Aug. 5, 1947. R. E. SNYDER 2,425,012

IMPACT DRILL

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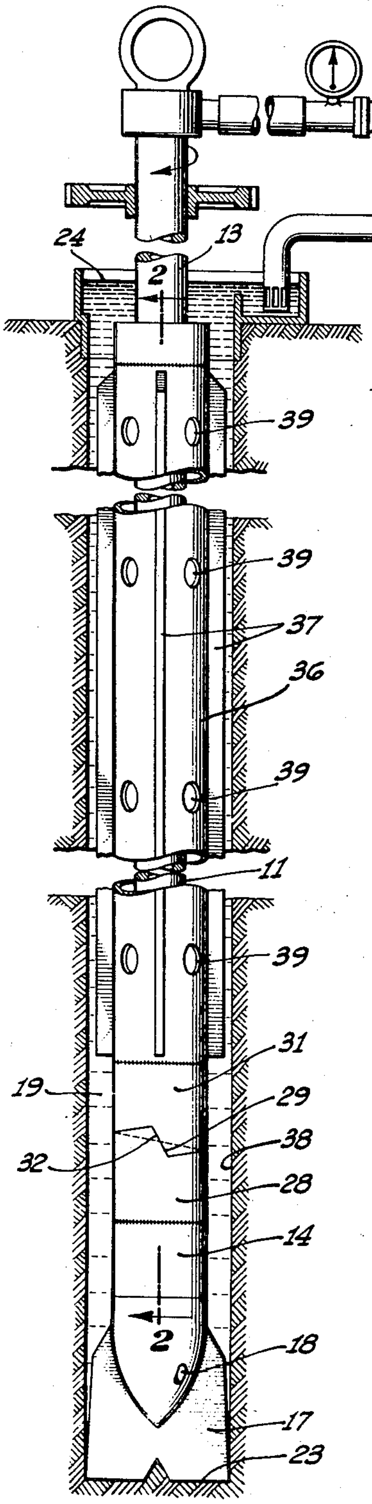

Fig. 1.

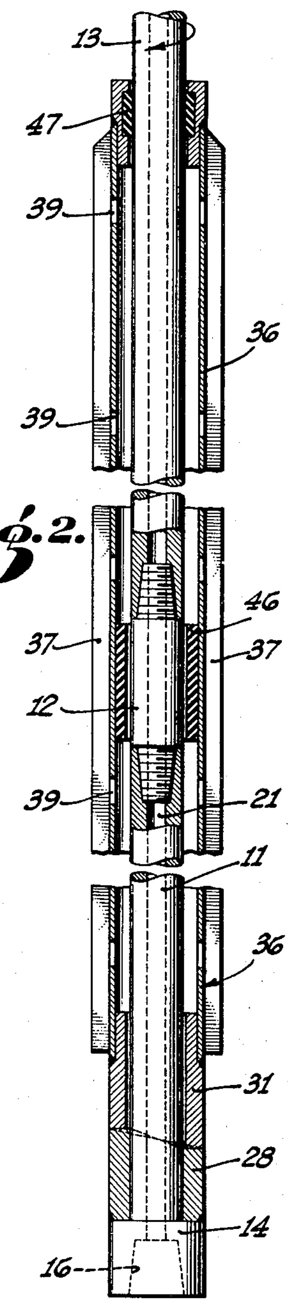

Fig. 2.

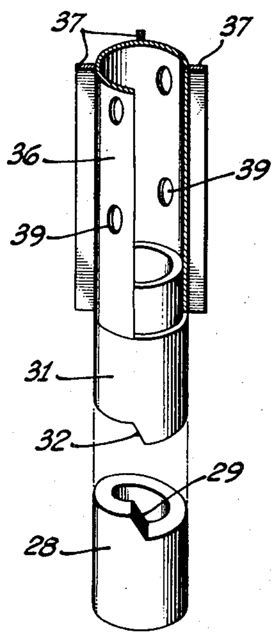

Fig. 3.

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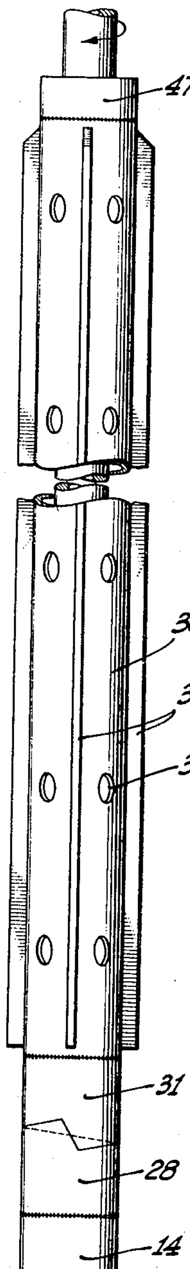

Fig. 4.

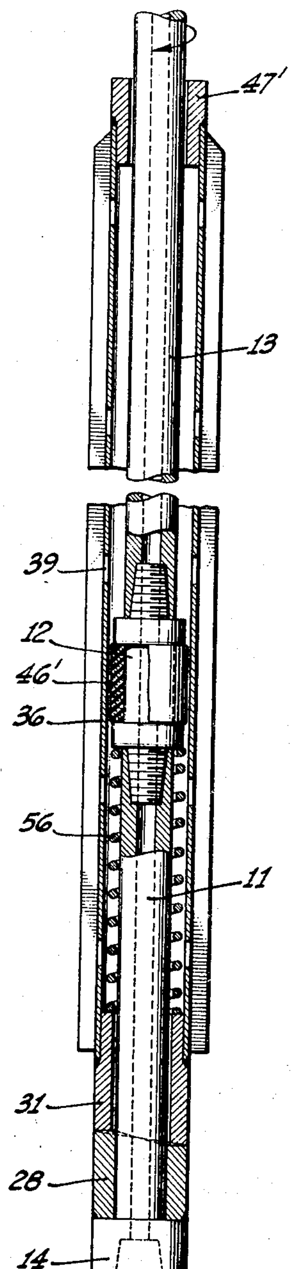

Fig. 5.

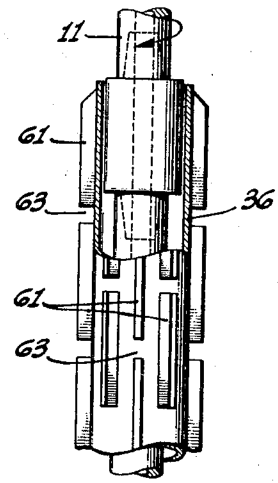

Fig. 6.

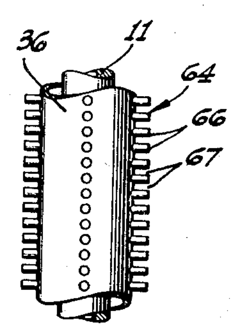

Fig. 7.

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Fig. 8.

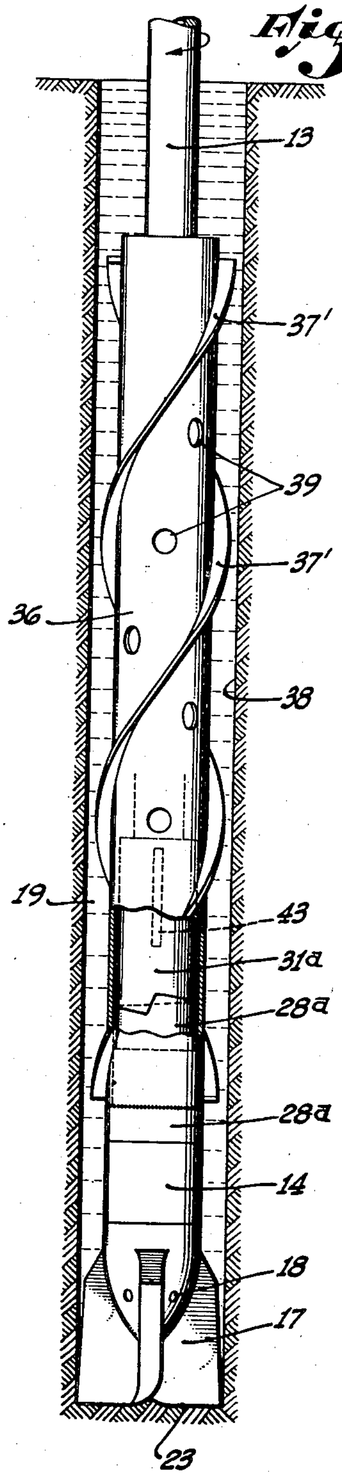
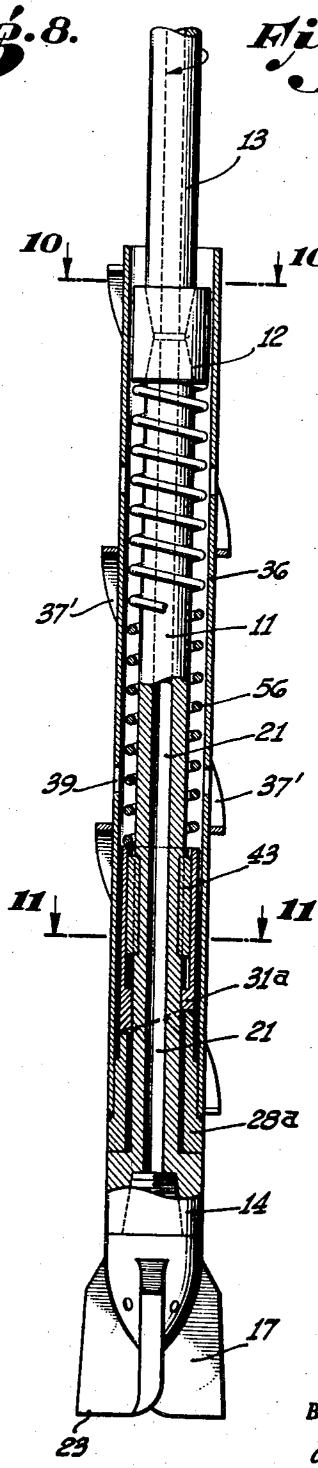


Fig. 9.



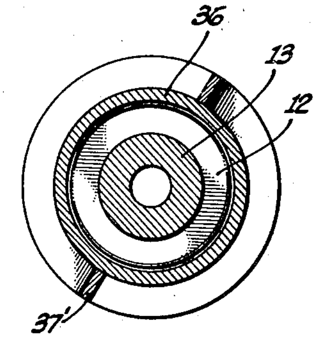


Fig. 10.

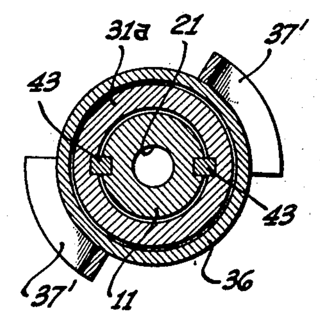


Fig. 11.

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Fig. 12.

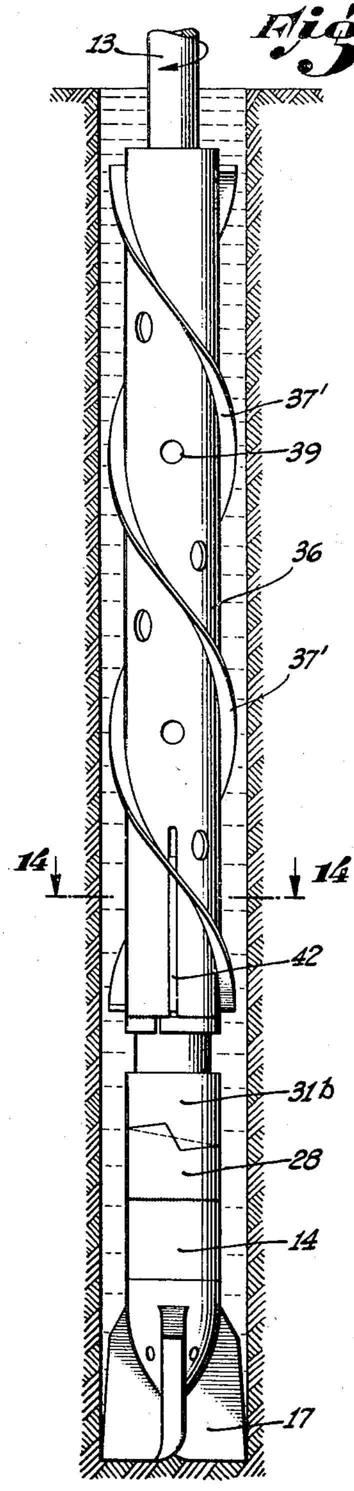
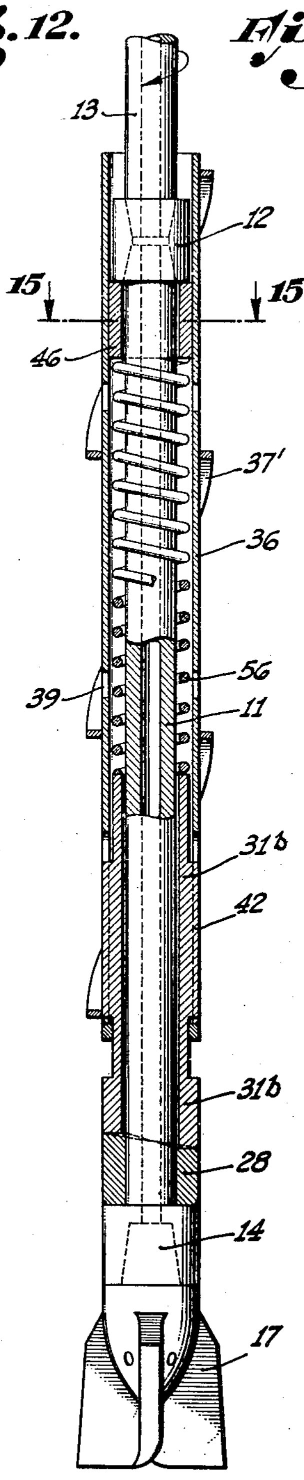


Fig. 13.



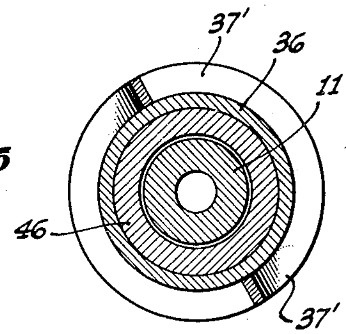


Fig. 15.

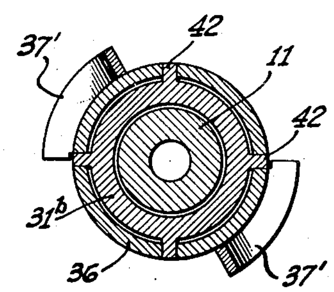


Fig. 14.

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Patented Aug. 5, 1947

2,425,012

UNITED STATES PATENT OFFICE

2,425,012

IMPACT DRILL

Robert E. Snyder, Pasadena, Calif., assignor to Snyder Oil Tool Corporation, a corporation of California

Application March 20, 1944, Serial No. 527,179

34 Claims. (Cl. 255—27)

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My invention relates generally to the art of earth boring, and more particularly to apparatus suitable for drilling deep wells by the rotary method. This present application is a consolidation and continuation in part of each of my copending applications Serial No. 388,627 and Serial No. 388,628, both filed on April 15, 1941, and includes only the apparatus disclosures and claims of each of said former cases; and the methods of using mud in drilling and controlling drilling shown in said former cases together with certain new matter are the subject matter of my copending application, Serial No. 528,095, filed March 25, 1945.

One of the objects of my invention is to provide means for periodically imparting shock or impact to a drill bit while it is being continuously rotated against the formation being drilled.

Another object of my invention is the provision of means for imparting impact to a rotary drill bit, which means is at all times under the direct control of the driller operating the equipment from his station on the derrick floor.

A further object of my invention is to provide impacting means which is actuated by the engagement of an element thereof with the drilling fluid within which the tool operates and does not depend for its operation upon contact with the walls or bottom of the hole being drilled.

Another object of my invention is to provide means actuated solely by contact with the drilling fluid for imparting impact to a rotary bit, wherein the fluid-engaging means is of such nature that the rate of impacting is both a function of the resistivity of the fluid and of the speed at which the drill is operated. In a modified form of my invention the fluid engaging means is such that the rate of impacting is also a function of the rate of circulation of the drilling fluid.

A further object is to improve upon drilling apparatus of this general nature by effecting a reduction in the number and complexity of the constituent parts thereof, thereby reducing the cost of production and operation of the apparatus without any impairment of operating efficiency.

My invention possesses other objects and advantages, some of which with those enumerated will be set forth in the following description of various embodiments of my invention which are illustrated in the drawings accompanying and forming a part of the specification. It is understood that I do not limit myself to the showing made by the drawings and description as I may

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adopt variations of the preferred embodiments within the scope of my invention as defined by the claims.

Referring to the drawings:

Fig. 1 is a view in side elevation of an impact drill embodying the principles of the present invention and shown in operative relation within a well being drilled. A portion of the fluid circulatory system is shown diagrammatically, and parts of the figure are broken away to reduce its size,

Fig. 2 is a view in longitudinal, medial section of that portion of the drill of Fig. 1 which serves to generate the percussion or impact. The plane of section is indicated by the line 2—2 of Fig. 1, and portions of the figure are broken away to reduce its size,

Fig. 3 in a detail view in perspective of the impact generating cams and the actuating means therefor. Portions of the figure are broken away and shown in section,

Fig. 4 is a side elevational view similar to Fig. 1 but showing a slightly modified form of impact drill. Portions of the figure are broken away to reduce its length,

Fig. 5 is a longitudinal sectional view of the modified form shown in Fig. 4,

Fig. 6 is a detail view in side elevation partly broken away of an impact drill employing a modified form of fluid-engaging blade,

Fig. 7 is a view similar to Fig. 6, showing a still further form of fluid-engaging means,

Fig. 8 is a view in side elevation of another form of impact drill embodying the principles of of the present invention, and shown in operative relation within a well being drilled. Portions of the figure are broken away and shown in section the better to reveal the interior construction,

Fig. 9 is a view in longitudinal section of the drill of Fig. 8,

Fig. 10 is a horizontal sectional view taken on the line 10—10 of Fig. 9,

Fig. 11 is a horizontal sectional view similar to Fig. 10 but taken on the line 11—11 of Fig. 9,

Fig. 12 is a view in side elevation of another form of my invention, shown in a well being drilled,

Fig. 13 is a longitudinal sectional view of the form shown in Fig. 12,

Fig. 14 is a horizontal section view taken on the line 14—14 of Fig. 12, and

Fig. 15 is a horizontal section taken on the line 15—15 of Fig. 13.

The present invention contemplates the provision of a drilling tool adapted to be secured to the lower end of a drill stem and rotated thereby after being lowered into a well. In order to expedite the drilling operation, the device of the present invention relies, in addition to the customary rotary motion of the bit at the lower end of the tool against the formation being drilled, upon impact or percussive action directed against the formation by the drill in a downwardly direction. The means for generating this impact preferably include a pair of opposed cooperating cams, one of which is connected to the drill to rotate therewith at all times, and the other of which is connected to an impeller carrying one or more vanes or blades which project into the circulation fluid which, being of a relatively thick or viscous nature, retards rotation of the impeller and the cam associated therewith, thereby developing a rotational differential of one cam with respect to the other which is necessary to cause them to override each other. The cams are urged toward each other by suitable means, such as by a spring or by gravity, with the result that as this overriding action occurs, the cams will come together with an appreciable shock or impact, thereby imparting a downward impact to the drill which materially increases its drilling efficiency. The impact-actuating means has sufficient clearance to avoid all contact with any part of the drilled hole walls or bottom, and is caused to operate solely by its engagement with fluid and fluid borne material in the drilled hole.

More specifically described and referring first to that modification of my invention which is illustrated in Figs. 1, 2 and 3, the impact drill of the present invention comprises a shank 11 provided at its upper end with a threaded sub 12 or other suitable means of attachment to the lower end of a conventional drill stem 13. To facilitate mounting a drill bit thereupon, an operating head 14 is formed upon the lower end of the shank 11. This head 14 has a tapered, interiorly threaded box 16 which may be of conventional construction whereby any suitable bit 17 may be attached thereto in operative position by having its pin (not shown) threaded into the box 16. In accordance with conventional practice, the bit 17 is provided with orifices 18 whereby circulation fluid 19 forced downward through the bore of the drill stem 13 and the bore 21 of the shank 11 by a pump 22 can escape into the hole being drilled adjacent the cutting edges 23 of the bit, whence the fluid 19 flows upwardly through the hole to the sump 24 provided at the top of the hole, carrying with it the detritus cut away from the formation being drilled.

Affixed rigidly upon the upper surface of he head 14 and encircling the lower end of the shank 11 is a lower cam 28 having one or more shoulders 29 on its upper surface. Disposed in cooperative relation above the lower cam 28 and rotatably mounted upon the shank 11 is an upper cam 31, the lower surface of which is provided with a shoulder or shoulders 32 corresponding and complementary to those on the lower cam 28. In addition to being rotatable upon the shank 11, the upper cam 31 is reciprocable thereon and is continually urged downwards by its own weight to frictional engagement with lower cam 28.

Carried by the upper cam 31 is a tubular body 36 which in the present modification is of such length that it extends upward for a material distance beyond the upper end of the shank 11 and into telescopic relation with the lower end of the drill stem 13. The tubular body 36 is provided with a suitable number of breather holes 39 and carries a plurality of vanes or blades 37 extending radially outwardly from the body 36. The blades 37, however, are relatively short in their radial extent, being proportioned so that they extend only part way from the body 36 to the wall 38 of the hole within which the tool is operating. It is apparent therefore that the only medium engaged by the blades 37 during the operation of the tool is the circulation fluid 19 and the material it carries.

This circulation fluid is conventionally of a relatively heavy nature, usually being composed of specially selected muds and/or chemicals appropriate to the particular drilling conditions. Moreover, the circulation fluid carries a relatively large proportionate content of solid particles, inasmuch as one of its principal functions is to carry the detritus away from the drill as it is formed. Accordingly, the circulation fluid will always be of a relatively thick, or viscous nature and will offer a certain amount of resistance to movement of the blades 37 therethrough. An important feature of my invention is that the extent to such resistance is not a constant factor, but varies with the speed of rotation of the blades 37 therethrough as well as with variations in the characteristics of the fluid which determine the resistance which it offers to rotation of an impeller blade through the fluid.

Inasmuch as the blades 37 are carried by the tubular body 36 which is in turn affixed to the upper cam 31, it is apparent that the normal rotation of the upper cam 31 by reason of its frictional engagement with cam 28 will be retarded because of the engagement of the blades 37 with the circulating fluid 19.

Because of the sloping nature of the interengaging surfaces of the cams, the upper cam 31 and the tubular body 36 will be lifted when the drill is rotated clockwise as indicated in the drawings, and this axial movement continues until the shoulder 32 of the cam 31 passes the shoulder 29 of the cam 28, whereupon the upper cam 31 and the tubular body 36 will drop sharply due to its own weight. This downward motion of the upper cam 31 and tubular body 36 is sharply arrested when the cams come together again, thereby imparting a shock or impact to the lower cam and through it to the drill bit 17. The percussion thus imparted to a rotating bit has been found to increase the drilling efficiency of the bit to a very appreciable degree.

It becomes apparent, therefore, that if drilling conditions are such that the operator desires the drill bit to rotate without any impact action, he can accomplish this by reducing the speed of rotation until the resistance to rotation of the tubular body and its associated cam is equal to or less than that of the frictional interengagement between the two cams which urges the upper cam and tubular body to rotate. On the other hand, if drilling conditions are such that the development of percussive action is desirable, the operator has merely to increase the speed of rotation of the drill stem until the resistance to rotation of the upper cam which is offered by impingement of the circulation fluid against the vanes 37 is greater than the frictional interengagement between the cam faces. When these conditions obtain the tubular body 36 will lag, i. e. will not rotate as fast as the portions of the tool which are rigidly connected to the drill stem, thus causing the upper cam 31 to lag with respect to the lower cam 28, thereby developing the desirable impact action.

It is apparent therefore that the impact action can be controlled in either of two ways: namely, (1) by keeping the fluid resistance constant and varying the speed of rotation of the drill in the fluid, or (2) by keeping the speed of rotation of the drill constant and varying the resistivity or viscosity of the fluid. It is further evident that the critical speed at which the impact action occurs is a function of the resistivity of the fluid to the movement of the blades therethrough, i. e. the greater that resistivity, the lower the drill stem R. P. M. at which the impact means will begin to operate.

In this connection, it should be observed that the expression "resistivity" of the circulation fluid, is concerned with those physical characteristics of the fluid, such as viscosity, density, gell strength, etc., which determine the physical resistance to the passage of the blades therethrough.

Inasmuch as relative speed of rotation between the drill stem 13 and the tubular body 36 is a matter of major importance as far as operation of my improved drill is concerned, it is desirable to provide means for minimizing the friction between these parts. To this end, I have provided bearing means here illustrated in the form of a bushing 46 rigidly affixed to the inside of body 36 and proportioned to establish bearing against a cooperative bearing face upon the outer surface of drill stem 13 or sub 12.

This arrangement minimizes the friction between the parts not only because of the very nature of the bearing surfaces, but also because it operates to retain the parts in coaxial relation. Operation of the tool with the parts out of axial alignment would result in the development of relatively great pressure of one part against the other by centrifugal force; and the increased friction resulting therefrom would interfere seriously with the establishment of the desired rotational differential.

The bearing 46 is illustrated as being composed of rubber, but it will be understood, that other bearing materials may be employed. An upper bearing 47 may also be employed and either or both of these bearings may be composed of rubber, as illustrated, or suitable soft metals such as bronze or the like in accordance with conventional practice.

It is also within the scope of the present invention to reverse the arrangement of parts of the bearing as in the modification of Figs. 4 and 5 wherein the bearing 46′ is rigid with the sub 12 and establishes bearing contact with the interior surface of the tubular body 36. This modification also is provided with an upper bearing 47′ of suitable design and illustrated as made of metal.

However, the outstanding point of differentiation between the modification shown in Figs. 4 and 5 and that of Figs. 1 and 2 is that the drill of Figs. 4 and 5 is provided with a compression spring 56 interposed between the sub 12 on the drill stem and the upper surface of the upper cam 31. The function of this spring 56 is to increase the percussion which develops when the cam 31 overrides and impacts upon cam 28.

Fig. 6 illustrates a modified form of fluid-engaging blade 61 which instead of being continuous throughout the length of the tubular body 36 is interrupted at intervals to present openings 63 through which the circulation fluid or drilling mud can flow and thereby reduce the tendency for the tool to "ball up." This construction possesses the added advantage of creating eddy currents around the blades which contribute to the development of the desired rotational differential.

Still greater advantage is taken of this same principle by the further modified form of impeller construction of Fig. 7 wherein each of the vanes of blades 64 is defined by a row of pins 66 disposed in sufficiently spaced relation to present openings 67 between adjacent pins.

A feature common to all of the foregoing forms of impeller blades is that they are substantially straight and parallel to the axis of the tool. Thus vertical movement of the tool in the hole, or vertical movement of the fluid past the tool, has no effect upon the blades. Only by rotation of the tool in the fluid is the resistance of the blades to passage through the fluid made manifest.

Referring now to that modification of my invention which is illustrated in Figs. 8–11, the numeral 11 again designates a shank, provided at its upper end with suitable means 12 of attachment to the lower end of a conventional drill stem 13. An operating head 14 at the lower end of the shank 11 provides convenient means of attachment for a bit 17. As before, the bit 17 may be provided with orifices 18 whereby circulation fluid 19 forced downward through the bore of the drill stem 13 and the bore 21 of the shank 11 can escape into the hole being drilled adjacent the cutting edges 23 of the bit 17. Such circulation of the fluid 19 may be effected as by any convenient means (not shown). Fluid 19 thus supplied to the bit 17 flows upwardly therefrom through the hole which has been drilled and into the sump, carrying with it the detritus which has been cut away from the formation being drilled.

In this form of my invention, the lower cam 28*a* instead of being fixed to the operating head 14 is mounted for free rotation upon the upper surface thereof about the lower end of the shank 11. In cooperative engagement with the cam surface on the upper end of cam 28*a* is an upper cam 31*a* connected to the shank 11 to be rotated thereby but for free axial movement with respect thereto, as by one or more feather keys 43. Reliance may be placed solely upon the weight of the upper cam 31*a* to urge it into engagement with the lower cam 28*a*, or a spring 56 may be employed under compression between the upper cam 31*a* and the sub 12 in a manner similar to that shown in Fig. 5.

As stated, the lower cam 28*a* is free to rotate upon the shank 11 and in this modification of my invention, the tubular body 36 is therefore rigidly attached to the lower cam instead of the upper one. The tubular body 36 is preferably of sufficient length to enclose the compression spring 56 and the sub 12, the latter of which can be relied upon with convenience to act as a guide for the upper end of the tubular body permitting rotational movement thereof without any material radial movement. As before, the tubular body 36 is provided with a plurality of perforations 39 and carries a plurality of vanes or blades 37′ extending radially outwardly from the body 36 but not so far as to permit them to engage the wall 38 of the drilled hole. It is apparent therefore that the only medium engaged by the blades 37′ during operation of the tool is the circulation fluid 19 and any material which it carries.

The blades 37′ in this form of my invention are of helical form; and the pitch of these blades is in that direction which causes the blades, as they rotate, to impose a thrust upon the circulation fluid 19 in its direction of flow. Inasmuch as the blades 37' are carried by the tubular body 36 which in turn is affixed to the lower cam 28a, it is apparent that rotation of the lower cam will be retarded because of the engagement of the blades 37' with the circulation fluid 19. However, the tubular body 36 and its associated cam 28a, being free to rotate upon the shank 11, are caused to rotate only through frictional engagement which occurs principally at the cam faces. This permits full advantage to be taken of the variation in the degree of resistance to movement of the vanes or blades 37' through the fluid in proportion to their speed. If the drilling operator desires that the drill bit rotate without any impact action, he should rotate the drill stem at such low speed that the resistance to rotation of the tubular body and its associated cam member is less than that of the frictional resistance between the two cams which urges the lower cam and tubular body to rotate. On the other hand, if drilling conditions are such that the development of percussive action is desirable in addition to the rotary motion of the drill, the operator has merely to increase the speed of rotation of the drill stem until the resistance to rotation of the lower cam, which is developed by impingement of the circulation fluid against the blades 37', is greater than the frictional interengagement between the two cam faces. When these conditions obtain, the tubular body 36 will lag, i. e. will not rotate as fast as the drill stem, thus causing the lower cam 28a to rotate at a lower speed than the upper cam 31a.

Because of the sloping nature of the interengaging surfaces of the cams, the upper cam 31a will be lifted as relative rotation between the two cams occurs, compressing the spring 56 until such time as the shoulder of one cam passes the corresponding shoulder of the cooperating cam, whereupon the upper cam 31a will drop sharply, due to its own weight augmented by the force of the spring 56. This downward motion of the upper cam 31a is sharply arrested when the cams come together again, thereby imparting a shock or impact to the lower cam 28a and through it to the drill bit 17.

Due to the fact that the helical blades 37' exert a thrust against the circulation fluid in the same direction as that in which the circulation fluid is flowing, it is apparent that in this form of my invention, the operator will have to rotate his drill at a relatively higher speed in order to develop the frictional resistance to rotation of the blades which is necessary to overcome the friction at the cam surfaces. Figs. 12–15, however, show a modified form of construction wherein the direction of angularity of the helical blades 37' is opposite to that shown in Figs. 8–11 already described. In the modification of Figs. 12–15 the drill bit is intended to operate at relatively lower rotational speeds, since the blades 37' in this case exert a thrust against the circulation fluid in the direction opposite to that in which the fluid is flowing, with the result that they do not need to rotate as fast in order to develop the same amount of resistance to rotation. It is apparent therefore that the tool can easily be designed to have its critical speed at any predetermined value, i. e. by varying the angularity of the spiral blades, or in some cases by actually reversing the direction of that angularity, the speed at which the drill develops percussive action can easily be determined.

The modification of Figs. 12–15 further differs from that of Figs. 8–11 in that the tubular body 36 carrying the blades 37' is connected to the upper cam 31b to rotate therewith as by spline connections 42. The lower cam 28 is rigid with the operating head 14, and accordingly, also rigid with the drilling bit 17. Consequently, when a rotational differential develops between the drill stem 13 and the tubular body 36, the upper cam 31b will be caused to rotate with respect to the lower cam 28; and the splined driving connection between the tube 36 and the upper cam 31b will permit the upper cam to reciprocate axially upon the shank 11 thus permitting the cams to override each other. The collar 46 fixedly mounted in tubular body 36 is supported against collar 12 of shank 13 by spring 56. Thus, when tubular body 36 rotates slower than shank 13, cam 31b overrides cam 28, and oscillates axially on shank 13. Inasmuch as body 36 cannot oscillate, cam 31b slides on keys 42 up and down in body 36 against and under the impress of spring 56. Key 42 has the function of rotating cam 31b with body 36 while at the same time permitting cam 31b to reciprocate with respect to body 36. The cams are urged toward each other as before by a suitable spring 56 with the result that as this overriding action occurs the cams will come together with considerable shock, thereby imparting sufficient impact to the drill to increase its drilling efficiency materially.

As stated, the impact-actuating means in each case has sufficient clearance to avoid all contact with any part of the walls or bottom of the drilled hole and is caused to operate solely by its engagement with the circulation fluid and material borne by that fluid. When the fluid-engaging means is of helical form, in addition to being operable by rotation of the drill within the fluid, it is also responsive to movement of the fluid itself in an axial direction.

The helical form of the blades causes them to exert a thrust against the fluid in an axial direction; and the extent or magnitude of the thrust thus developed is readily subject to control, which in turn facilitates the design of the drill to confine its critical speed between relatively narrow limits. If the direction of the thrust exerted by the helical blades is the same as that in which the circulation fluid is flowing, the drill must be operated at a higher rotational speed before the cams are caused to operate. On the other hand, if the blades be oppositely inclined then the impact action of the drill will commence while the drill is being rotated at a considerably lower speed. Furthermore, it is believed that the helical blades will be materially more efficient in developing the frictional resistance to rotation because of the eddy currents which they tend to set up in the circulation fluid as a result of which adjacent particles of the fluid are forced to impinge against each other and thereby develop friction within the fluid itself in addition to that which develops at the surfaces of the blades and the tubular body which carries them.

While the particular apparatus herein shown and described in detail is fully capable of attaining the objects and providing the advantages hereinbefore stated, it is to be understood that it is merely illustrative of the presently preferred embodiment of my invention, and that I do not mean to limit myself to the details of construction or design herein shown, other than as defined in the appended claims.

I claim:

1. A combination rotary and impact drill having impact means adapted to be operated by rotation of said drill in a fluid, comprising a rotatable shank, a bit mounted upon said shank, means for attaching said shank to a rotating means, a body revolubly mounted upon said shank, means between said body and said shank for maintaining coaxial relation therebetween, cam means interposed between said body and said shank for imparting reciprocatory motion to said body with respect to said shank when rotation therebetween occurs, said cam means comprising a cam on said shank and a cam on said body, and means associated with said body extending into and engaging said fluid to retard rotation of said body when said drill is rotated in said fluid whereby said body cam reciprocates and impacts upon said shank cam to deliver impact to said bit.

2. A combination rotary and impact drill comprising a shank, means for attaching said shank to a rotary drill stem, a body revolubly mounted on said shank, cams between said body and said shank, one of said cams being rigid with said body and the other of said cams being rigid with said shank, said body cam being adapted to impact upon said shank cam when rotation therebetween occurs, a tubular structure upon said body, bearing means between said tubular structure and said shank for maintaining coaxial alignment therebetween, and fluid-engaging means upon said tubular structure extending radially into said fluid to resist rotation of said tubular structure within said fluid and thereby retard rotation of said body with respect to said shank.

3. A combination rotary and impact drill comprising a shank, means for attaching said shank to a rotary drill stem, a body revolubly mounted on said shank, cams between said body and said shank, one of said cams being rigid with said body and the other of said cams being rigid with said shank, said body cam being adapted to impact upon said shank cam when rotation therebetween occurs, a tubular structure upon said body, and fluid-engaging means upon said tubular structure extending radially into said fluid to resist rotation of said tubular structure within said fluid and thereby retard rotation of said body with respect to said shank.

4. In a drill having impact means adapted to be operated by rotation of said drill in a fluid, a shank, means for attaching said shank to a rotary drill stem, impact means upon said shank comprising a cam rotated by said shank, and a free cam rotatable with respect thereto, said free cam being urged to rotate with said shank cam by virtue of frictional engagement between the faces of said two cams and said cams being adapted to impact when rotated with respect to each other, and fluid-engaging means revolubly mounted on said shank and engaging said free cam comprising a tubular structure and a helical blade extending into engagement with said fluid, said helical blade being adapted to urge adjacent fluid axially with respect to said shank when rotated by said free cam, and to retard rotation of said free cam with respect to said shank when resistance to rotation of said blade through said fluid becomes greater than friction between the faces of said two cams.

5. In a drill having impact means adapted to be operated by rotation of said drill in a fluid, a shank, means for attaching said shank to a rotary drill stem, impact means upon said shank comprising a cam rotated by said shank, and a free cam rotatable with respect thereto, said free cam being urged to rotate with said shank cam by virtue of frictional engagement between the faces of said two cams and said cams being adapted to impact when rotated with respect to each other, and fluid-engaging means revolubly mounted on said shank and engaging said free cam comprising a tubular structure and a helical blade extending into engagement with said fluid, said helical blade being adapted to urge adjacent fluid upwardly in the drilled hole when rotated by said free cam, and to retard rotation of said free cam with respect to said shank when resistance to rotation of said blade through said fluid becomes greater than friction between the faces of said two cams.

6. In a drill having impact means adapted to be operated by rotation of said drill in a fluid, a shank, means for attaching said shank to a rotary drill stem, impact means upon said shank comprising a cam rotated by said shank, and a free cam rotatable with respect thereto, said free cam being urged to rotate with said shank cam by virtue of frictional engagement between the faces of said two cams and said cams being adapted to impact when rotated with respect to each other, and fluid-engaging means revolubly mounted on said shank and engaging said free cam comprising a tubular structure and a helical blade extending into engagement with said fluid, said helical blade being adapted to urge adjacent fluid downwardly in the drilled hole when rotated by said free cam, and to retard rotation of said free cam with respect to said shank when resistance to rotation of said blade through said fluid becomes greater than friction between the faces of said two cams.

7. In a combination rotary and impact drill having impact means adapted to be operated by rotation of said drill in a fluid, a shank, means for attaching said shank to a drill stem, a body revolubly mounted on said shank, a cam rigid with said body, a second cam upon said body cam, said second cam being adapted to impact against said body cam when rotation therebetween occurs, coupling means between said second cam and said shank whereby said second cam reciprocates with respect to said shank and rotates therewith, and fluid-engaging means associated with said body and adapted to retard rotation of said body with respect to said shank and comprising a tubular structure and fluid-engaging elements extending radially from said tubular structure into said fluid and adapted to resist rotation therein whereby the rotation of said body is retarded with respect to said shank and said second cam impacts upon said body cam.

8. A combination rotary and impact drill having impact means adapted to be operated by rotation of said drill in a fluid, comprising a shank, means for attaching said shank to a rotary means, a body revolubly mounted on said shank, impact means between said body and said shank comprising a cam rigid with said body and a cam rigid with said shank, said body cam being adapted to impact upon said shank cam when rotation between said body and said shank occurs, and fluid-engaging means associated with said body and adapted to retard rotation of said body with respect to said shank comprising a tubular structure, coupling means between said tubular structure and said body whereby said body may reciprocate axially with respect to said tubular structure and is rotated with said tubular struc-

ture, and fluid-engaging elements extending radially from said tubular structure into said fluid and adapted to resist rotation in said fluid and retard rotation of said body with respect to said shank.

9. A rotary impact drill for earth boring, which includes: a shank adapted to have a bit attached thereto; means for attaching said shank to a rotary drill stem whereby said shank and bit can be rotated in a hole having drilling fluid therein; a driving cam mounted on said shank and rotatable therewith; a driven cam mounted on said shank and adapted to be rotated by rotation of said driving cam, one of said cams being reciprocable on said shank; and means rotatable with said driven cam extending into an engaging said fluid sufficiently to retard rotation of said driven cam by engagement with said fluid to thereby establish relative rotation between said cams and cause said reciprocable cam to reciprocate and produce an impact on said shank, said fluid engaging means remaining rotatable with respect to the wall of said hole.

10. A rotary impact drill for earth boring, which includes: a shank adapted to have a bit attached thereto; means for attaching said shank to a rotary drill stem whereby said shank and bit can be rotated in a hole having drilling fluid therein; a driving cam mounted on said shank and rotatable therewith; a driven cam mounted on said shank and adapted to be rotated by rotation of said driving cam, one of said cams being reciprocable on said shank; and a body rotatable with said driven cam provided with a radially extending blade of substantial size to sufficiently retard rotation of said driven cam by engagement with said fluid to thereby establish relative rotation between said cams and cause said reciprocable cam to reciprocate and produce an impact on said shank, said body remaining rotatable with respect to the wall of said hole.

11. A rotary impact drill for earth boring, which includes: a shank adapted to have a bit attached thereto; means for attaching said shank to a rotary drill stem whereby said shank and bit can be rotated in a hole having drilling fluid therein; a driving cam mounted on said shank and rotatable therewith; a driven cam mounted on said shank and adapted to be rotated by rotation of said driving cam, one of said cams being reciprocable on said shank; and a body rotatable with said driven cam provided with a radially extending helical blade extending into and engaging said fluid sufficiently to retard rotation of said driven cam by engagement with said fluid to thereby establish relative rotation between said cams and cause said reciprocable cam to reciprocate and produce an impact on said shank, said body remaining rotatable with respect to the wall of said hole.

12. A rotary impact drill for earth boring, which includes: a shank adapted to have a bit attached thereto; means for attaching said shank to a rotary drill stem whereby said shank and bit can be rotated in a hole having drilling fluid therein; a driving cam mounted on said shank and rotatable therewith; a driven cam mounted on said shank and adapted to be rotated by rotation of said driving cam, one of said cams being reciprocable on said shank; and a body rotatable with said driven cam provided with a plurality of radially extending blades of sufficient total area to materially retard rotation of said driven cam by engagement with said fluid to thereby establish relative rotation between said cams and cause said reciprocable cam to reciprocate and produce an impact on said shank, said body remaining rotatable with respect to the wall of said hole.

13. A rotary impact drill for earth boring, which includes: a shank adapted to have a bit attached thereto; means for attaching said shank to a rotary drill stem whereby said shank and bit can be rotated in a hole having drilling fluid therein; a driving cam mounted on said shank and rotatable therewith; a driven cam mounted on said shank and adapted to be rotated by rotation of said driving cam, one of said cams being reciprocable on said shank; and a body rotatable with said driven cam provided with a plurality of radially extending helical blades disposed at different angles and of sufficient size to materially retard rotation of said driven cam by substantial engagement with said fluid to thereby establish relative rotation between said cams and cause said reciprocable cam to reciprocate and produce an impact on said shank, said body remaining rotatable with respect to the wall of said hole.

14. A rotary impact drill for earth boring, which includes: a shank adapted to have a bit attached thereto; means for attaching said shank to a rotary drill stem whereby said shank and bit can be rotated in a hole having drilling fluid therein; a driving cam mounted on said shank and rotatable therewith; a driven cam mounted on said shank and adapted to be rotated by rotation of said driving cam, said driven cam being reciprocable on said shank; and means rotatable with said driven cam extending into and engaging said fluid sufficiently to retard rotation of said driven cam by engagement with said fluid to thereby establish relative rotation between said cams and cause said driven cam to reciprocate and produce an impact on said shank, said fluid engaging means remaining rotatable with respect to the wall of said hole.

15. A rotary impact drill for earth boring, which includes: a shank adapted to have a bit attached thereto; means for attaching said shank to a rotary drill stem whereby said shank and bit can be rotated in a hole having drilling fluid therein; a driving cam mounted on said shank and rotatable therewith; a driven cam mounted on said shank and adapted to be rotated by rotation of said driving cam, said driving cam being reciprocable on said shank; and means rotatable with said driven cam extending into and engaging said fluid sufficiently to retard rotation of said driven cam by engagement with said fluid to thereby establish relative rotation between said cams and cause said driving cam to reciprocate and produce an impact on said shank, said fluid engaging means remaining rotatable with respect to the wall of said hole.

16. A rotary impact drill for earth boring which includes: a shank adapted to have a bit attached thereto; means for attaching said shank to a rotary drill stem whereby said shank and bit can be rotated in a hole having drilling fluid therein; an impact member rotatably mounted on said shank and movable axially thereof to deliver impact thereto; means on said shank cooperating with means on said impact member tending to rotate said impact member with said shank and to reciprocate said impact member when relative rotation between it and said shank is established; and means rotatable with said impact member extending into and engaging said fluid sufficiently to retard rotation of said impact member by en-

gagement with said fluid to thereby establish relative rotation between said impact member and said shank, said fluid engaging means remaining rotatable with respect to the wall of said hole.

17. A rotary impact drill for earth boring which includes: a shank adapted to have a bit attached thereto; means for attaching said shank to a rotary drill stem whereby said shank and bit can be rotated in a hole having drilling fluid therein; an impact member reciprocably mounted on said shank and rotatable therewith for delivery of impact thereto; means on said impact member cooperating with means rotatably mounted on said shank for reciprocating said impact member when relative rotation between said shank and said rotatable member is established; and fluid engaging means operable with said rotatable member adapted to retard rotation thereof solely by engagement with said fluid to thereby cause said relative rotation, said fluid engaging means remaining rotatable with respect to the wall of said hole.

18. Apparatus for delivering impact to a drill bit being rotated in a hole having drilling fluid therein, which includes: an impact member reciprocably mounted with respect to said bit and adapted to deliver impact thereto; means operably associated with said bit and impact member for reciprocating the latter; and actuating means rotatably mounted with respect to said bit but urged to rotate therewith, adapted to actuate said reciprocating means when relative rotation is established between said actuating means and said bit, said actuating means having blade means extending into and engaging said fluid sufficiently to retard rotation of said actuating means with respect to said bit while permitting it to remain rotatable with respect to the wall of said hole.

19. Apparatus for delivering impact to a drill bit being rotated in a hole having drilling fluid therein, which includes: an impact member reciprocably mounted with respect to said bit and adapted to deliver impact thereto; means associated with said bit and impact member for reciprocating the latter, said means including a member rotated with said bit, and a cooperating member rotatable with respect to said bit but frictionally urged to rotate therewith by said first member; and fluid engaging blade means of extensive area connected to said rotatable member and extending into and engaging said fluid sufficiently to retard rotation of said rotatable member solely in response to the drag of said fluid on said blade means, to thereby reciprocate said impact member, said fluid engaging means remaining rotatable with respect to the wall of said hole.

20. A rotary impact drill for earth boring which includes: a shank adapted to have a bit attached thereto and to be rotated in a hole having drilling fluid therein; impact means reciprocably mounted on said shank; fluid drag means of extensive area rotatably mounted on said shank but adapted to be rotated by said shank; and means responsive to relative rotation between said shank and said drag means for operating said impact means, while said fluid drag means is rotating with respect to the wall of said hole.

21. A rotary impact drill for earth boring which includes: a shank adapted to have a bit attached thereto and to be rotated in a hole having drilling fluid therein; impact means reciprocably mounted on said shank; and fluid engaging means normally urged to rotate by and with said shank; and means responsive to the retardation of said fluid engaging means due solely to the drag of said fluid thereon for operating said impact means even though said fluid engaging means is rotating with respect to the wall of said hole.

22. In a drill having impact means adapted to be operated by rotation of said drill in a fluid, a shank, means for attaching a bit to said shank, means for attaching said shank to a rotary drill stem, impact means upon said shank comprising a cam rotated by said shank, and a free cam rotatable with respect thereto, said free cam being urged to rotate with said shank cam by virtue of frictional engagement between the faces of said two cams and said cams being adapted to impact when rotated with respect to each other, and fluid-engaging means rotatably mounted on said shank and fixed to said free cam comprising a tubular structure and a blade fixed thereto extending into engagement with said fluid, said blade being adapted to retard rotation of said free cam with respect to said shank when resistance to rotation of said blade through said fluid becomes greater than friction between the cam faces, said fluid engaging means remaining rotatable with respect to the wall of said hole.

23. A rotary impact drill for earth boring, which includes: a shank adapted to have a bit attached thereto; means for attaching said shank to a rotary drill stem whereby said shank and bit can be rotated in a hole having drilling fluid therein; a tubular impact member reciprocably mounted on said shank coaxially therewith; a pair of overriding cam members coaxially mounted on said shank for reciprocating said impact member, one of said cams being rotatable with said shank, and the other being rotatable thereon but frictionally urged to rotate therewith; and a tubular body rotatably mounted on said shank and provided with blades extending into said fluid to engage the same and be sufficiently retarded thereby to cause relative rotation between said cam members and reciprocation of said impact member while said body is rotating with respect to the wall of said hole.

24. A rotary impact drill for earth boring which includes: a shank adapted to have a drill bit attached thereto; means for attaching said shank to a drill stem for rotation in a hole having drilling fluid therein; a tubular body mounted coaxially on said shank and rotatable thereon; a blade on the outside of said body extending into said fluid and having a maximum radius of rotation less than the radius of rotation of said bit and an area sufficient to retard rotation of said body with respect to said shank due to the drag of said fluid against said blade becoming greater than the frictional urge tending to rotate said body with said shank; and impact means between said body and shank including complemental cam means, one part of which is rotatable with said shank and the other part of which is rotatable with said body, said cam parts being adapted to override and actuate said impact means when said body is retarded by the engagement of said blade with said fluid.

25. A combination rotary and impact drill comprising a shank adapted to have a bit attached thereto, means for attaching said shank to a rotary drill stem, a body revolubly mounted on said shank, cams between said body and said shank, one of said cams being rotatable with said body and the other of said cams being rotatable with said shank, said body cam being adapted to impact upon said shank cam when rotation therebetween occurs, a tubular structure upon said body, and fluid-engaging means upon said tubu-

lar structure extending radially into said fluid to resist rotation of said tubular structure within said fluid and thereby retard rotation of said body with respect to said shank.

26. A combination rotary and impact drill comprising a shank adapted to have a bit attached thereto, means for attaching said shank to a rotary drill stem, a body revolubly mounted on said shank, cams between said body and said shank, one of said cams being rotatable with said body and the other of said cams being rotatable with said shank, one of said cams being adapted to impact on the other when rotation therebetween occurs, a tubular structure upon said body, and fluid-engaging means upon said tubular structure extending radially into said fluid to resist rotation of said tubular structure within said fluid and thereby retard rotation of said body with respect to said shank.

27. A combination rotary and impact drill having impact means adapted to be operated by rotation of said drill in a fluid, comprising a rotatable shank adapted to have a bit attached thereto, means for attaching said shank to a rotating means, a body revolubly mounted upon said shank, cam means interposed between said body and said shank for imparting reciprocatory motion to said body with respect to said shank when rotation therebetween occurs, said cam means comprising a cam on said shank and a cam on said body, and means associated with said body extending into and engaging said fluid to retard rotation of said body when said drill is rotated in said fluid whereby said body cam reciprocates and impacts upon said shank cam to deliver impact to said bit.

28. In a drill having impact means adapted to be operated by rotation of said drill in a fluid, a shank adapted to have a bit attached thereto, means for attaching said shank to a rotary drill stem, impact means upon said shank comprising a cam rotated by said shank and a free cam rotatable with respect thereto, said free cam being urged to rotate with said shank cam by virtue of frictional engagement between the faces of said two cams, said cams being adapted to impact when rotated with respect to each other, and fluid-engaging means revolubly mounted on said shank and fixed to said free cam comprising a tubular structure and a blade extending into engagement with said fluid, said blade being adapted to retard rotation of said free cam with respect to said shank when resistance to rotation of said blade through said fluid becomes greater than friction between the faces of said two cams.

29. In a drill having impact means adapted to be operated by rotation of said drill in a fluid, a shank adapted to have a bit attached thereto, means for attaching said shank to a rotary drill stem, impact means upon said shank comprising a cam rotated by said shank and a free cam rotatable with respect thereto, said free cam being urged to rotate with said shank cam by virtue of frictional engagement between the faces of said two cams, said cams being adapted to impact when rotated with respect to each other, and fluid-engaging means revolubly mounted on said shank and fixed to said free cam comprising a tubular structure and longitudinally extending blade means having sections separated by spaces and extending into engagement with said fluid, said blade being adapted to retard rotation of said free cam with respect to said shank when resistance to rotation of said blade through said fluid becomes greater than friction between the faces of said two cams.

30. In a combination rotary and impact drill having impact means adapted to be operated by rotation of said drill in a fluid, a shank adapted to have a bit attached thereto, means for attaching said shank to a drill stem, a body revolubly mounted on said shank, a cam rotatable with said body, a second cam upon said body cam, one of said cams being reciprocable and adapted to impact on the other when rotation therebetween occurs, coupling means between said second cam and said shank whereby said second cam rotates with said shank, and fluid-engaging means associated with said body and adapted to retard rotation of said body with respect to said shank and comprising a tubular structure and fluid-engaging elements extending radially from said tubular structure into said fluid and adapted to resist rotation therein whereby the rotation of said body is retarded with respect to said shank and said cams are caused to impact, said body remaining rotatable with respect to the wall of said hole.

31. A rotary impact drill for earth boring, which includes: a shank adapted to have a bit attached thereto; means for attaching said shank to a rotary drill stem whereby said shank and bit can be rotated in a hole having drilling fluid therein; a driving cam coaxially mounted on said shank and rotatable therewith; a driven cam coaxially mounted on said shank and adapted to be rotated by said driving cam, one of said cams being reciprocable on said shank and adapted to impact upon the other of said cams; and means rotatable with said driven cam extending into said fluid and adapted to sufficiently retard rotation of said driven cam by engagement with said fluid to thereby establish relative rotation between said cams and cause said reciprocable cam to reciprocate and impact upon the other of said cams, said body remaining rotatable with respect to the wall of said hole.

32. A rotary impact drill for earth boring, which includes: a shank adapted to have a bit attached thereto; means for attaching said shank to a rotary drill stem whereby said shank and bit can be rotated in a hole having drilling fluid therein; a driving cam coaxially mounted on said shank and rotatable therewith; a free cam coaxially mounted on said shank and adapted to be rotated by said driving cam, one of said cams being reciprocable on said shank; and means rotatable with said free cam in permanent engagement with the fluid in said hole and adapted to sufficiently retard rotation thereof by engagement solely with said fluid to thereby establish relative rotation between said cams and cause said reciprocable cam to reciprocate and produce an impact on said shank, without engagement with the wall of said hole.

33. A rotary impact drill for earth boring, which includes: a shank adapted to have a bit attached thereto; means for attaching said shank to a rotary drill stem whereby said shank and bit can be rotated in a hole having drilling fluid therein; a driving cam coaxially mounted on said shank and rotatable therewith; a free cam coaxially mounted on said shank and urged to rotate by said driving cam, one of said cams being reciprocable on said shank; and means rotatable with said free cam of sufficient fluid-engaging area to offer resistance to rotation of said free cam greater than the force urging it to rotate with said driving cam to thereby retard rotation thereof solely by engagement with said

fluid to thereby establish relative rotation between said cams and cause said reciprocable cam to reciprocate and produce an impact on said shank, without engagement with the wall of said hole.

34. A rotary impact drill for earth boring, which includes: a shank adapted to have a bit attached thereto; means for attaching said shank to a rotary drill stem whereby said shank and bit can be rotated in a hole having drilling fluid therein; a driving cam coaxially mounted on said shank and rotatable therewith; a free cam coaxially mounted on said shank and adapted to be rotated by said driving cam, one of said cams being reciprocable on said shank; and a body rotatable with said free cam provided with a radially extending blade of less radius than that of said hole adapted to materially retard rotation thereof by engagement with said fluid to

thereby establish relative rotation between said cams and cause said reciprocable cam to reciprocate and produce an impact on said shank, while said body remains rotatable with respect to the wall of said hole.

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