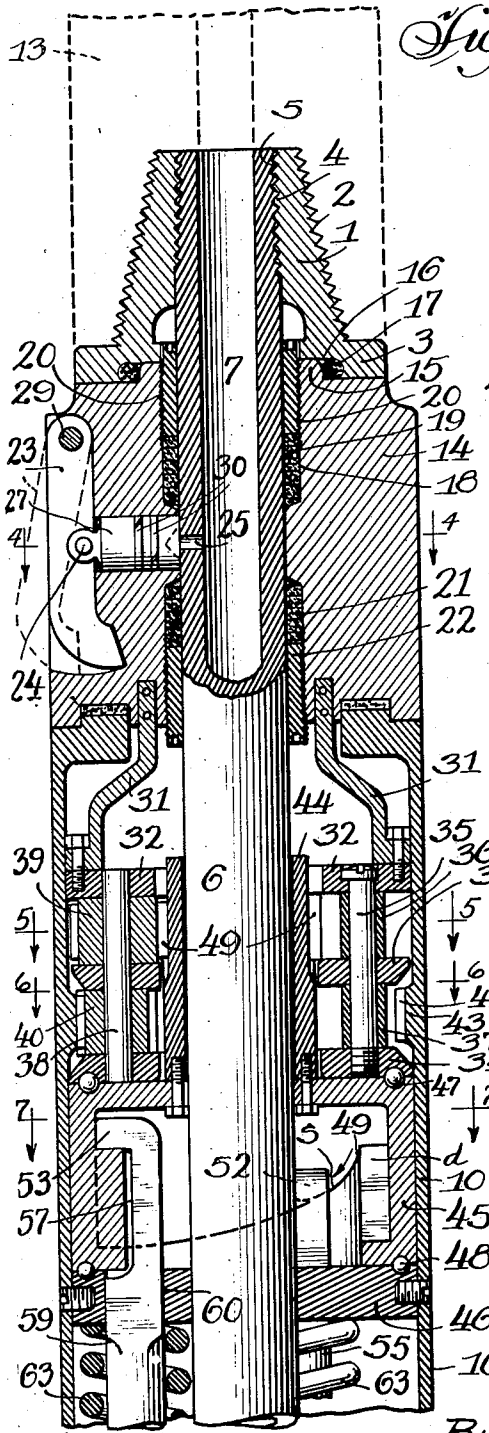
May 13, 1941. J. J. McNAMARA 2,241,712

DRILL

Filed Feb. 7, 1938 3 Sheets-Sheet 1

Fig. 1.



Witnesses:
Chas. L. Kourek.

Fig. 4.

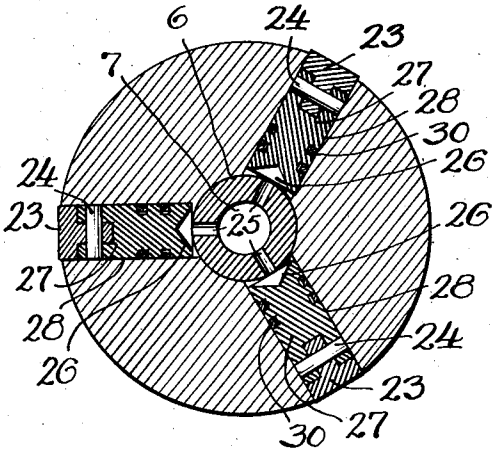


Fig. 5.

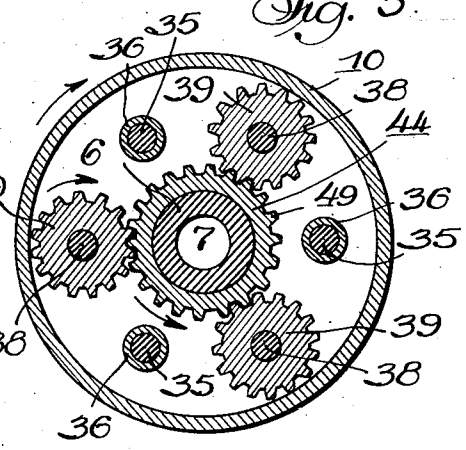
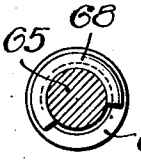


Fig. 15.



Inventor,
John J. McNamara
By Parkinson & Lane, Attys.

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DRILL

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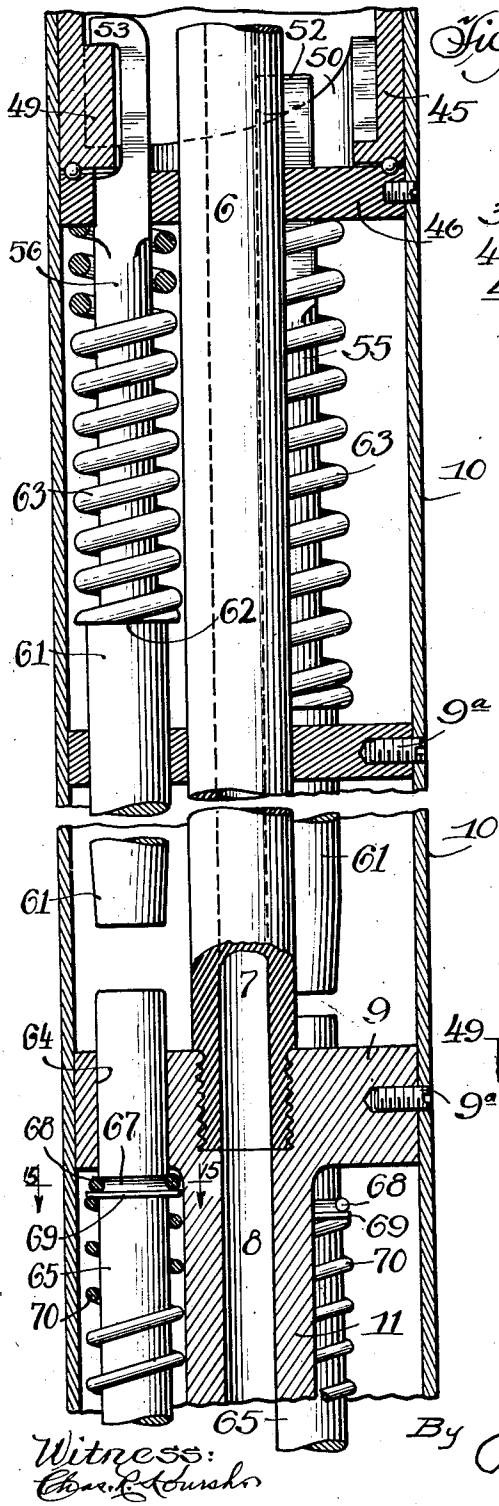


Fig. 2.

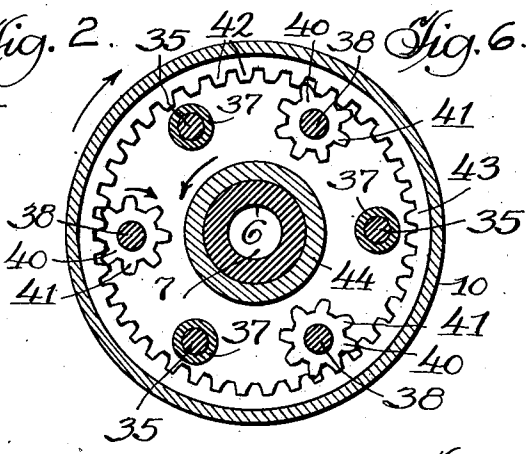


Fig. 6.

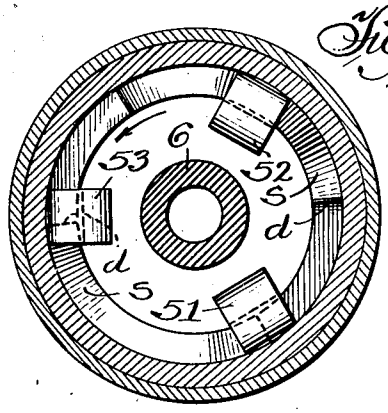


Fig. 7.

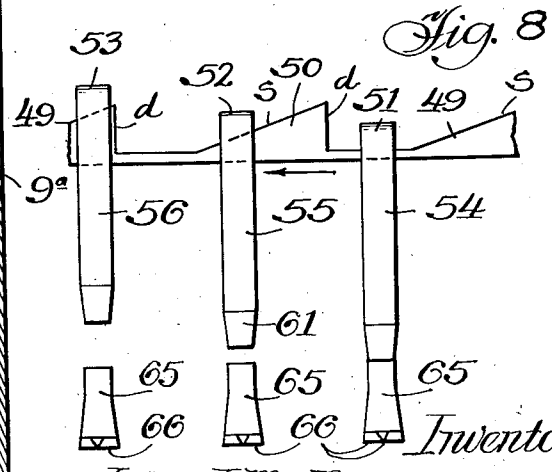


Fig. 8

Witness:
Chas. L. Kirsch

By

Inventor,
John J. McNamara,
Parkinson & Lane, Attys.

May 13, 1941. J. J. McNAMARA 2,241,712

DRILL

Filed Feb. 7, 1938 3 Sheets-Sheet 3

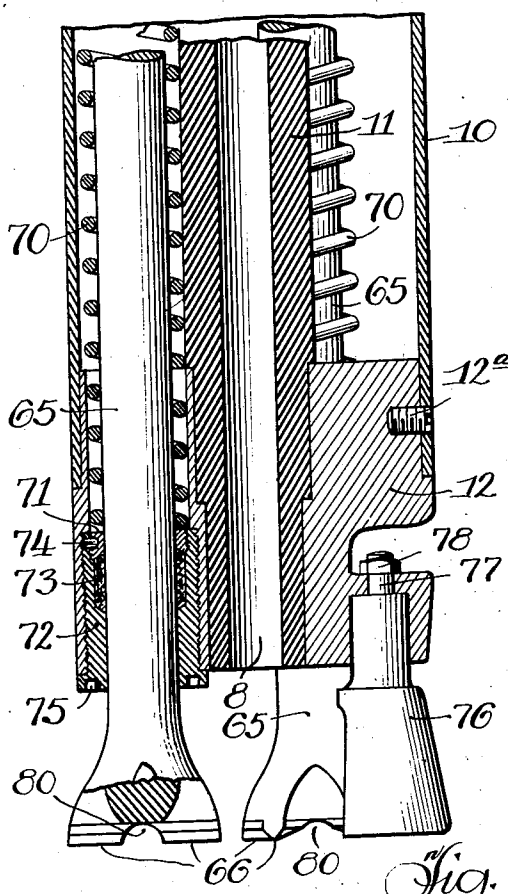


Fig. 3.

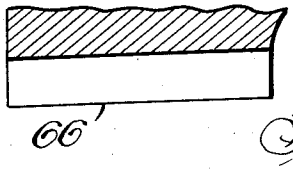


Fig. 10.

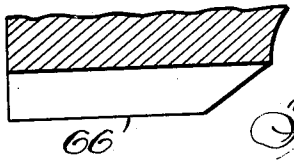


Fig. 11.

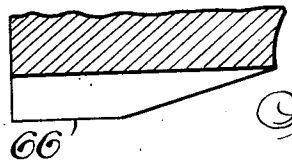


Fig. 12.

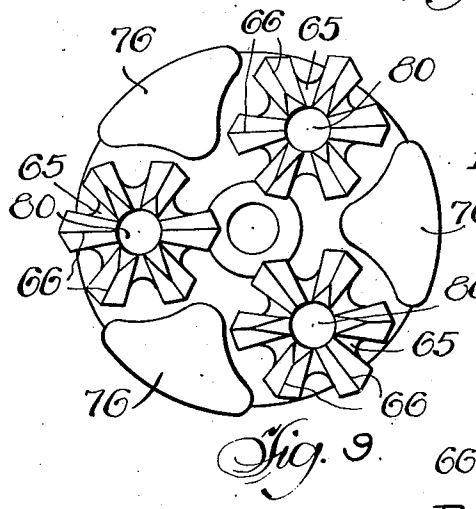


Fig. 9.

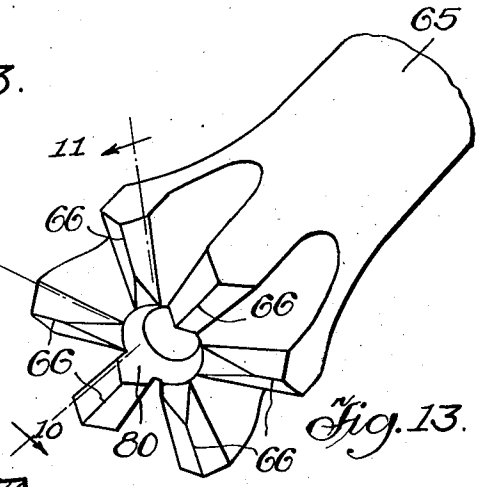


Fig. 13.



Fig. 14

Inventor,
John J. Mc. Namara,
By Parkinson & Lane, Attys.

Witness:
Chas. K. Kousek.

Patented May 13, 1941

2,241,712

UNITED STATES PATENT OFFICE

2,241,712

DRILL

John J. McNamara, Chicago, Ill., assignor to Oil Well Drill—Ltd., Chicago, Ill., a trust

Application February 7, 1938, Serial No. 189,063

12 Claims. (Cl. 255—4)

This invention relates to drills of the hammer type for drilling holes in the ground and through rock and the like, for any purpose for which such holes may be desired, such as for oil wells, water wells, or other purposes.

As is well known, in the drilling of oil wells and the like, the drill often encounters rock that is sometimes very hard in nature. The forms of drill heretofore known are not satisfactory for many reasons, among which are that they become too quickly dulled and lack the desired efficiency of operation, as well as lacking durability and economy. In the drilling of holes for the purposes contemplated herein, it is essential for economy as well as for other reasons, that the drill be kept operating as continuously as possible. When a drill becomes dull or broken it is necessary to stop operations, pull the drill out of the ground, remove the old drill and put in a fresh one, and again lower it into the ground. All this entails great loss of time and labor, as well as considerable expense in supplying fresh drills. For these and other reasons it is highly desirable that such drills be of maximum efficiency and durability.

Among the objects of my invention is to provide a drill that will overcome to a considerable extent the objections and possess the advantages referred to above.

A further object is to simplify the construction and operation of such drills while at the same time increasing their efficiency and durability.

A still further object is the provision of a drill having a very greatly improved hammer action on the cutting bits simultaneously with the rotation of the drill as a whole.

Another object is the provision of improved means for holding the head of the drill against rotation in the hole, while at the same time providing improved means below said head for operating the cutting bits.

Still another object is the provision of an improved cutting face or faces on the bit to improve its cutting efficiency, especially in hard work.

A further object is the provision of a drill of maximum safety in the drilling operation whereby to practically eliminate expensive fishing jobs, it being necessary to put only very little weight on the drill.

Further to make more possible the drilling of a straight hole.

Also to provide a drill having a clearance when going through a casing, and yet will cut a hole the full size of, or larger than the inside diameter of, the casing when on the bottom.

Another object is to provide a drill that will automatically change from a hard rock hammer drill to a regular digging bit when soft formation is encountered, and back to a hard rock drill again when such rock is again reached.

A further object is the provision of a drill that requires no change to use it on any rotary rig, all that is necessary being to screw it on where any old drill comes off and put it to work.

Further the provision of a drill that will dig a greater distance in less time and at less cost, and which requires less power to drive it.

Also another object is to materially lessen the time required for changing the cutting bit.

Other objects, advantages and capabilities inherently possessed by my invention will later more fully appear.

My invention further resides in the combination, construction and arrangement of parts illustrated in the accompanying drawings, and while I have shown therein preferred embodiments I wish it understood that the same are susceptible of modification and change without departing from the spirit of my invention.

In the drawings:

Fig. 1 is a fragmentary longitudinal section of the upper portion of the drill taken on a median plane, some parts being shown in elevation for convenience and clarity.

Fig. 2 is a view similar to Fig. 1 but showing the intermediate portion of the drill.

Fig. 3 is a view similar to Figs. 1 and 2 but showing the bottom portion of the drill.

Fig. 4 is transverse section taken on the line 4—4 of Fig. 1 and looking in the direction of the arrows.

Fig. 5 is transverse section taken on the line 5—5 of Fig. 1 and looking in the direction of the arrows.

Fig. 6 is a transverse section taken on the line 6—6 of Fig. 1 and looking in the direction of the arrows.

Fig. 7 is a transverse section taken on the line 7—7 of Fig. 1 and looking in the direction of the arrows.

Fig. 8 is a diagrammatic development of the bits, hammers and cams, showing these parts in their relative positions, but laid out flat for the sake of clearness.

Fig. 9 is a bottom end view of the drill.

Fig. 10 is a fragmentary section radially through one of the cutting portions of the bit, taken on the line 10 of Fig. 13.

Fig. 11 is a fragmentary section radially through another of the cutting portions of the bit, taken on the line 11 of Fig. 13.

Fig. 12 is a fragmentary section radially through still another of the cutting portions of the bit, taken on the line 12 of Fig. 13.

Fig. 13 is a fragmentary perspective view of the lower end portion of the bit showing the arrangement of the cutting edges thereof.

Fig. 14 is a fragmentary transverse section through one of the cutting edges of the bit taken in a direction longitudinally of the bit.

Fig. 15 is a transverse section through the upper portion of one of the bits, taken on the line 15—15 of Fig. 2, and looking in the direction of the arrow.

Referring more in detail to the drawings, I have shown the upper portion of the drill in Fig. 1, the intermediate portion in Fig. 2, and the lower portion in Fig. 3, so that when these three figures are considered together the entire length of the drill is shown, but the lower end of Fig. 1 slightly duplicates or overlaps portions of the top of Fig. 2, and the lower end of Fig. 2 may or may not slightly duplicate or overlap a small portion of the top of Fig. 3, depending on the total length of the drill. I have also shown a portion of the length of the hammers and associated parts broken away in Fig. 2, for the conservation of space. These hammers may be of any length desired and are described in detail hereinafter.

At the top of my drill, as shown in Fig. 1, is the tapered screw-joint member 1 formed with the tapered threads 2 and a base portion 3. Joint member 1 is provided with a central opening formed with interior screw threads 4 adapted to be threaded onto the threads 5 formed on the upper end portion of the tubular drive shaft 6 provided with the central longitudinal bore 7 through which water under considerable pressure (approximately 200 pounds per square inch) is forced to and through a corresponding alined tubular opening 8 in the upper bit-supporting member 9, which is fixed to the casing 10 by screws 9a or the like, to rotate therewith. Tubular opening 8, as seen in Fig. 3, extends to the bottom of the drill to conduct the water under pressure to the cutting end of the bits in order to circulate the cuttings from the drill upwardly along the outside of the casing to the top of the hole. The upper bit-supporting member 9 has a downward extension 11 which at its lower end has a tight fit in a central opening in the foot member 12, which latter is also fixed to the casing 10 by screws or the like 12a, to rotate therewith.

The threads 2 of the screw-joint member 1 are adapted to be screwed tightly into threaded engagement with complemental threads in the lower end of the drill stem 13 shown in dotted lines in Fig. 1, and which drill stem extends to the floor of the derrick on the surface where it is operated in a well known manner in usual practice. Immediately below the screw-joint member 1 is the stationary head member 14 having the upstanding flange 15 seated in the counterbore 16, suitable packing 17 being provided and firmly held between these parts to prevent cuttings from passing through the joint between these parts and between the rotating drive shaft 6 and the stationary head 14.

Head member 14 is counterbored at 18 to receive packing 19 held in place by packing gland 20, which has screw-threaded connection with head member 14 for adjusting purposes. A similar packing 21 is similarly provided at the lower end of head member 14, which latter packing is held in adjusted position by a similar threaded packing gland 22. The reason for the packing 19 and 21 is because of the relative rotation of tubular drive shaft 6 with relation to the stationary head 14. To further insure that head 14 is held stationary during operation of the drill, I provide any suitable number of circumferentially spaced levers or holding lugs 23 pivoted at 29 to the stationary member 14, so as to permit an outward swinging movement of the lower end of each of these lugs so as to be forced into binding or holding connection with the walls of the hole being drilled. The hole in each of lugs 23 for receiving the pivot pin 24 may be elongated or not as desired.

The power medium for forcing these lugs outwardly into holding engagement with the walls of the opening is the water under pressure within the opening 7 in the tubular drive shaft 6, which water under pressure is admitted through openings 25 to the inner face 26 of each of piston heads 27 slidably mounted in each of openings 28, formed radially in the stationary head 14. Each of piston heads 27 is formed with any suitable number of packing rings 30 to prevent undue leakage of pressure by these pistons.

From the above it is seen that the water under pressure will act against each of these pistons and by forcing the bottom end of the holding lugs 23 outwardly into tight engagement with the walls of the opening will insure that head member 14 is positively held against rotation while the remainder of the drill is in rotation. Also lugs 23 will permit the drill to move downwardly as the hole is made deeper. Fixed to the lower portion of stationary head 14 are downwardly extending arms 31, which may be of any suitable number, preferably three or four (there being four contemplated in Fig. 1). Due to these arms 31 being fixed to head 14 they will also be held against rotation. The lower end of each of these arms 31 is bolted or otherwise fastened to the upper ring 32 of a composite cage, comprising in addition to the upper annular plate 32 the intermediate annular plate 33 and the lower annular plate 34, which three plates are securely fastened together as a unit by suitably spaced bolts, machine screws or the like 35, around which are mounted the spacer sleeves 36 and 37 which hold the annular plates 32, 33 and 34 properly and suitably but rigidly spaced so as to form a composite unit. There are three of these spacing bolts, screws or the like 35, shown in Figs. 5 and 6.

Also extending through the spaced annular plates 32, 33 and 34 and mounted to rotate therein, are the three preferably equally spaced shafts 38, to each of which shafts between plates 32 and 33 are fixed the gears 39, and between plates 33 and 34 are fixed to said shaft 38 the drive pinions 40, whereby the drive pinions 40 and the gears 39 will rotate together as a unit and at the same number of revolutions per minute. The teeth 41 of drive pinions 40 mesh with the teeth 42 of the ring gear 43 which, as seen in Fig. 1, is fixed to casing 10 by being formed either integral therewith or securely attached thereto, so as to rotate at all times together with the casing. It is also to be noted that surrounding the tubular shaft 6 and positioned within the central opening of the three annular plates 32, 33 and 34, is a sleeve 44 which is freely rotat-

able on drive shaft 6 and has fixed to its lower end to rotate therewith the annular cam head 45, which is rotatably mounted between the lower plate 34 and the base plate 46, there being suitable ballbearings 47 and 48 or other desirable anti-friction means provided between these parts to lessen the friction therebetween.

Formed on sleeve 44 are teeth 49 (see Fig. 5) in the space between the top annular plate 32 and the intermediate plate 33, which when the parts are assembled as shown in Fig. 1, mesh with complemental teeth on the gears 39. Meshing with the teeth 42 of the ring gear 43 are the teeth 41 of the drive pinions 40. The cam head 45 is around its interior circumference formed with any suitable number (two being shown in the drawings in the form illustrated) of cams 49 and 50, which extend inwardly a suitable distance from the inner face of the cam head or sleeve 45. These cams are preferably equally spaced apart in an annular direction. As seen in Fig. 8, these cams are provided with a cam surface *s* and a vertical drop surface *d*, so that as these cams are rotated, as later more fully explained, the heads 51, 52 and 53 of the hammers 54, 55 and 56 will in succession be moved upwardly by said cam surfaces *s* and drop vertically a substantial distance by reason of the drop surfaces *d*. The upper end portion of these hammers are diminished in thickness at 57 to provide suitable clearance for the metal of the cam portions, and at their upper ends are flanged outwardly to form the heads 51, 52 and 53 the under surfaces of which heads are in direct contact with said cam surfaces to ride thereover to produce the up and down movement of the hammers.

The upper end portion of the hammers is also from the point 59 to the top formed either square or rectangular in cross-section so as to slidingly fit correspondingly shaped openings 60 in the base plate 46 in order to prevent rotation of the hammers and guarantee that they constantly maintain the proper position for engagement with the cams. These hammers will be more clearly understood in their entirety in Fig. 2, in which it is seen that they are somewhat enlarged in diameter at their bottom portion 61, which forms a shoulder 62 against which abuts the coil spring 63 which at its upper end is in contact with the lower face of the base plate 46, these springs being held between said parts in compression so that when the top flanged ends 51, 52 and 53 of the hammers drop off of the drop portion *d*, these springs will by expansion quickly drive said hammers downwardly to produce a hammer blow on the bits, as later more fully explained. Each of these hammers 54, 55 and 56 is constructed alike and they are preferably equally spaced in an annular direction.

Longitudinally slidably mounted in suitable equally spaced openings 64 of the upper bit supporting member 9, are the cutting bits 65 preferably circular in cross-section, and which at their lower end are formed into cutting edges 66, later more fully described. Near the upper end of each of these cutting bits 65 is formed therein an annular groove 67, which receives the spring collar 68, which due to its resilient nature can be forced into said grooves over the cutting bit, and which collar when in final position will spring back into gripping engagement with said annular groove 67 (see Fig. 15). Also encircling the cutting bit is an annular washer 69 which fits tight on the shank of the cutting bit and forms an abutment for the coil spring 70, which surrounds the cutting bit and extends downwardly from collar 69 to the threaded sleeve 71, threaded as shown in Fig. 3 to the interior of the upper end of the counterbore in the sleeve 72, which is threaded into a complemental opening in the lower end of the foot member 12, it being understood that there are illustrated three of these cutting bits, the construction of each of which is similar to that now being described.

Sleeve 71 serves as a gland for the packing 73 in said counterbore, sleeve 71 after being screwed inwardly to the desired amount to adjust said packing being fastened against further movement by a threaded or other suitable pin 74. Sleeve 72 at its lower end is formed with suitable openings 75 for a spanner wrench or other suitable tightening implement.

From the above description it is seen that spring 70 is compressed between the lower face of the washer 69 and the upper face of gland sleeve 71, so that the normal tendency of this spring is to hold the cutting bit upwardly in the position shown in Fig. 2, in which normal position it is ready to receive the blow from its hammer, which blow drives the cutting bit downwardly to perform the cutting action, after which spring 70 will return the cutting bit upwardly into position to receive its next succeeding blow, these blows being delivered with great rapidity, as later pointed out. This upward movement of the cutting bit by spring 70 also prevents the dragging of the cutting edges 66 against the material being cut during rotation of the drill, thus insuring a good sharp cutting blow with an immediate recession of the bit from the material being cut. Each of the cutting bits is independently rotatable in the casing whereby to cut a hole larger than the inner diameter of the casing, and yet be withdrawable through the piping lining the hole.

It is here pointed out that the weight of the drill is not carried upon the cutting edges but is relieved therefrom by the provision of any desired number of suitably spaced supporting feet 76, which at their upper ends are secured in place by a threaded extension 77 and nut 78, which obviously could be of any formation desired, such as a threaded opening in the shank of foot 76 to receive the threaded lower end of a machine screw, or the like. As seen in Fig. 3, the lower end of each of feet 76 is normally lower than the lowermost portion of the cutting edges 66, except when the cutting bit is driven downwardly by the hammer during the short decisive cutting blow, after which it is instantly moved upwardly above the lower end of feet 76 by spring 70.

From the above it is seen that the rotating tubular drive shaft 6 is at its lower end (see Fig. 2) tightly screwed or otherwise fastened into the upper end of the upper bit supporting member 9, which in turn is fixed to casing 10, the foot member 12 also being fixed to the casing 10 at 12a, it being understood that the lower end of the downwardly extending portion 11 of the bit supporting member will be tightly fixed to foot member 12 by being either screwed thereinto, keyed thereto or tightly secured thereto in any desired manner, so that these two parts rotate together and in turn rotate the casing 10. They may also be integral, as made of one part, if desired. This rotation of casing 10 (see Fig. 1) will through the medium of the teeth 42 of the ring gear 43 drive each of the drive pinions 40

at a certain speed determined by the number of teeth therein, which in turn will drive shaft **38** and also drive the gears **39** which are fixed to shaft **38**, gears **39** in turn through teeth **49** driving the sleeve **44** causing rotation of cam sleeve **45** and at a greater speed than that of the casing, because of there being a greater number of teeth in each of gears **39** than in each of drive pinions **40**, the latter two mentioned gears rotating at the same speed on shaft **38**. This difference in speed of rotation of the cam sleeve with relation to the casing may be varied as desired by suitably changing the ratios of the gears with relation to each other, and thereby increase or decrease the number of blows per minute on the cutting bits.

In the form shown in the drawings the direction of rotation of the cam sleeve and the cams is opposite to that of the direction of rotation of the casing, which is desirable because of thereby automatically giving a greater speed of rotation of the cam sleeve and the cutting bits relatively to each other. Also this movement of the cams in a rotational direction opposite to that of the hammer heads increases the sharpness of the blow of the hammers against the cutting bits, and in turn the sharpness of the cutting action of the bit in the material, such as hard rock, or the like, being cut, and also increases the frequency of the blows.

Attention is also called to the convenience of assembly of the parts of my improved drill, for example, the hammer heads may be assembled with relation to the cams and cam sleeve before these parts are inserted into the casing with their spring **63** mounted thereon, and the cutting bits **65** mounted in place in the assembled upper cutting bit supporting member **9** and foot member **12**, with the sleeve member **72** screwed into place into its threaded opening in the foot member **12**, with its packing and gland previously adjusted, and these parts inserted as a unit into the casing and secured by screws or the like as shown. Finally the entire assembly is brought into final form and the parts properly drawn together by screwing into place the screw joint member **1** upon the threaded upper end of the tubular drive shaft **6** as shown in Fig. 1.

Referring to each of the cutting bits **65**, it will be seen in Figs. 9 to 14, inclusive, that I have provided a novel arrangement of cutting edges **66**. For example, as seen in Figs. 9 to 13, inclusive, one of these cutting edges (Fig. 10) is of full length from the middle counterbore **80** to the outer circumferential edge of the enlarged bottom end of the cutting bit. The next alternate bit proceeding in a counterclockwise direction in Fig. 13 and Fig. 19 has a small portion of the inner end of cutting edge **66** removed by beveling this inner end inwardly and upwardly, thus providing a somewhat less length of cutting edge than in the one described immediately preceding. Continuing to the next cutting edge in a counterclockwise direction in Figs. 9 and 13, the inner end of the cutting edge **66** is removed to a still greater extent by providing at this end an inwardly and upwardly beveled portion. This creates an even shorter cutting edge than the one last described. The next cutting edge proceeding in a counterclockwise direction in Figs. 9 and 13 is again of full length extending from the counterbore **80** to the outer end. The cutting edges then are successively formed in the manner described above, each of the next two having progressively larger amounts beveled off from their inner ends as described above.

The advantage of this is to throw the greater amount of cutting at and adjacent the outer circumferential edge of the cutting portion of the bit, and to progressively lessen the amount of cutting edge toward the center of the bit, where less cutting is required, and yet cut entirely up to the central counterbore in the lower face of the bit, and leaving only such a small portion at the center of the cutting face without cutting edges that the uncut portion thus left will readily and easily break off during cutting operation of the tool.

As will be understood in drill cutting bits, the outer end of each of the cutting edges will wear off faster in a four cutting edge tool than they will in a six cutting edge tool. In the use of the cutting bits it is of utmost importance to preserve the outer circular contour of the outer edge of the cutting edges in order to keep the size of the hole out to gauge. It is also understood that a six cutting edge bit, if all of the cutting edges extend inwardly the full distance, will present greater resistance than a four cutting edge bit, but in the form of bit described above it will be seen that this greater resistance is diminished by the removing of different amounts of the inner end portion of the cutting edges without sacrificing any of the amount of penetration, and at the same time preserving the maintenance of the circular contour of the outer ends of the cutting edges to prevent undue wearing and keeping the hole out to gauge.

Having now described my invention, I claim:

1. In a drill, a drive shaft and a casing rotatable together in one direction, a hammer mounted for longitudinal reciprocation in said casing and carried therewith as the latter rotates, a head on said hammer, a cam movable under said head, means for causing said cam to positively rotate in a rotational direction opposite to that of the head to cause movement of the hammer longitudinally of the casing, yieldable means for moving the hammer in the opposite direction after the cam has passed beyond it, said first mentioned means including gearing driven by the casing.

2. In a drill, a non-rotatable head member, a shaft rotatably mounted in the head member, a casing rotatable with said shaft, hammers longitudinally slidable in said casing and rotatable therewith, a cam for operating said hammers, said cam moving in a rotational direction opposite to that of the hammers and casing, bits operated by said hammers, and gearing operating between the casing and cam for positively causing the rotation of the cam in a plane at right angles to the axis of the shaft and in a direction opposite to that of the rotation of the casing.

3. In a drill, a non-rotatable head member, a shaft rotatably mounted in the head member, a casing rotatable with said shaft, hammers longitudinally slidable in said casing, a cam for operating said hammers, said cam moving in a rotational direction opposite to that of the hammers and casing, bits operated by said hammers, spring means associated with said hammers and bits for normally moving them longitudinally toward each other, and gearing operating between the casing and cam for positively causing the rotation of the cam in a plane at right angles to the axis of the shaft and in a direction opposite to that of the rotation of the casing.

4. In a drill, a non-rotatable head member, a

shaft rotatably mounted in the head member, a casing fixed to said shaft to be rotatable therewith, hammers longitudinally slidable in said casing, a cam for operating said hammers, said cam moving in a rotational direction opposite to that of the hammers and casing, bits operated by said hammers, spring means associated with said hammers and bits for normally moving them longitudinally toward each other, and means for moving said cam at a greater rotational speed than that of said hammers and in said opposite direction.

5. In a drill for oil wells and the like, a non-rotatable head, a tubular drive shaft rotatable in said head and of substantial length, a casing rotatable with said shaft, a gear assembly carried by said head, a cam sleeve in said casing, gears in said gear assembly driven by rotation of the casing and driving the cam sleeve in a rotational direction opposite that of the casing, hammers longitudinally slidably in said casing and operated by said cam sleeve, and bits operated by said hammers.

6. In a drill of the character described, a rotatable drive shaft, a casing fixed to said shaft to rotate therewith, hammers longitudinally slidable in said casing, springs for urging said hammers downwardly, a cam sleeve, gearing between the casing and cam sleeve for rotating the cam sleeve in a direction opposite to that of the casing and hammers, a cam on said sleeve arranged to move said hammers longitudinally in the casing as the sleeve is rotated, cutting bits longitudinally slidable in the casing, springs for urging said bits upwardly, said hammers operating said bits, said bits being also each rotatable on its own axis in said casing.

7. In a drill of the character described, a rotatable drive shaft, a casing fixed to said shaft to rotate therewith, hammers longitudinally slidable in said casing, springs for urging said hammers downwardly, a cam sleeve rotatable in a direction opposite to that of the casing and shaft, a cam on said sleeve arranged to move said hammers as the sleeve is rotated, cutting bits longitudinally slidable in the casing, springs for urging said bits upwardly, said hammers operating said bits, said bits being also rotatable in said casing, a gear assembly in said casing operated by said casing and in turn driving the cam sleeve.

8. In a drill of the character described, a non-rotatable head, a gear assembly fixed to said head, gears in said assembly, a tubular drive shaft rotatably mounted in said head, a casing fixed to said shaft to rotate therewith, a sleeve surrounding said shaft and rotatable with relation thereto, a ring gear in said casing for rotating some of the gears in the gear assembly for driving others of the gears therein, said other gears driving said sleeve in a rotational direction opposite to that of the drive shaft and casing, a cam sleeve fixed to said first mentioned sleeve to rotate therewith, cams formed on said cam sleeve, hammers longitudinally slidable in said casing and normally urged in a downwardly direction, heads on said hammers, said cams slidable under said heads, and cutting bits operated by said hammers.

9. In a drill of the character described, a non-rotatable head, a gear assembly fixed to said head, gears in said assembly, a tubular drive shaft rotatably mounted in said head, a casing fixed to said shaft to rotate therewith, a sleeve surrounding said shaft and rotatable with relation thereto, a ring gear in said casing for rotating some of the gears in the gear assembly for driving others of the gears therein, said other gears driving said sleeve in a rotational direction opposite to that of the drive shaft and casing, a cam sleeve fixed to said first mentioned sleeve to rotate therewith, cams formed on said cam sleeve, hammers longitudinally slidable in said casing and normally urged in a downwardly direction, heads on said hammers, said cams slidable under said heads, cutting bits operated by said hammers, and water under pressure passing downwardly through said tubular shaft to the bottom of the casing and upwardly of the casing sides to wash out the cuttings.

10. In a drill of the character described, a rotatable drive shaft, a casing fixed to said shaft to rotate therewith, hammers longitudinally slidable in said casing, springs for urging said hammers downwardly, a cam sleeve, means for rotating said cam sleeve in a direction opposite to that of the casing and shaft, a cam on said sleeve arranged to move said hammers as the sleeve is rotated, cutting bits longitudinally slidable in the casing, springs for urging said bits upwardly, said hammers operating said bits, said bits being also rotatable in said casing, and a plurality of supporting feet on the bottom of the casing, the bottom end of said feet being lower than the normal position of the bottoms of said bits.

11. In a drill for oil wells and the like, a rotatable casing, cutting bits longitudinally movable in said casing, said bits being also rotatable with said casing and each bit being further independently rotatable upon its own axis, a hammer in said casing in longitudinal alignment with each bit, a cam for actuating said hammers, and means for positively rotating the cam in a direction opposite to the rotation of the casing.

12. In a drill for oil wells and the like, a hollow rotatable casing surrounded by water during operation of the drill, cutting bits longitudinally movable in said casing and protruding from the lower end of the casing, said bits being rotatable with said casing and each bit being further independently rotatable upon its own axis, a hammer in said casing in longitudinal alignment with each bit, a cam for actuating said hammers, means for positively rotating the cam in a direction opposite to the rotation of the casing, said casing being closed against the entry of water into its hollow interior during operation of the drill.

JOHN J. McNAMARA.