fluid chamber 50 is provided in the body 10 at the lower end of its socket 13. The chamber 50 receives the circulation fluid pumped downwardly through the drilling string. Ports 51 are provided in the body 10 and extend downwardly from the chamber 50 to the spaces between the adjacent legs 14 and 15. The ports 51 are inclined downwardly and outwardly and direct the circulation fluid against the cutting teeth 20 of the cutters 11. The upper ends of the openings 34 are in communication with the fluid chamber 50. The cutter supporting pins 35 are tubular having central longitudinal openings 52. The upper ends of the openings 52 are in communication with the chamber 50 while the lower ends of the openings 52 communicate with the sockets 31. The openings 52 conduct the circulation fluid downwardly from the chamber 50 to the sockets 31 to effect the full flushing and cleaning of the active cutting edges 32 of the cutters 12.

In the operation of the bit provided by this invention the body 10 carrying the various other parts of the tool is connected with the lower end of a suitable well drilling string. The drilling string is lowered into the well and is rotated and fed downwardly in the usual manner to advance the bit into the formation. The roller cutters 11 are formed and positioned to cut a relatively narrow channel in the earth formation at the periphery of the well bore. This cut formed by the cutters 11 is slightly less than the desired gauge of the well bore. The cutters 11 operating by a crushing or rolling action take or transmit a substantial portion of the feed pressures on the bit relieving the cutters 12 of excessive feed pressures.

The cutting edges 32 of the slightly tilted cutters 12 have scraping engagement with the bottom wall of the well bore within the cut made by the cutters 11. The cutting edges 32 being endless or annular have smooth even engagement with the formation to effectively cut away the same by a scraping action. As above described, the side walls of the sockets 31 are hard faced with tungsten carbide or the like to provide the cutting edges 32. As the tool operates the relatively soft metal surrounding and backing the cutting edges 32 wears away leaving the edges 32 sharp. The metal surrounding the edges 32 trails the edges 32 as they engage the formation and these trailing parts of the cutters 12 are worn away more rapidly than the edges 32. Further, a small core may be left standing between the cutters 12 and the lower outer parts of the cutters 12 may be worn away due to their engagement with the core. The lower outer portions of the cutters 12 are relatively close to the center of the bit and are moving at a relatively high velocity when they engage the core and, therefore, wear away rather quickly. This wearing away of the metal about the edges 32 automatically maintains the edges 32 sharp. Thus the cutters 12 are self-sharpening through use.

The reaming teeth 33 have a larger effective diameter than the edges 32 and cutters 11 and engage the formation at the side wall of the well bore to cut the bore to the desired gauge. This reaming engagement of the cutting teeth 33 with the side wall of the well bore effects the positive rotation of the cutters 12 making the cutting edges 32 particularly efficient and long wearing. It will be noted that the cutters 12 present endless or annular principal cutting edges 32 for acting on the formation at the bottom of the well bore and do not have projecting blades liable to breakage or failure. The cutters 11 and 12 are spaced and related to assure the smooth even operation of the tool. The roller cutters 11 in taking a substantial portion of the down feed

downwardly and slightly forwardly inclined axes to have scraping contact with the bottom wall of the bore.

15. A rotary well drill including, a body, substantially diametrically opposite pairs of spaced legs projecting from the lower end of the body, pins supported by said legs, roller cutters supported on said pins for rotation about downwardly and inwardly inclined axes to have rolling contact with the peripheral portion of the bore, and cutters rotatably supported by the body between said pairs of legs to rotate about downwardly and slightly forwardly inclined axes, the last mentioned cutters having scraping edges at their lower ends contacting the bottom wall of the well and reaming teeth contacting the side wall of the bore.

16. A rotary well drill including, a body, substantially diametrically opposite pairs of spaced legs projecting from the lower end of the body, pins supported by said legs, roller cutters supported on said pins for rotation about downwardly and inwardly inclined axes to have rolling contact with the peripheral portion of the bore, and cutters rotatably supported by the body between said pairs of legs to rotate about downwardly and slightly forwardly inclined axes, the last mentioned cutters having annular scraping edges at their lower ends contacting the bottom wall of the well, and reaming teeth of longer effective diameter than the lower portions of said cutters contacting the side wall of the bore.

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