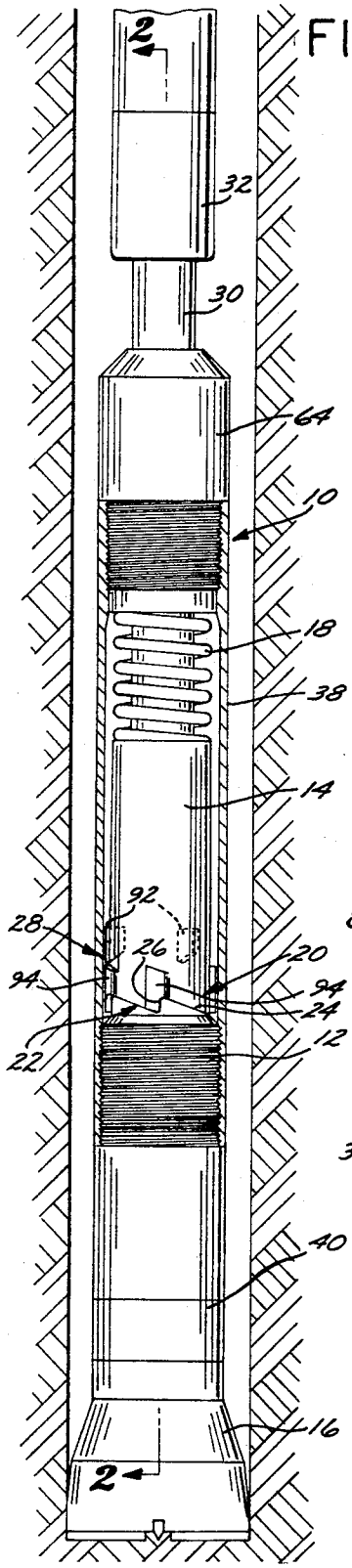
Aug. 13, 1968 J. K. MENTON 3,396,807

ROTARY-IMPACT DRILL

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FIG. 1



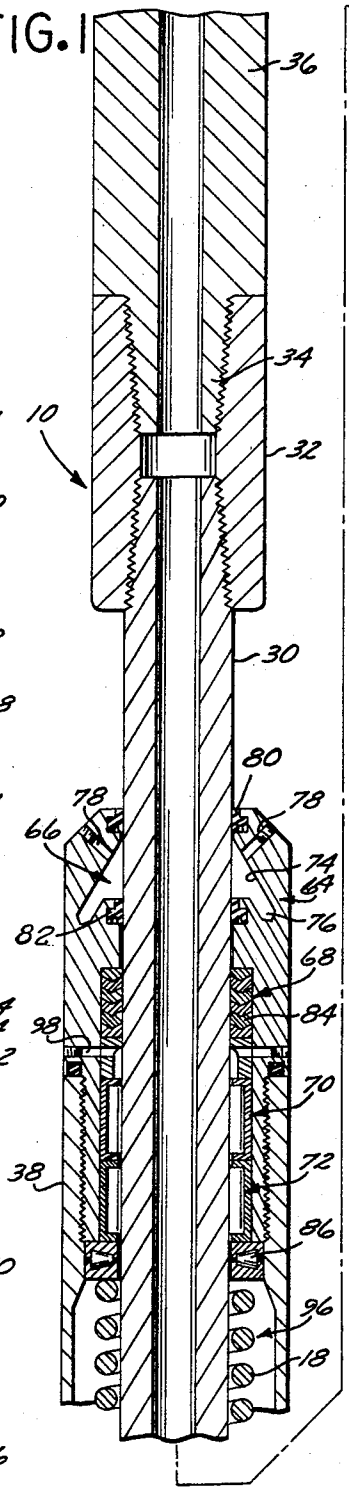
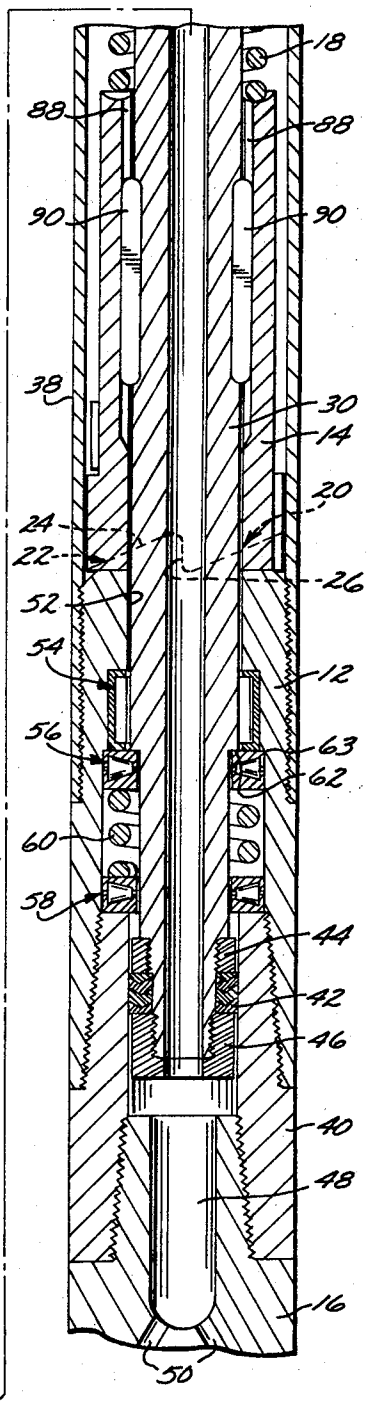


FIG. 2



INVENTOR.
JACK K. MENTON
BY Fulwider, Patton, Rieber, Lee and Utecht
ATTORNEYS

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ROTARY-IMPACT DRILL

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FIG. 3

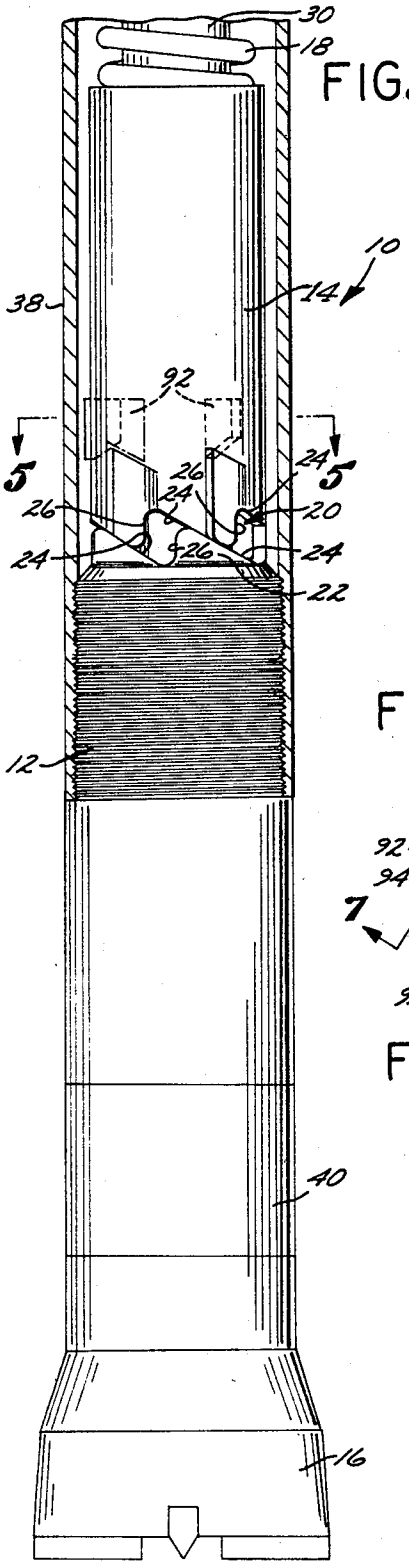


FIG. 4

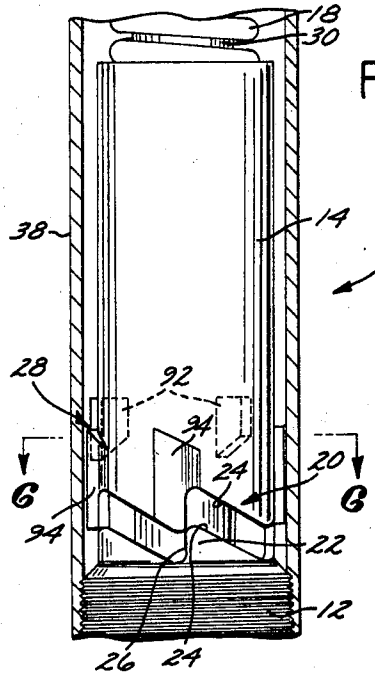


FIG. 5

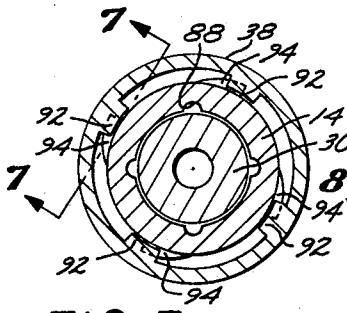


FIG. 6

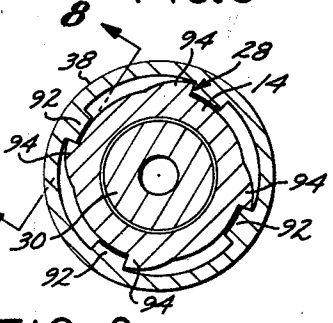


FIG. 7

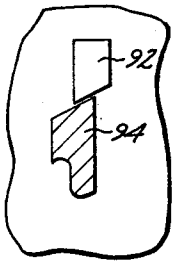
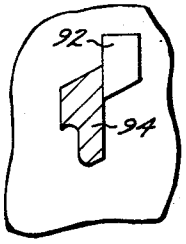


FIG. 8



INVENTOR.
JACK K. MENTON
BY Fulwider, Patton, Rieber, Lee and Utecht
ATTORNEYS

United States Patent Office 3,396,807 Patented Aug. 13, 1968

3,396,807

ROTARY-IMPACT DRILL

Jack K. Menton, 11191 Saratoga Drive, Los Alamitos, Calif. 90720

Filed Sept. 27, 1966, Ser. No. 582,405
8 Claims. (Cl. 175—293)

The present invention relates to earth boring equipment such as commonly used in drilling oil wells, and, more particularly, to an improved rotary-impact drill.

Generally speaking, a rotary-impact drill is an earth boring drill which is adapted to deliver impacts to its drill bit while the latter is being rotated. To accomplish this, it is common for rotary-impact drills to include an anvil and a hammer spring biased toward each other. The anvil is connected to the drill bit for the rotary-impact drill, while a hammer is mounted above the anvil for axial movement relative to and for rotation with a rotary drive member such as a drive shaft. Complementary, tooth-shaped hammer and anvil cams are carried on the top and bottom of the anvil and hammer, respectively. The cams are shaped such that as the hammer turns relative to the anvil and earth boring drill bit, the hammer cams ride up along sloping surfaces of the anvil cams and upon reaching shoulders on the cams, drop heavily onto the anvil. In this manner, the vertical drop of the hammer onto the anvil imparts simultaneous vertical and rotational impulses to the drill bit as it bores into the earth.

In theory, all conventional rotary-impact drills operate on the principle just described. Unfortunately, however, presently available rotary-impact drills fall far short of their maximum theoretical efficiency and are subject to numerous practical problems. For example, conventional rotary-impact drills do not develop either maximum rotational or vertical impacts upon hammer drop. One cause for the less than maximum vertical impact is the fact that the hammer drop is not vertical. Rather, it is at a downward angle. This means (1) that the hammer cams strike the mid-portions rather than the lower base portions of the sloping anvil cams, (2) that the hammer does not travel through its maximum stroke prior to striking the anvil, and (3) that the hammer therefore does not reach a maximum downward velocity prior to impact. By the same token, since the hammer cams strike the anvil cams at an angle, the rotational impact is less than would be developed if there were horizontal impact relative to the vertical axis of the drive shaft or the hammer.

In addition to the foregoing shortcomings, the efficiency of conventional rotary-impact drill operation is materially affected by sand and water seeping into and around the working parts in the drill. In particular, sand tends to work its way around the rotating drive shaft and into the area of seals between the drive shaft and the casing surrounding the workings of the drill. The sand quickly damages the seals which therefore require periodic servicing and replacement. Upon passing the seals, the sand materially impairs the operation of the drill.

Also, in rotary-impact drills, it is common that the casing surrounding the workings of the drill define a closed chamber for receiving oil. Unfortunately, in some drills the inner volume of the oil chamber changes due to the telescopic action of the drill during drilling operations to effect a pumping action which draws water and debris into the chamber to further impair efficient drill operation.

Furthermore, a rotary-impact drill should work equally well in tension or compression. If a drill with this ability became stuck, it could easily drill its way upward out of the drill hole in response to an upward pull. Presently available rotary-impact drills do not possess this feature.

In view of the foregoing problems, it is a general object of the present invention to provide an improved rotary-impact drill which is capable of developing separate, maximum rotational and vertical impacts and thereby provide improved drilling results.

Another object of the present invention is to provide an improved rotary-impact drill in which the workings of the drill are sealed from water and debris.

A further object of the present invention is to provide an improved rotary-impact drill including means for trapping sand and other debris and preventing same from damaging seals in the drill.

Still another object of the present invention is to provide an improved rotary-impact drill wherein the oil chamber within the drill structure has a constant volume and does not pump water and debris into the chamber during drill operation.

A still further object of the present invention is to provide a rotary-impact drill which will operate equally well in tension and compression at maximum efficiency.

The foregoing as well as other objects and advantages of the present invention may be more clearly understood by reference to the following detailed description when considered with the drawings which, by way of example only, illustrate a preferred form of the rotary-impact drill of the present invention.

In the drawings:

FIGURE 1 is a side view of the rotary-impact drill, partially in section, illustrating the drill boring a hole within the earth;

FIGURE 2 is a sectional view taken along the line 2—2 in FIGURE 1 showing the inner workings and construction of the rotary-impact drill;

FIGURE 3 is a fragmentary sectional view of the lower portion of the rotary-impact drill illustrating its anvil and hammer cam arrangement with the hammer cams riding upward along the sloping surfaces of the anvil cams;

FIGURE 4 is a fragmentary sectional view of the hammer and anvil cam portions of the rotary-impact drill illustrating the positions of the cams just prior to vertical drop of the hammer onto the anvil;

FIGURE 5 is a sectional view taken along the line 5—5 in FIGURE 3;

FIGURE 6 is a sectional view taken along the line 6—6 in FIGURE 4;

FIGURE 7 is a fragmentary sectional view taken along the line 7—7 in FIGURE 5; and

FIGURE 8 is a fragmentary sectional view taken along the line 8—8 in FIGURE 6.

In the drawings, the rotary-impact drill is represented by the numeral **10** and generally speaking includes an anvil **12** and a hammer **14**. The anvil **12** is connected to and carries a drill bit for the rotary-impact drill **10**, while the hammer **14** is mounted for axial movement above and for rotational movement relative to the anvil, and is continuously urged downward toward the anvil by a coil spring **18**. The lower and upper surfaces of the hammer **14** and the anvil **12** carry complementary, tooth-shaped hammer and anvil cams **20** and **22** including cooperating vertically sloping surfaces **24** terminating in substantially vertical shoulders **26**. The hammer and anvil, as well as the hammer cams and anvil cams, are arranged relative to each other such that as the hammer **14** rotates relative to the anvil **12**, the hammer cams **20** repeatedly ride up along the sloping surfaces **24** of the anvil cams and under the influence of the coil spring **18** drop heavily onto the anvil cams upon leaving the sloping surfaces and reaching the shoulders of the anvil cams.

The foregoing structural arrangement is somewhat similar to conventional rotary-impact drills. From this point on, however, the present invention differs substan-

tially and in extremely important respects from conventional drills by the inclusion of cooperative means represented generally by the numeral **28**. The cooperative means **28** are connected to the anvil **12** and to the hammer **14** and are adapted to direct the hammer cams **20** vertically downward during each drop with the shoulders **26** of the hammer cams dropping along and immediately adjacent the shoulders **26** on the anvil cams. This insures a maximum hammer stroke prior to striking the anvil. It also insures that the hammer **14**, under the influence of the coil spring **18**, reaches a maximum velocity prior to impact with the anvil **12** and hence insures a maximum hammer and anvil vertical impact for each hammer drop. The cooperative means **28** are also designed to impart a maximum rotational impact to the anvil **12** and drill bit **16** just prior to each drop of the hammer **14**.

Accordingly, in the rotary-impact drill **10**, the drill bit **16** is repeatedly subjected to a maximum rotational impulse followed immediately by a maximum vertical impulse. The resulting drilling action has proven to be vastly superior to conventional rotary-impact drills employing simultaneous vertical and rotary impulses of lesser magnitude.

More particularly, as illustrated most clearly in FIGURES 1 and 2, the rotary drive for the hammer **14** and hence for the anvil **12** and drill bit **16** is through a tubular drive shaft **30**. In this regard, the upper end of the drive shaft **30** is threadedly connected to the lower end of a tubular box member **32** which in turn is threadedly connected to a tubular pin **34** extending from the bottom of a drill collar **36**.

The drive shaft **30** extends downwardly from the box member **32** through a tubular cover member **38** and the hammer **14** and anvil **12** housed therein and terminates inside a crossover sub **40** connecting the drill bit **16** to the anvil. At its lower end, chevron seals **42** extend around the drive shaft **30** and tightly against the inside of the sub **40** to isolate the inside of the cover member and the workings of the drill **10** from the end of the drive shaft. The seals **42** are held in place by upper and lower retaining nuts **44** and **46** on the threaded lower end of the drive shaft **30**.

Thus arranged, the lower end of the drive shaft **30** opens into a chamber **48** in the upper end of the drill bit **16**. Side ports **50** extend from the lower end of the chamber to the cutting face of the drill bit **16**. Accordingly, a straight, unbroken circulation path is provided completely through the drill **10** and allows fluid or air to be circulated in either direction through the drive shaft **30** without fear of contaminating the workings of the drill sealed within the cover member **38**.

As indicated most clearly in FIGURE 2, the anvil **12** is of a tubular design having a central opening **52** for axially receiving the drive shaft **30**. The inner lower end of the anvil is threaded and is connected to the sub **40** securing the drill bit **16** to the anvil while the upper surface of the anvil includes the previously described anvil cams **22** which extend around the central opening **52**.

Within the anvil **12** and below the cams **22**, the central opening **52** is of enlarged radial dimension and houses a roller bearing unit **54**, upper and lower thrust bearing units **56** and **58** and a coil spring **60**. The bearings of the roller bearing unit **54** engage and roll around the outer surface of the drive shaft to support the anvil for rotary movement around and relative to the drive shaft.

In drilling operations, upper thrust bearing unit **56** is forced against the bottom of an annular shoulder **62** on the drive shaft **30** while the lower thrust bearing unit **58** is forced against the top of the sub **40** by the coil spring **60** which extends around the drive shaft. In this arrangement, the coil spring **60** transmits the weight of the drive shaft **30** and any axial forces thereon to the drill bit **16** through the sub **40**. The coil spring **60** also cushions the drive shaft against rebound of the drill bit and anvil after vertical impact of the hammer **14**. The design also allows the hammer **14** to work equally well should the drill bit **16** become stuck and upward pull on the drive shaft **30** be required during drilling operation. In particular, an upward pull on the drive shaft **30** causes the drive shaft to move upwardly relative to the hammer **14** until the nut **44** engages the bottom of the thrust bearing unit **58**. Thereafter, the upward pull on the drive shaft **30** compresses the spring **60** and forces the thrust bearing unit **56** upward against an annular shoulder **63** on the anvil **12**. The continued upward pull then forces the anvil **12** and drill **10** upwardly as the drill bit **16** drills its way out of the drill hole in response to the rotary and vertical impulses applied thereto.

The upper, outer portion of the anvil **12** is threaded and tightly mates with the internally threaded lower end of the tubular cover member **38**. Thus connected, the cover member **38** extends vertically from the anvil and is adapted to axially receive the hammer **14**, the drive shaft **30**, and the coil spring **18** which extends around the drive shaft above the hammer.

The upper end of the cover member **38** is closed by a retainer nut **64**. The nut **64** extends around and axially receives the drive shaft **30**. Also, the nut houses a sand trap **66**, a seal unit **68** and a pair of roller bearing units **70** and **72**.

With respect to the sand trap **66**, it comprises an annular recess **74** on the inside of the nut **64** around the central opening receiving the drive shaft **30**. The recess **74** is generally of an annular, frusto-conical shape having outwardly projecting lower annular pocket **76**. Set screw covered side ports **78** extend from the outside of the nut **64** to the recess to provide means for depositing oil within the trap and upper and lower wiper rings **80** and **82** are seated in the inner surface of the nut above and below the recess to provide means for wiping the outer surface of the drive shaft as it is telescoped relative to the cover member **38**.

In operation, any sand seeping around the outside of the drive shaft **30** and into the top of the nut **64** enters the top of the recess **74**. As the drive shaft **30** turns and as the cover member **38** rotates relative to the drive shaft, the sand is thrown outwardly and travels down along the sloping inner surfaces of the recess into the pocket **76**. The sand is thus trapped in the pocket and prevented from travelling further along the drive shaft into the area of the seal unit **68**. In the latter respect, the seal unit **68** comprises chevron seals **84** extending tightly around the drive shaft and seated within the retainer nut **64** below the sand trap **66**. Since sand is prevented from working its way into the chevron seals **84**, they have a much longer useful life than in conventional rotary-impact drills and provide efficient sealing between the drive shaft **30** and the cover member **38** over long periods of drill operation.

With regard to the upper and lower roller bearing units **70** and **72**, they are seated within the nut **64** with their bearing around and engaging the outer surface of the drive shaft **30** to support the nut and cover member **38** for rotation around the drive shaft. The roller bearing units are retained within the lower end of the retainer nut **64** by a thrust bearing unit **86** which engages the lower end of the retainer nut and the bottom of the lower roller bearing unit. The thrust bearing unit **86** is in turn continuously urged upward against the bottom of the retainer nut **64** by the coil spring **18** which also continuously bears downward on the top of the hammer **14**.

As most clearly illustrated in FIGURES 2 and 5, the hammer **14** is of tubular construction for receiving the drive shaft **30** and carries the hammer cams **20** on its lower surface. The hammer **14** is also mounted for axial movement along as well as rotary movement with the drive shaft **30**. To accomplish this, the inner surface of the hammer **14** includes four equally spaced radially extending keyways **88** for receiving keys **90** extending radially

from the outer surface of the drive shaft **30**. The keys **90** ride axially along the keyways **88** to permit the hammer **14** to move vertically along the drive shaft. The keys, however, engage the sides of the keyways to lock the hammer for rotation with the drive shaft, while the coil spring **18** continuously urges the hammer downward against the top of the anvil **12**. Accordingly, as the drive shaft **30** rotates, it produces a like turning of the hammer **14**. When the drill bit **16** is turning in relatively soft earth such as sand, the hammer cams **20** remain locked to the anvil cams **22** and the rotation of the hammer produces a like rotation of the anvil and drill bit. However, as the drill bit bores into more solid earth, the drill bit tends to stick therein and the hammer cams tend to rotate relative to the anvil cams with the foregoing rotational and vertical impacts imparted to the drill bit under the control of the previously referred to cooperative means **28**.

More particularly, as illustrated most clearly in FIGURES 3–8, the cooperative means **28** includes a plurality of shoulders **92**, one for each anvil cam **22**. The shoulders **92** include inclined lower surfaces, are equally spaced from each other, radially spaced from the hammer **14**, and are connected to and extend inwardly from the inner surface of the cover member **38** above the upper surface of the anvil cams **22**. Since the shoulders **92** are connected to and extend from the cover member **38**, they are fixedly located relative to the anvil cams and rotate therewith.

In addition to the shoulders **92**, the cooperative means **28** includes a plurality of lugs **94**, one for each shoulder. The lugs **94** include inclined top surfaces complementary to the lower surfaces of the shoulders **92**, are spaced equally from each other, and extend radially outward from the lower end of the hammer **14** adjacent the hammer cams **20**. Thus positioned, the lugs **94** are adapted to only strike vertical sides of the shoulders **92** when the hammer cams move vertically to the top of and off the anvil cams. In this respect, the shoulders **92** and lugs **94** are spaced relative to each other and to the anvil and hammer cams such that the lugs only strike the shoulders and impart rotary impulses to the anvil **12** when the hammer cams are moving in a horizontal plane with a maximum annular velocity, that is when they have just left the sloping surfaces of the anvil cams and when the anvil and hammer cam shoulders are in substantial vertical alignment (see FIGURES 6 and 8).

Accordingly, with the illustrated arrangement of the shoulders **92** and lugs **94**, maximum rotary impulses are imparted to the anvil **12** and hence to the drill bit **16** each time the hammer cams **20** ride completely up the sloping surfaces **24** of the anvil cams **22** and just prior to the vertical drop of the hammer **14** onto the anvil. In this respect, the vertical sides of the shoulders **92** act to direct the hammer **14** in a vertical direction downward against the anvil **12** during the drop of the hammer. In particular, as the hammer **14** drops onto the anvil **12**, the shoulders **26** of the anvil and hammer cams pass immediately adjacent each other to insure the maximum stroke for the hammer during each drop. Since the hammer travels through a maximum distance before striking the anvil, the coil spring **18** imparts a maximum downward velocity to the hammer prior to impact. Accordingly, the hammer **14** contacts the anvil **12** with a maximum momentum to impart a maximum vertical impulse to the anvil and the drill bit **16**.

In the foregoing manner, when the drill bit **16** is stuck in or its rotation retarded by relatively firm soil, the hammer **14** repeatedly imparts rotational impulses to the drill bit **16** each followed by a maximum vertical impulse to free the bit and cause it to rotate and bore into the soil.

As previously indicated, the hammer **14**, anvil **12** and spring members **18** comprise the workings of the rotary-impact drill **10** and are sealed within the cover member **38**. In particular, the workings are sealed and operate within an oil chamber **96** defined by the cover member **38** and the upper and lower chevron seals **84** and **42** around the drive shaft **30**. The chamber is adapted to be oil filled through set screw covered side ports **98** located immediately below the upper chevrons **84**. In the illustrated form of the present invention, the outer diameter of the upper portion of the shaft **30** is equal to the outer diameter of the seals **42**. Therefore, the oil chamber **96** maintains a constant volume during operation of the rotary-impact drill. Accordingly, there is no pumping action of fluid within the cover member **38** and water and debris is not drawn into the oil chamber during drilling operations.

From the foregoing, it is appreciated that the present invention provides an improved rotary-impact drill which develops separate maximum rotational and vertical impacts on a drill bit while the bit is boring into the earth. The rotary-impact drill also is constructed such that its workings operate within the sealed container free from sand, debris or water which would otherwise impair its efficient operation.

While a particular form of rotary-impact drill has been described in some detail herein, changes and modifications may be made in the illustrated form without departing from the spirit of the invention. It is therefore intended that the present invention be limited in scope only by the terms of the following claims.

I claim:

1. A rotary-impact drill, comprising:

an anvil adapted for connection to a drill bit for turning therewith;

a hammer mounted for axial and rotational movement relative to said anvil;

spring means continuously urging said hammer toward said anvil;

complementary, tooth-shaped hammer and anvil cams on said hammer and anvil, respectively, including cooperative vertically sloping surfaces terminating in substantially vertical shoulders whereby as said hammer rotates relative to said anvil, said hammer cams repeatedly ride up along said sloping surfaces said anvil cams and under the influence of said spring means drop heavily onto said anvil cams upon leaving said sloping surfaces and reaching said shoulders of said anvil cams;

and cooperative means connected to said anvil and hammer for directing said hammer cams vertically downward during ecah drop with said shoulders of said hammer cams dropping along and immediately adjacent said shoulders of said anvil cams to insure a maximum hammer stroke and a maximum hammer and anvil impact during each drop.

2. The combination of claim **1** wherein said cooperative means are further adapted to impart rotational impulses to said anvil and drill bit just prior to each drop of said hammer.

3. The combination of claim **2** wherein said cooperative means includes:

a plurality of shoulder means, one for each anvil cam, said shoulder means being equally spaced from each other, radially spaced from said hammer and connected to said anvil above said anvil cams to turn therewith;

a plurality of lugs, one for each shoulder means, said lugs being spaced equally from each other and extending radially from said hammer to strike said shoulder means when said hammer cams move off said anvil cams sloping surfaces and above said anvil cams;

and said shoulder means and lugs being spaced relative to each other and to said anvil and hammer cams such that said lugs strike said shoulder means and impart rotational impulses to said anvil when said hammer cams are rotating at a maximum angular velocity and leave said sloping surfaces of said

anvil cams and said anvil and hammer cams shoulders are in substantial vertical alignment, and such that said shoulder means then direct said hammer cams downward to impact with said anvil cams, corresponding ones of said cam shoulders passing immediately adjacent each other to insure a maximum hammer stroke and a maximum hammer and anvil impact upon each hammer drop.

4. The combination of claim 2 further including:

vertical drive shaft means for turning about its longitudinal axis;

means mounting said hammer for axial movement along and rotational movement with said drive shaft;

means mounting said anvil for rotation relative to said drive shaft;

and second spring means between said drive shaft and said drill bit carried by said anvil for carrying and transmitting the weight of said drive shaft and axial forces thereon to said drill bit.

5. The combination of claim 2 further including:

a vertical drive shaft for turning about its longitudinal axis;

means mounting said hammer for axial movement along and rotational movement with said drive shaft;

means mounting said anvil for rotation relative to said drive shaft;

a tubular cover means closed at its lower end by and connected to said anvil for axially receiving said hammer;

first sealing means between said drive shaft and said cover means above said hammer;

and second sealing means between said drive shaft and said anvil defining a closed constant volume oil chamber within said cover means housing said hammer, anvil and spring means.

6. The combination of claim 5 further including a

sand trap above said first seal means including an annular recess in said cover means open to said drive shaft, said recess including a lower, outer, annular pocket for receiving sand and the like which seeps around said drive shaft and into said cover means and which is thrown outward upon a turning of said cover means and said drive shaft.

7. The combination of claim 5 wherein said drive shaft is tubular and provides a flow path for high pressure fluid downward through ports in said drill bit.

8. The combination of claim 5 wherein said spring means is stationed within said chamber above said hammer and bears downward on a top surface of said hammer and upward on said cover means around said drive shaft, and wherein said combination further includes second spring means in said chamber below said anvil cams, said second spring means bearing downward on said drill bit carried by the bottom of said anvil and upward on said drive shaft during downward drilling and upward on said anvil when said drive shaft is pulled upward to work said bit from its drill hole whereby said second spring means carries and transmits the weight of said drive shaft and axial forces thereon to said drill bit during downward drilling and transmits tension pull on drive shaft to anvil as said drill bit is worked upward in said drill hole.

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CHARLES E. O'CONNELL, *Primary Examiner.*

R. E. FAVREAU, *Assistant Examiner.*