United States Patent [19]

Sweeney

[11] **3,874,464**

[45] **Apr. 1, 1975**

[54] **PROCESS OF DRILLING AN EARTH FORMATION**

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Related U.S. Application Data

[62] Division of Ser. No. 283,208, Aug. 23, 1972.

[52] **U.S. Cl.** **175/58,** 173/73, 173/80, 175/236

[51] **Int. Cl.** **E21b 1/06,** E21b 5/00, E21b 49/02

[58] **Field of Search** 175/58, 92, 105, 236, 257, 175/389, 390; 173/73, 80, 91, 72, 78, 71, 119, 15, 132, 92

[56] **References Cited**

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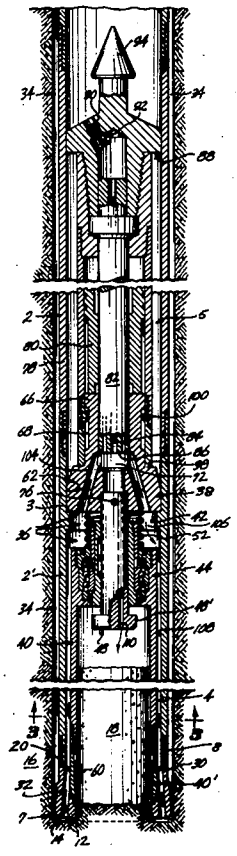
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Attorney, Agent, or Firm—Christopher Duffy

[57] **ABSTRACT**

The process employs a rotary drill rod comprising an elongated pipe having a longitudinally extending bore therethrough and a percussive bit at the distal end thereof. An abutment is provided relatively transverse the bore adjacent the bit, which is operatively connected with the bit to receive and transmit hammer blows into the working face of the bit. Moreover, a piston-like member is inserted into the bore of the pipe, which is slidably engageable with the wall of the bore and has a hammer mechanism thereon. The hammer of the mechanism is reciprocated between the member and the abutment to apply blows to the abutment, while fluid is passed through the member and exhausted into the region adjacent the working face of the bit. The exhausted fluid is discharged from said region toward the proximal end of the pipe on the opposite side of the pipe from the piston-like member and a pressure differential is generated across the piston-like member longitudinally of the bore to maintain the hammer mechanism in operative relationship to the abutment during the application of the blows.

24 Claims, 5 Drawing Figures



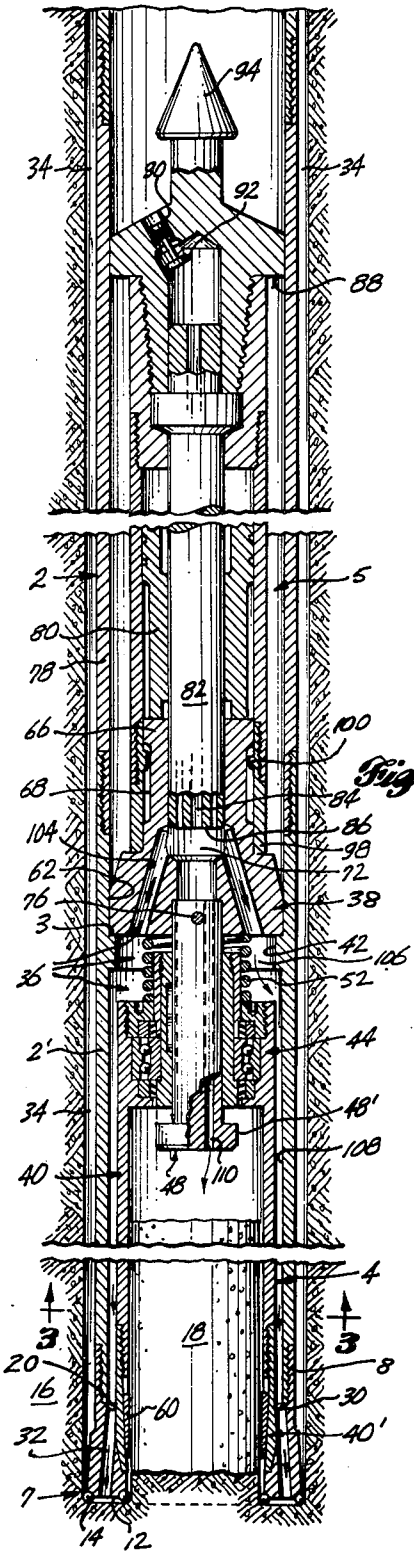


Fig. 1.

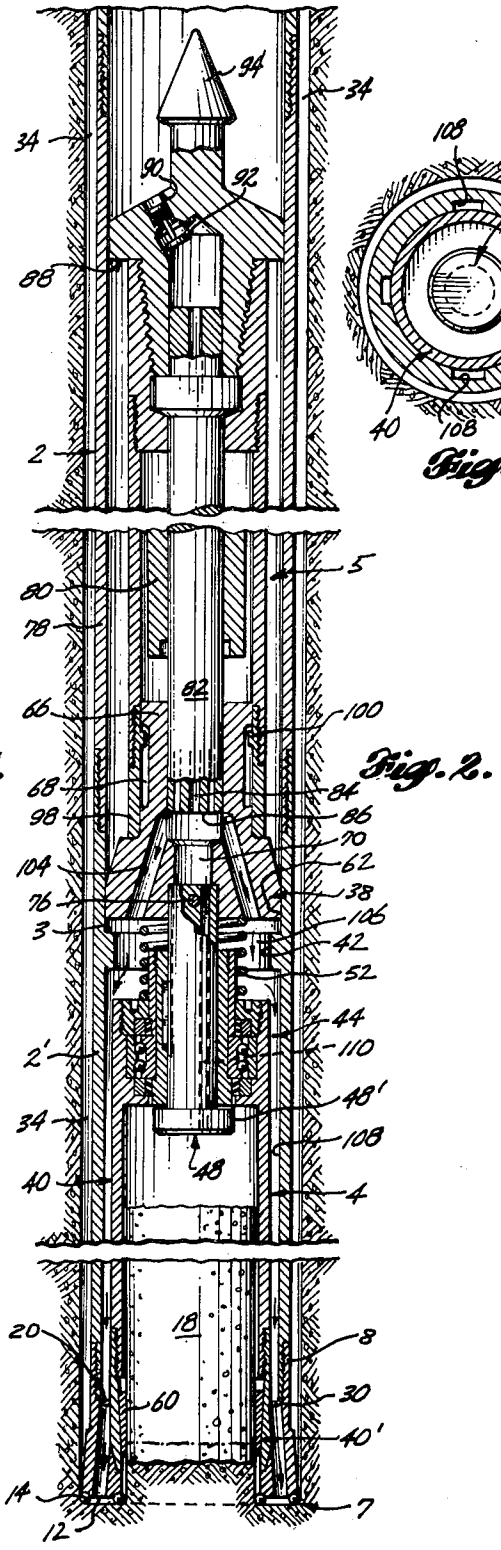


Fig. 2.

Fig. 3.

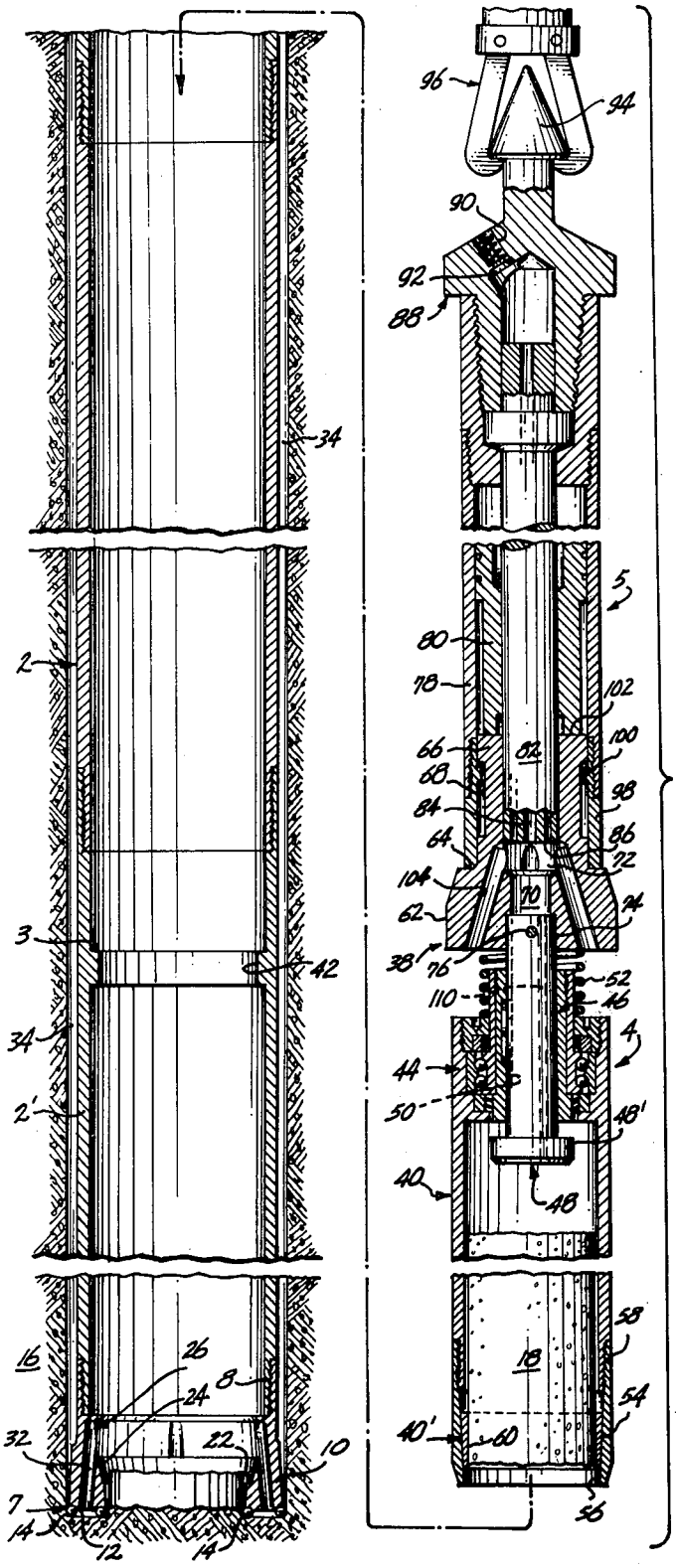

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Fig. 4.

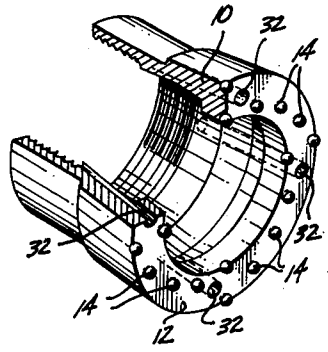

10
32
14
32
32
14
14
12
32

Fig. 5.

PROCESS OF DRILLING AN EARTH FORMATION

This is a divisional of application Ser. No. 283,208, filed Aug. 23, 1972.

THE INVENTION IN GENERAL

According to the invention, the process employs a rotary drill rod comprising an elongated pipe having a longitudinally extending bore therethrough and a percussive bit at the distal end thereof. An abutment is provided relatively transverse the bore adjacent the bit, which is operatively connected with the bit to receive and transmit hammer blows into the working face of the bit. Moreover, a piston-like member is inserted into the bore of the pipe, which is slidably engageable with the wall of the bore and has a hammer mechanism thereon. The hammer of the mechanism is reciprocated between the member and the abutment to apply blows to the abutment, while fluid is passed through the member and exhausted into the region adjacent the working face of the bit. The exhausted fluid is discharged from said region toward the proximal end of the pipe on the opposite side of the pipe from the piston-like member and a pressure differential is generated across the piston-like member longitudinally of the bore to maintain the hammer mechanism in operative relationship to the abutment during the application of the blows.

The hammer mechanism may be fluid operated and the fluid may be exhausted into the region adjacent the working face of the bit after the mechanism has operated.

The bit may have a greated diameter than the pipe, and the fluid may be discharged through an annulus which is disposed between the pipe and the wall of the excavated hole. The pipe may be rotated during the operation, and the bit may be engaged on the distal end of the pipe to rotate in conjunction therewith. Also, the fluid may be exhausted through the body of the bit, and the outer periphery of the bit may be adapted to enable the exhausted fluid to discharge thereacross into an annulus formed by the pipe and the wall of the excavated hole.

An anvil may be relatively reciprocably interposed in the bore between the hammer and the abutment to receive and transmit the blows to the abutment. The bit may be annular and the operation may further comprise providing excavation means on the distal end of the anvil adjacent the inner peripheral opening of the bit. The anvil may be engaged with the abutment and the excavation means may be interposed between the abutment and the mouth of the opening. Also the excavation means may be recessed and the recess may be interposed between the anvil and the mouth of the opening to receive earth material through the opening.

The anvil may define a passage for the fluid and the fluid may be exhausted through the anvil passage. The excavation means may define a continued passage for the fluid with the rod, and the fluid may be exhausted through the continued passage. Also the bit may define a port for the fluid through the body thereof, and the fluid may be exhausted through the port.

The anvil and the piston-like member may be retractably inserted in the bore, the anvil may be operatively connected with the piston-like member, and the member and the anvil may be conjointly retracted from the bore. The anvil also may be slidably engaged with the wall of the bore.

The proximal end portion of the bore may be fluid pressurized, and the pressure differential may be generated by causing a pressure drop across the member in the direction of the distal end of the bore.

The piston-like member may define a passage for the fluid and the passage may have a throttle valve therein which is biased to close the passage to fluid flow until a predetermined fluid pressure is achieved at the proximal end thereof. Moreover, the proximal end portion of the bore may be fluid pressurized to a pressure below said predetermined pressure, to pump the member lengthwise of the bore, and then pressurized to a pressure above said predetermined pressure to pass fluid through the member.

The hammer mechanism may be interposed between the piston-like member and the distal end of the bore in spaced relationship to the abutment and the wall of the bore.

The piston-like member may be retractably inserted in the bore and may be retracted from the bore by a wire line retriever or the like.

The bit may be annular, an anvil may be relatively reciprocably interposed in the bore between the hammer and the face of the bit to receive and transmit the blows to the bit, and the fluid may be exhausted through the anvil. The anvil may be inserted in the pipe and slidably engaged with the wall of the bore between the hammer and the bit.

The bit may be annular, the piston-like member may be retractably inserted in the bore of the pipe, and the operation may further comprise retractably inserting excavation means in the inner peripheral opening of the bit, operably connecting the piston-like member with the excavation means, and conjointly retracting the piston-like member and the excavation means from the rod adjacent the proximal end thereof. The excavation means may be recessed and a core sample may be captured in the recess thereof before the excavation means is retracted from the rod. The abutment may be disposed on the pipe and the excavation means may be inserted therethrough into the inner peripheral opening of the bit. An anvil may be operably connected with the excavation means and interposed between the piston-like member and the excavation means to receive and transmit the hammer blows into the working face of the bit.

BRIEF DESCRIPTION OF THE DRAWINGS

These features will be better understood by reference to the accompanying drawings wherein:

FIG. 1 is a part longitudinal cross-sectional view of a rotary drill rod as it is modified in accordance with the invention, and as it is seen in use for a down-the-hole core drilling operation, and with the hammer mechanism in the bottomed condition thereof;

FIG. 2 is another such view as the hammer mechanism is in the upstroke thereof;

FIG. 3 is a transverse cross-sectional view along the line 3–3 of FIG. 1;

FIG. 4 is another part longitudinal cross-sectional view when the hammer mechanism has been retracted from the drill rod; and

FIG. 5 is a part perspective view of the bit employed in the drill rod.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings, it will be seen that the drill rod comprises an elongated, fluid pressurized pipe **2**, which is assembled from equal-diameter sections that are perhaps 10′ in length and threaded and flush-coupled to one another as illustrated. With the exception of the interior of the bottommost or distal end section 2′ of the pipe, the sections are otherwise similar to one another, and are added to and subtracted from the pipe as is necessary during the drilling operation. The distal end section 2′ differs, however, in that it has a stepped or counterbored interior configuration which forms an inner peripheral shoulder **3** at a point near the top thereof. The shoulder serves as an abutment for a drive means **4**, which is retractable from the rod, as shall be explained; and which includes a standard, fluid-operated down-the-hole hammer mechanism **5**.

The pipe is pressurized and driven by a conventional drilling mechanism, such as that shown in U.S. Pat. 3,391,543, and is typically driven at slow speeds such as 10 RPM, that is, at speeds simply sufficient to index the percussion bit **7** seen at the bottom or distal end of the pipe. The bit **7** is annular in configuration, and has an interiorly threaded collar **8** at the upper end thereof, that flush-couples to the distal end section 2′ of the pipe. Below the collar, however, the bit is flared radially outwardly and forms an enlarged head **10** which terminates with a flatfaced annulus **12** at the working end thereof. The annulus has sets of button-like percussion points **14** seated in raised condition thereon, which are spaced apart in angularly spaced, clockwise, convolutional lines that are symmetrically arranged about the axis of the bit. See FIG. **5**. In addition, the endmost points **14** on each line, are seated in the head so as to project slightly inside and outside of the inner and outer peripheries of the annulus, respectively. As a consequence, when the rod is rotated and hammered into an earth formation **16**, the bit excavates an annular recess the outside diameter of which is not only greater than the outside diameter of the pipe itself, but also greater than the outside diameter of the flared head **10** of the bit. Likewise, the core **18** of earth material which is captured within the end of the rod, has an outside diameter of slightly lesser dimension than the inside diameter of the head of the bit.

Otherwise, the bit has a stepped or counterbored interior configuration forming an annular shoulder **20** inside of and about the bottom end of the collar **8**. The interior of the bit also has another annular shoulder **22** therebelow, which is of lesser inside and outside dimensions than the shoulder **20**, by virtue of there being an inwardly chamfered surface **24** at the bottom of the cylindrical socket **26** separating the two shoulders. The lower shoulder **22** and the socket **26** form a seat for a core barreling tube **40** on the drive means, as shall be explained; whereas the upper shoulder **20** has an annular groove **30** recessed therein, from which a series of symmetrically angularly spaced ports **32** open through the body of the head **10** to the working face **12** of the bit, between the points **14** thereon. The ports are also canted to the axis of the head, and are so angled into the shoulder that they open into the socket **26**.

During the drilling operation, the compressed fluid is intermittently discharged to the ports **32** to flush the removed earth material back through the clearance **34** between the pipe **2** and the wall of the excavation. The fluid reaches the ports through a series of passages **36** which are formed within the drive means and the distal end section 2′ of the pipe, as shall be explained more fully hereinafter.

The drive means **4** also includes an annular anvil **38** which is slidably engageable in the upper, thinner walled portion of the distal end section 2′, and sized to seat on the shoulder **3**. The core barreling tube **40** is slidably engageable in the bore **42** of the lower, thicker walled portion of the section 2′, and suspended from the anvil to seat relatively rotatably within the socket **26** of the bit. The tube is equipped with a bushed, ball bearing mounted swivel head **44** on the upper end thereof, and the bushing **46** of the head is slidably engaged on, but rotationally keyed to a flanged swivel pin **48**, which is fastened upright to the underside of the anvil. Moreover, the keyway **50** for the bushing, and the length of the bushing, are sized in relation to the pin, to allow for play between the tube and the anvil, axially thereof; and a coiled spring **52** is interposed about the bushing **46**, between the head and the underside of the anvil, to bias the tube in the downward direction, toward the flange **48**′ of the pin. Thus, when the drive means **4** is lowered into the bore of the pipe **2**, the tube **40** is urged to seat within the bit, both by the spring **52** and by the force of gravity; yet it is also free to undergo displacement in relation to the anvil, where there is earth material lodged within the bit. The earth material may be dislodged, however, either by the anvil, or by the fluid discharge, or by both, as shall be explained hereinafter.

In addition to being adapted to mate with the bit, the forward end portion **40**′ of the tube **40** is also adapted to "lift" or separate the core **18** from the earth formation when the drive means **4** is retracted from the bore of the pipe. The tube **40** is formed in two threaded and flush-coupled parts, the more forward **40**′ of which is chamfered at the end, so as to mate with the chamfered socket **26** of the bit, and form an essentially air tight joint therebetween. The more forward portion **40**′ also has an upwardly and outwardly tapered surface **54** formed between the cylindrical mouth **56** and the threaded collar **58** of the same; and when the two parts of the tube are assembled, a tapered wedge-like annular core lifter **60** is inserted within the more forward portion, to perform the core lifting and separating function in conventional fashion.

The outer cylindrical surface **62** of the anvil is closely machined to form a fluid seal with the bore of the pipe. Above the surface, however, the anvil is swaged inwardly and provided with a filleted shoulder **64** thereabout, from which a nipple-like shank or embossment **66** is upstanding on the axis of the anvil, and equipped with a wide circumferential groove **68** thereabout. The bore **70** of the anvil is counterbored from above and below, and the upper counterbore **72** of the same is adapted to interengage with the hammer mechansim, as shall be explained, whereas the lower counterbore **74** provides a socket for the swivel pin **48**, which is secured in the socket by means of a dowel **76**.

The hammer mechanism **5** is a modified version of a standard down-the-hole air hammer mechanism, comprising an outer tubular casing **78** having a pipe hammer **80** reciprocably engaged about a stationary control rod **82** therein. The control rod **82** is ported and infrastructured to enable the compressed fluid to reciprocate the hammer in known manner, and alternately to exhaust through porting **84** in the distal end **86** of the control rod. The fluid enters the control rod through a port or ports **90** in a spear-headed, piston-like cap **88** which is threaded onto the upper end of the casing and adapted to slidably engage with the wall of the bore of the pipe **2**, as illustrated. The ports **90** are equipped with spring-loaded throttle valves **92** that operate to produce a pressure drop between the upper and lower sides of the drive means, so that the fluid can assist in seating the anvil on the shoulder **3** of the pipe.

The anvil is coupled to the hammer mechanism by telescopically engaging a threaded, two-part, inner ribbed collar **98** about the embossment **66** of the anvil **38**, and flush-coupling the collar to the distal end of the casing **78**, the inner circumferential rib **100** of the collar, meanwhile interengaging in the groove **68** of the embossment. The drive means is retracted from the rod by an overhead hoist, such as a standard wire-line retriever, the dogs **96** of which are engaged about the spearhead **94** of the cap.

During the drilling operation, the hammer **80** interfaces with the annulus **102** at the upper end of the anvil, and applies intermittent blows to the anvil, as the pipe **2** is rotated thereabout. Thus, the bit is continually advanced in the axial direction by the percussive effect of the hammer, and at the same time, is continually rotated by the pipe, so that the points **14** of the bit are reindexed with respect to the face of the excavation, each time that the hammer strikes. Moreover, due to the telescoping relationship between the tube **40** and the pipe, and the relatively reciprocable, swiveled relationship between the tube and the anvil, the tube remains substantially stationary with respect to the pipe, as the pipe is rotated and advanced into the formation.

During the drilling operation, moreover, the exhaust porting **84** in the control rod is placed in communication with the passages **36**, so as to exhaust the fluid about the bit. As seen, the distal end portion **86** of the control rod is slidably inserted in the bore **72** of the anvil; and in the bore, there is a series of symmetrically angularly spaced and outwardly slanted ports **104**, which open to the underside of the anvil, opposite the chamber **106** which is formed between the head **44** of the tube and the anvil. From there, the fluid enters a series of symmetrically angularly spaced flutes **108** in the bore **42** of the pipe, which commence below the level of the shoulder **3**, and terminate in the distal end of the pipe, to communicate with the groove **30** and the ports **32** in the bit. In the engaged and socketed condition of the tube **40**, the open sides of the flutes are closed by the main body of the tube, and the socket **26** is occupied by the forward portion **40'** thereof, so that the fluid can escape only through the ports **32**. Until the tube is socketed in the bit, however, a portion of the fluid will discharge through the axial opening of the bit, so as to assist in flushing out any accumulated debris which would otherwise prevent the tube from seating in the socket of the bit.

Moreover, in such a case, the spring **52** will be compressed by the tube to the point where the bushing **46** of the swivel head engages the face of the anvil; and thereafter, when the hammer **80** is applied to the anvil, the force of the hammer will operate on the tube only, until the piston anvil re-engages the shoulder **3** of the pipe. Thus, the operator can be assured that the tube will be properly seated before the drilling operation is begun.

In the seating process, moreover, a passage **110** through the pin **48**, assures that the tube **40** is also pressurized, so that the debris can move only in the direction outward through the clearance **34**.

Of course, as drilling progresses, more and more sections are added to the drill pipe **2**. If necessary or desired, the tube can be changed at the same time to account for wear of the inner points of the bit; or the bit can be changed; or both can be changed.

For overhead or sidewall drilling, the fluid may also be employed as a means of seating the drive means; as for example, where the drive means is run into the rod at a pressure below that at which the valves **92** open, and then the pressure is raised to open the valves and commence drilling.

Where it is desired to drill for a period without coring, a plug-like bit can be substituted for the core barreling tube, and interengaged either with the pipe or with the annular bit, to rotate conjointly with the same.

I claim:

1. In the process of drilling an earth formation using a rotary drill rod comprising an elongated pipe having a longitudinally extending bore therethrough and percusive bit at the distal end thereof, the steps of providing relatively transverse the bore adjacent the bit an abutment which is operatively connected with the bit to receive and transmit hammer blows into the working face of the bit, inserting into the bore of the pipe, a piston-like member which is slidably engagable with the wall of the bore and has a hammer mechanism thereon, reciprocating the hammer of the mechanism between the member and the abutment to apply blows to the abutment, while passing fluid through the member and exhausting the fluid into the region adjacent the working face of the bit, discharging the exhausted fluid from said region toward the proximal end of the pipe on the opposite side of the pipe from the piston-like member and generating a pressure differential across the piston-like member longitudinally of the bore to maintain the hammer mechanism in operative relationship to the abutment during the application of the blows.

2. The drilling operation according to claim **1** wherein the hammer mechanism is fluid operated and the fluid is exhausted into the region adjacent the working face of the bit after the mechanism has operated.

3. The drilling operation according to claim **1** wherein the bit has a greater diameter than the pipe, and the fluid is discharged through an annulus which is disposed between the pipe and the wall of the excavated hole.

4. The drilling operation according to claim **3** wherein the pipe is rotated during the operation, and the bit is engaged on the distal end of the pipe to rotate in conjuction therewith.

5. The drilling operation according to claim **3**

wherein the fluid is exhausted through the body of the bit, and the outer periphery of the bit is adapted to enable the exhausted fluid to discharge thereacross into an annulus formed by the pipe and the wall of the excavated hole.

6. The drilling operation according to claim **1** wherein an anvil is relatively reciprocably interposed in the bore between the hammer and the abutment to receive and transmit the blows to the abutment.

7. The drilling operation according to claim **6** wherein the bit is annular and the operation further comprises providing excavation means on the distal end of the anvil adjacent the inner peripheral opening of the bit.

8. The drilling operation according to claim **7** wherein the anvil is engaged with the abutment and the excavation means is interposed between the abutment and the mouth of the opening.

9. The drilling operation according to claim **7** wherein the excavation means is recessed and the recess is interposed between the anvil and the mouth of the opening to receive earth material through the opening.

10. The drilling operation according to claim **7** wherein the anvil defines a passage for the fluid and the fluid is exhausted through the anvil passage.

11. The drilling operation according to claim **10** wherein the excavation means defines a continued passage for the fluid with the rod, and the fluid is exhausted through the continued passage.

12. The drilling operation according to claim **11** wherein the bit defines a port for the fluid through the body thereof, and the fluid is exhausted through the port.

13. The drilling operation according to claim **6** wherein the anvil and the piston-like member are retractably inserted in the bore, the anvil is operably connected with the piston-like member, and the member and the anvil are conjointly retracted from the bore.

14. The drilling operation according to claim **13** wherein the anvil is also slidably engaged with the wall of the bore.

15. The drilling operation according to claim **1** wherein the proximal end portion of the bore is fluid pressurized, and the pressure differential is generated by causing a pressure drop across the member in the direction of the distal end of the bore.

16. The drilling operation according to claim **1** wherein the piston-like member defines a passage for the fluid and the passage has a throttle valve therein which is biased to close the passage to fluid flow until a predetermined fluid pressure is achieved at the proximal end thereof, and wherein the proximal end portion of the bore is fluid pressurized to a pressure below said predetermined pressure, to pump the member lengthwise of the bore, and then pressurized to a pressure above said predetermined pressure to pass fluid through the member.

17. The drilling operation according to claim **1** wherein the hammer mechanism is interposed between the piston-like member and the distal end of the bore in spaced relationship to the abutment and the wall of the bore.

18. The drilling operation according to claim **1** wherein the piston-like member is retractably inserted in the bore and is retracted from the bore by a wire line retriever or the like.

19. The drilling operation according to claim **1** wherein the bit is annular, an anvil is relatively reciprocably interposed in the bore between the hammer and the face of the bit to receive and transmit the blows to the bit, and the fluid is exhausted through the anvil.

20. The drilling operation according to claim **19** wherein the anvil is inserted in the pipe and slidably engaged with the wall of the bore between the hammer and the bit.

21. The drilling operation according to claim **1** wherein the bit is annular and the piston-like member is retractably inserted in the bore of the pipe, and wherein the operation further comprises retractably inserting excavation means in the inner peripheral opening of the bit, operably connecting the piston-like member with the excavation means, and conjointly retracting the piston-like member and the excavation means from the rod adjacent the proximal end thereof.

22. The drilling operation according to claim **21** wherein the excavation means is recessed and a core sample is captured in the recess thereof before the excavation means is retracted from the rod.

23. The drilling operation according to claim **21** wherein the abutment is disposed on the pipe and the excavation means is inserted therethrough into the inner peripheral opening of the bit.

24. The drilling operation according to claim **21** wherein an anvil is operably connected with the excavation means and interposed between the piston-like member and the excavation means to receive and transmit the hammer blows into the working face of the bit.

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