Aug. 29, 1961 M. J. DEMO 2,998,086

RECIPROCATING CORE DRILL

Original Filed June 25, 1951 2 Sheets-Sheet 1

Fig. 1.

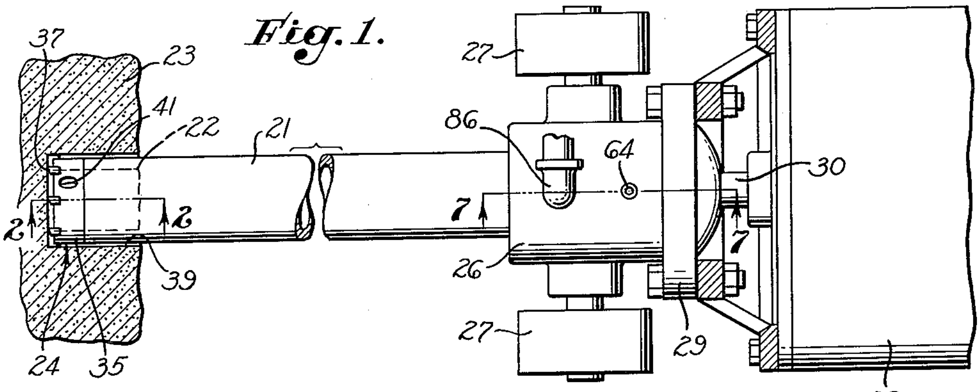


Fig. 2.

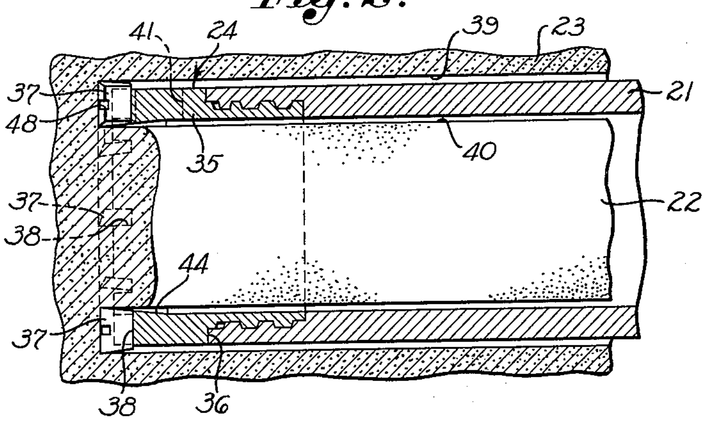


Fig. 5.

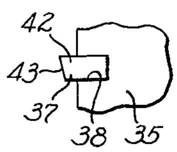


Fig. 6.

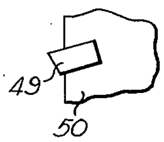


Fig. 3.

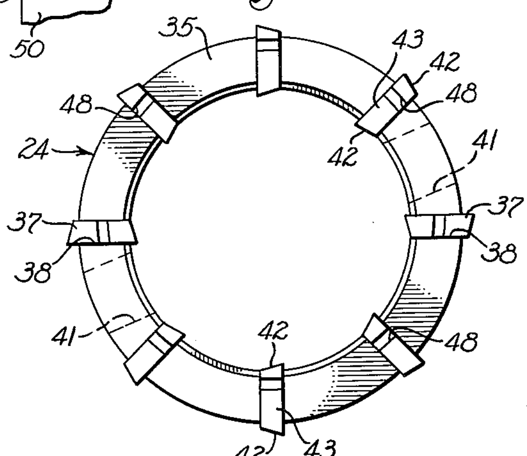
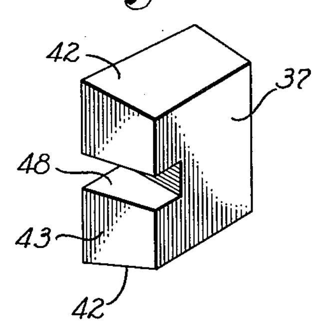


Fig. 4.



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RECIPROCATING CORE DRILL

Original Filed June 25, 1951 2 Sheets-Sheet 2

Fig. 7.

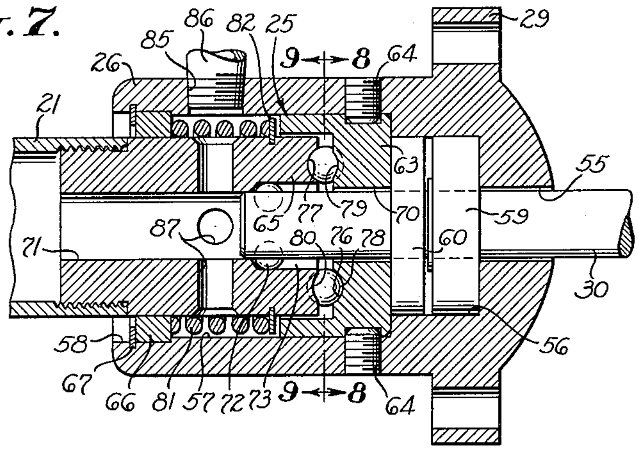


Fig. 10.

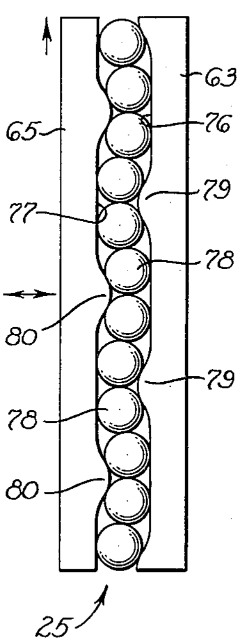


Fig. 11.

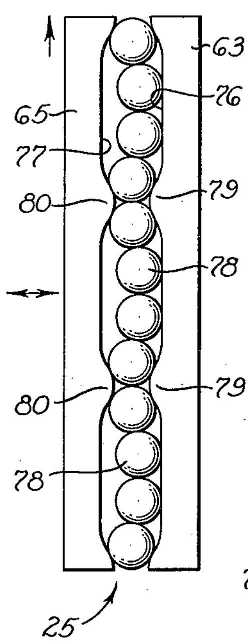


Fig. 8.

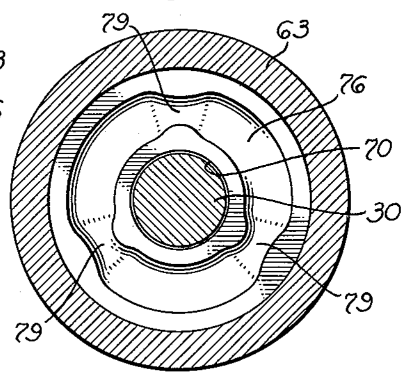
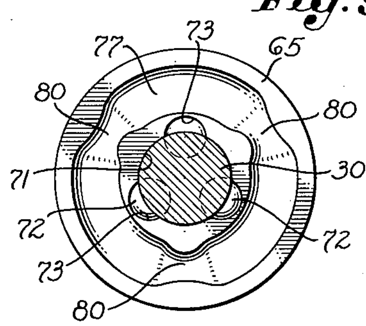


Fig. 9.



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2,998,086

RECIPROCATING CORE DRILL

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Substitute for abandoned application Ser. No. 233,312, June 25, 1951. This application Sept. 27, 1954, Ser. No. 458,464
5 Claims. (Cl. 175—138)

This application is a substitute for my application Serial No. 233,312, filed June 25, 1951, and now abandoned, and is a continuation in part of my copending application Serial No. 218,210, filed March 29, 1951, now Patent No. 2,701,711, granted February 8, 1955.

The present invention relates in general to drilling equipment and, since the invention was originally embodied in and is particularly applicable to drilling equipment for use in mines, highway and railroad tunnels, aqueduct tunnels, and the like, it will be considered in such connection herein for purposes of illustration with the understanding that it is susceptible of other applications. Also, although the invention is capable of being embodied in gang drilling equipment incorporating a plurality of drilling units, the invention will be considered in connection with a single drilling unit as a matter of convenience and with no intention of limiting it thereto.

As is well known in the field to which this invention relates, mine operators, tunnel contractors and the like encounter a wide variety of formations which require drilling, such formations ranging from extremely soft ones to extremely hard ones such as granite and marble, the latter being encountered in quarrying operations, for example. Also, viscous formations tending to clog prior drilling equipment are frequently encountered. In accordance with prior, conventional practice, it has been necessary to employ different types of drills for different types of formations, which is an obvious disadvantage, particularly where a single hole must be drilled through more than one such formation. Considering an example in this connection, a vein of coal may be covered by a soft, and perhaps gummy, formation, the latter being in turn covered by a hard formation such as sandstone. With such conditions, it is desirable to support the roofs of tunnels through which the vein of coal is mined by means of suspension roof bolts set in the aforementioned sandstone or other hard layer. Consequently, it is necessary to drill holes through the softer formation overlying the vein of coal and into the superimposed hard layer, and, in accordance with prior practice, this requires the use of two different drills for each hole. Obviously, the loss of time and the labor involved in the frequent drill changes necessitated by such prior practice add materially to the expense of the project.

I have found that the foregoing disadvantages of prior practice may be avoided through the use of a reciprocating core drill, i.e., a core drill which is reciprocated longitudinally by a hammer means or hammer device incorporated therein, the provision of such a drill being a primary object of the invention.

More particularly, an object of the invention is to provide a drill which includes a drill or core tube having a core bit at one end and having at its other end actuating means for rotating the core tube and the core bit and for simultaneously reciprocating the core tube and the core bit longitudinally of the axis of the core tube, such reciprocation of the core tube and bit taking place continuously during the operation of the drill so that cutters carried by the bit continually strike the formation being drilled, thereby greatly increasing the drilling rate, which is an important feature.

Another object is to provide a core bit comprising a collar having cutters on one end thereof for removing an annulus from the formation to produce a core which passes through the collar.

An important object is to provide cutters on such a core bit having cutting edges arranged in a circle which is eccentric to the axis of rotation of the core bit so that each cutter removes only a part of the material from the annulus around the core, thereby providing clearances adjacent the cutting edges of each cutter into which the material removed may be displaced.

Another object is to provide a core bit wherein the cutters are grooved circumferentially, the grooves in the cutters being arranged in an eccentric circle to provide the aforementioned clearances into which the material removed by the cutters may be displaced.

A further object is to provide means for feeding a fluid, such as water or air, through the core tube to the core bit so as to continuously remove the material cut away by the cutters, the latter preferably extending radially outwardly beyond the outer periphery of the collar of the core bit to provide an annular clearance around the collar of the core bit and the core tube through which the cuttings may be washed by the water, air, or water-air mixture, circulated through the core tube.

Another object is to provide a core bit the collar of which is provided with at least one radial outlet passage for the fluid circulated through the core tube.

An important object is to provide a reciprocating core drill of the foregoing character which includes a hammer device having a rotatable cam connected to the core tube and having a stationary cam which cooperates with the rotatable cam to reciprocate the core tube and the core bit in response to rotation of the rotatable cam relative to the stationary cam. A related and important object is to provide a drive means for the core tube and core bit which is connected to the rotatable cam so that continuous rotation of the rotatable cam is required to drive the core tube and core bit, thereby simultaneously producing continuous longitudinal reciprocation of the core tube and the core bit.

Another object is to provide stationary and rotatable cams having transverse, annular cam faces which face each other and which cooperate to reciprocate the rotatable cam, the core tube and the core bit in response to rotation of the rotatable cam relative to the stationary cam.

An important object is to provide a hammer device wherein the cam faces are spaced apart and are separated by rotatable bearing elements, such as tapered rollers or balls, the latter being preferable. A related object is to make the cam faces in the form of races for the balls or other rotatable bearing elements. With this construction, friction and wear of the cam faces are minimized, which are important features.

Another object is to provide a reciprocating core drill wherein the cam faces of the rotatable and stationary cams are provided with a plurality of rises and wherein the core bit is provided with a plurality of cutters so that the end of the annulus formed by the core bit is subjected to a very large number of blows during each revolution of the bit. This results in much faster drilling than is attainable with nonreciprocating core drills, which is an important feature of the invention.

Another object of the invention is to provide a drive shaft for the rotatable cam which extends through the stationary cam and which is connected to the rotatable cam by a connection permitting relative axial movement of the rotatable cam and the shaft, but preventing rotation of the shaft relative to the rotatable cam. Another object is to provide a connection between the shaft and the rotatable cam which includes balls rotatable in longitudinal grooves.

Another object is to provide a housing for the cams and to provide means for securing the stationary cam in the housing and bearing means for rotatably mounting the rotatable cam in the housing.

Another object is to provide spring means anchored relative to the housing and relative to the rotatable cam for continuously biasing the rotatable cam against the stationary cam, i.e., against the balls between the two cam faces.

Another object is to provide passages through the rotatable cam for conducting a fluid, such as water, air, or an air-water mixture, into the core tube so that such fluid may flow through the core tube to the core bit as hereinbefore discussed, an object being to provide a fluid inlet in the housing which constantly communicates with the passages through the rotatable cam so that fluid may be introduced into the core tube continuously.

Another object is to provide a hammer device wherein the bearings for the rotatable cam, including the bearing elements between the two cam faces, are lubricated by water introduced through the aforementioned inlet in the housing.

The foregoing objects and advantages of the present invention, together with various other objects and advantages thereof which will become apparent, may be attained with the exemplary embodiments of the invention which are illustrated in the accompanying drawings and which are described in detail hereinafter. Referring to the drawings:

FIG. 1 is a view partly in section on a reduced scale illustrating a single drilling unit which embodies the invention;

FIG. 2 is an enlarged sectional view, taken along the arrowed line 2—2 of FIG. 1, of a core bit and one end of a core tube incorporated in the drill of the invention;

FIG. 3 is an enlarged end view of the core bit;

FIG. 4 is an enlarged isometric view of a cutter incorporated in the core bit;

FIG. 5 is a fragmentary elevation view showing a single cutter mounted on one end of the collar forming part of the core bit;

FIG. 6 is a view similar to FIG. 5 but illustrating an alternative embodiment;

FIG. 7 is an enlarged sectional view, taken along the arrowed line 7—7 of FIG. 1, illustrating a hammer means or device of the invention for reciprocating the core tube and the core bit longitudinally of the core tube;

FIGS. 8 and 9 are transverse sectional views respectively taken along the arrowed lines 8—8 and 9—9 of FIG. 7; and

FIGS. 10 and 11 are developed views illustrating the operation of a cam means incorporated in the hammer device of the invention.

Referring first to FIG. 1 of the drawings, illustrated therein is a drill of the invention which includes a drill or core tube **21** adapted to receive a core **22** produced in a formation **23** by a core bit **24** secured to one end of the core tube. The core tube **21** may be of any desired length and is adapted to be rotated about its axis through a hammer device **25**, FIG. 7, which is disposed in a housing **26**. The housing **26** is adapted to be mounted in any suitable manner on a supporting structure **27** which may, for example, be carried by a boom of a drill jumbo, or the like. Alternatively, the drill illustrated in FIG. 1 may be mounted in a manner similar to that disclosed in my copending application Serial No. 218,210, filed March 29, 1951. The core tube **21** and core bit **24** are adapted to be driven through the hammer device **25** by a drive means **28** which is illustrated as bolted onto a flange **29** on the housing **26** for purposes of illustration. The drive means **28** may be an electric motor, hydraulic motor, air motor, or any other suitable device. The drive means **28** includes a shaft **30** which extends into the housing **26** and is connected to the hammer device **25** in a manner to be described hereinafter.

Referring to FIGS. 2 to 5 of the drawings, the core bit **24** includes a collar **35** having a portion of reduced diameter which is threaded into the core tube **21**, the collar having a shoulder **36** which abuts the end of the core tube. The core bit **24** is provided with a plurality of circumferentially spaced tips or cutters **37** on the outer end of the collar **35**. These cutters are preferably formed of a material such as carbide and are illustrated as set in notches **38** in the outer end of the collar **35**, the cutters being suitably secured in the notches **38**, as by silver soldering, for example. The cutters **37** project radially outwardly beyond the outer periphery of the collar **35** and the core tube **21** and project radially inwardly beyond the inner periphery of the core tube to provide an outer clearance **39** around the core tube **21** and an inner clearance **40** around the core **22**. With this construction, water may be circulated through the inner clearance **40**, through the spaces between the cutters **37** and through the outer clearance **39** so that the cuttings removed by the cutters **37** are carried out of the hole being drilled by way of the outer clearance **39**. The water flow between the cutters **37** continually removes the cuttings from the cutters to prevent fouling or clogging thereof. In order to permit additional water flow so as to convey the cuttings out of the hole rapidly through the outer clearance **39**, the collar **35** is provided with radial passages or ports **41** which provide additional fluid communication between the outer clearance **39** and the inner clearance **40**.

As best shown in FIG. 3, the cutters **37** are provided with side rake angles of, for example, 15°, i.e., the side faces **42** of the cutters make angles of, for example, 15° with tangents to the collar **35**. Similarly, as best shown in FIG. 5, the cutters **37** are provided with end or top rake angles of, for example, 15°, i.e., the end faces **43** make angles of, for example, 15° with a plane normal to the axis of the collar **35**. Also, as best shown in FIG. 2, the cutters **37** taper rearwardly toward the core tube **21**. For example, each side face **42** may make an angle of 5°, for example, with the axis of the collar **35**. This rearward taper of the inner side faces of the cutters is carried rearwardly into the collar **35**, as indicated at **44**, this extension of the rearward taper of the cutters into the collar being continuous around the entire periphery of the collar so that the inner periphery of the collar diverges rearwardly. This renders the interior of the collar perfectly smooth and free from obstructions so that the core **22** may be ejected from the core tube **21** readily by an air blast, or otherwise, there being no projections extending into the core tube or collar **35** on which the core can hang up.

An important feature of the core bit **24** is that each cutter **37** is provided with a circumferentially extending groove **48**, these grooves being arranged in a circle which is eccentric with respect to the axis of the core bit. Each groove **48** divides the cutting edge of its cutter **37** into two cutting edges, the inner and outer cutting edges of the cutters **37** similarly being arranged in eccentric circles. With this construction, the individual cutters do not operate on the entire end face of the annulus being drilled in the formation, each cutter serving to remove material from only a part of the end face of the annulus. With this construction, the material cut from the formation by the cutters may enter and pass through the grooves **48** in the cutters, the grooves thus acting to provide additional clearance for the cutters so that any tendency of the cutters to clog is minimized.

In the embodiment just described, the cutters **37** are shown as set perpendicular to the end of the collar **35**. However, the cutters may be set at other angles to the end of the collar, as exemplified by the cutter **49** and collar **50** in FIG. 6.

Referring particularly to FIG. 7 of the drawings, the housing **26** is generally cup-shaped and is provided with a bore **55** therethrough and progressively larger counterbores **56**, **57** and **58**. The drive shaft **30** extends through the bore **55** into the housing, a bearing **59** for the drive shaft being pressed into the counterbore **56**. An oil or grease seal **60** is also pressed into the counterbore **56** and serves to keep water introduced into the housing in a manner to be described out of the bearing **59**.

The hammer device **25** comprises cam means which includes a stationary cam **63** pressed into the counterbore **57** in the housing and seated against a shoulder formed at the junction of the counterbores **56** and **57**. The cam **63** is held stationary relative to the housing **26** by set screws **64**. The stationary cam **63** is generally cup-shaped and receives one end of a rotatable cam **65**, the latter being journalled in a bearing or bushing **66**, which may be formed of bronze, for example. The bearing **66** is pressed into the counterbore **58** and is seated against a shoulder formed at the junction of the counterbores **57** and **58**, the bearing being retained by a ring **67** disposed in a groove in the housing. The outer end of the rotatable cam **65** is of reduced diameter and is threaded into the core tube **21** so that rotation of the rotatable cam **65** serves to rotate the core tube, and the core bit **24** connected thereto. The drive shaft **30** extends through a bore **70** through the stationary cam **63** into a bore **71** through the rotatable cam **65**, the drive shaft being provided with hemispherical sockets therein the balls **72** which fit into axially extending grooves **73** in the rotatable cam. With this construction, rotation of the drive shaft **30** is communicated to the rotatable cam **65** by the keying action of the balls **72**, the grooves **73** permitting axial movement of the rotatable cam **65** relative to the drive shaft when the rotatable cam reciprocates axially as will be described. The use of the balls **72** for this keying action minimizes friction, as will be apparent.

The bottom wall of the cup-shaped stationary cam **63** and the inner end wall of the rotatable cam **65** respectively provide transverse, annular cam faces **76** and **77**, the cam face **76** being shown in plan in FIG. 8, and the cam face **77** being shown in plan in FIG. 9. Disposed between the cam faces **76** and **77** are a plurality of rotatable bearing elements, which are preferably balls **78**, although tapered rollers, not shown, might be used. The cam faces **76** and **77** are arcuate in radial cross section to provide races for the balls **78**, this radial concavity of the cam faces being best shown in FIG. 7.

Each of the cam faces **76** and **77** is provided with at least one and preferably a plurality of rises, three rises for each cam face being illustrated. The three rises on the cam face **76** are identified by the numeral **79** and the three rises on the cam face **77** are identified by the numeral **80**. Referring to FIGS. 10 and 11, whenever the rises **80** register with the rises **79** during rotation of the rotatable cam **65** relative to the stationary cam **63**, the rotatable cam is forced axially away from the stationary cam by the balls **78** therebetween, three such longitudinal reciprocations of the rotatable cam **65** being produced for each revolution thereof with the three-rise construction illustrated.

In order to bias the rotatable cam **65** toward the stationary cam **63**, a compression spring **81** is employed, this spring encompassing the rotatable cam and being seated against the bearing **66** at one end and against a ring **82** disposed in a groove in the rotatable cam at its other end.

In order to introduce water, or other fluids such as air, the housing **26** is provided with a radial passage or port **85** into which a fitting **86**, adapted to receive a hose, for example, is threaded. The port **85** communicates with an annular space around the rotatable cam **65**, such annular space being substantially closed at its outer end by the bearing **66**. The rotatable cam **65** is provided with radial passages or ports **87** which also communicate with the annular space around the rotatable cam and which communicate with the bore **71** through the rotatable cam. Thus, a fluid, such as water or air, introduced through the fitting **86** passes through the radial passages **87** in the rotatable cam and the bore **71** therein into the core tube **21**, the fluid flowing through the core tube to the core bit **24** to remove cuttings in a manner hereinbefore described. Normally, water will be introduced into the system in this manner during cutting, and this water serves to lubricate the interface between the bearing **66** and the rotatable cam **65**, there being a slight clearance therebetween to permit a slight leakage for lubrication purposes. Also, the balls **78** between the cam faces and the balls **72** for keying the rotatable cam **65** to the drive shaft **30** are water lubricated in a manner which will be apparent in FIG. 7.

It is thought that the operation of the drill of the invention will be apparent from the foregoing description so that a detailed description of the operation is unnecessary. Briefly, rotation of the drive shaft **30** produces rotation of the rotatable cam **65** because of the keying action of the balls **72**. As the rotatable cam **65** is rotated in this manner, the cam faces **76** and **77**, acting through the balls **78**, cause the rotatable cam **65** to reciprocate longitudinally, thereby reciprocating the core tube **21** and the core bit **24** to cause the cutters **37** of the core bit to strike the end face of the annular hole being drilled. This percussing action of the cutters on the end face of the hole being drilled results in extremely high drilling speeds as compared to conventional, nonreciprocatory core drilling. While the hole is being drilled, water is preferably introduced through the fitting **86** and flows into the core tube **21**, the water flowing through the inner clearance **40** around the core **22** and thence outwardly through the outer clearance **39** around the core tube **21**. The water flows from the inner clearance to the outer clearance through the circumferential spaces between the cutters **37** to continually wash the cuttings away from the cutters, and also flows outwardly through the radial passages **41** in the collar **35** of the cutter to convey the cuttings outwardly through the outer clearance **39**.

The drive means **28** may rotate the rotatable cam **65** at a rotational speed of, for example, 2000 revolutions per minute. Under such conditions, with the three-rise cam faces shown and with eight divided cutters **37** on the core bit **24**, it will be apparent that the end face of the annular hole being drilled is subjected to 96,000 blows per minute, although this value will vary with the rotational speed, the number of cutters and the number of rises. The large number of blows struck by the cutters results in extremely rapid penetration of even very hard formations, a drilling rate of 7 to 60 inches per minute being typical for materials having Mohs' scale Nos. from 1 to 9.

The drill of the invention will also handle very soft and sticky formations very efficiently, as well as hard formations. The tendency of such soft formations to clog the core bit **24** is prevented by the circulation of water described previously, the flow of water keeping the cutters clean at all times. Thus, the present invention may be employed to drill a single hole through several formations, which is an important feature.

If desired, the fitting **86** for introducing water may be connected to a selector valve, not shown, by means of which either water or air may be introduced. As hereinbefore discussed, water is normally introduced during drilling, but it is desirable to introduce a blast of air after drilling has been completed to eject the core **22** from the core tube **21**. In this connection, the previously described taper **44** of the collar and the taper of the cutters **37** are important since they provide the core bit with a smooth inner periphery to keep the core from hanging up when it is ejected in this manner.

Although I have disclosed exemplary embodiments of my invention, it will be understood that various changes, modifications and substitutions may be incorporated therein without departing from the spirit of the invention, and that the invention may be employed for other purposes without departing from the spirit thereof.

I claim as my invention:

1. In a hammer device for reciprocating a drill, the combination of: a housing providing an axis; and cam means in said housing and including a stationary cam secured to said housing and a rotatable cam rotatable about said axis, said rotatable and staionary cams respectively providing transverse, annular cam faces which are concentric with respect to said axis and which face each other, said cam faces cooperating to reciprocate said rotatable cam in response to rotation of said rotatable cam relative to said stationary cam, said rotatable cam being adapted to have a drill connected thereto, said rotatable cam being provided with an axial fluid passage and at least one radial fluid passage communicating with said axial passage, said housing being provided with a fluid inlet communicating with said radial passage, and said hammer device including an annular bearing between said housing and said rotatable cam, said bearing communicating with said fluid inlet to provide for lubrication thereof by fluid introduced through said inlet.

2. A rotary hammer device comprising: a housing; a shaft mounted in the housing for rotary and limited axial movement; means on said shaft and within said housing for connection to a rotary driving element; and cooperating cam means on said shaft and housing for imparting impacts to the shaft along its axis of rotation when the shaft is rotated in the housing, said cooperating cam means comprising a plurality of circumferentially arranged camming portions on an end face of said shaft and rotating therewith, and a plurality of cooperating circumferentially arranged camming portions on the housing and held stationary thereby.

3. A rotary hammer device comprising: a housing having a bore extending therethrough; a shaft mounted in said bore for rotary and limited axial movement; means on said shaft for connection to a rotary driving member held against axial movement; means forming an annular shoulder on said housing at one end of the bore, the adjacent end face of the shaft having a plurality of circumferentially arranged depressions therein defining camming surfaces; and a plurality of circumferentially arranged projections defining stationary cam elements on said shoulder, said camming surfaces being adapted to rotate and ride over said stationary cam elements when the shaft is rotated in the housing to impart axial impacts to the shaft.

4. In a drill, the combination of: a rotary hammer device as set forth in claim 2; a core tube connected at one end to said shaft; and a core bit connected to the other end of said core tube, said core bit being tubular so that a core cut thereby passes therethrough into said core tube as said core bit cuts in response to said impacts imparted to said shaft by said cam means.

5. A rotary hammer device as defined in claim 2 wherein said cam means on said housing is provided with an axial opening therethrough for said rotary driving element.

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