ABSTRACT

A method and apparatus for impact drilling and casing a large diameter borehole is described utilizing a drill pipe having an outside diameter smaller than the diameter of the borehole. The apparatus includes a double walled drill pipe with an annular bit having a diameter at its radial cutting edge equal to the diameter of the borehole, an anvil cap assembly at the upper end of the drill pipe and a casing having an outside diameter equal to the diameter of the borehole mounted over the drill pipe and drill bit and coaxially therewith. While the anvil is subjected to impact energy, compressed air at relatively low pressure is passed down the annular passage of the drill pipe, through passages in the bit and into the axial bore of the bit while water at relatively high pressure is passed between the drill pipe and casing. The water passes into the axial bore of the bit through spaces between the bit teeth and passes upwards through the central passage of the drill pipe together with the compressed air and borehole fragment.

7 Claims, 2 Drawing Figures
1 METHOD AND APPARATUS FOR DRILLING AND CASING A LARGE DIAMETER BOREHOLE

This invention relates to the impact drilling of overburden and the recovery of overburden fragments therefrom. More particularly, it relates to an improved method of drilling and recovering overburden fragments from a borehole having a relatively large diameter.

Various impact drilling apparatus utilizing fluid for the removal of fragments are known in the art. For example, an apparatus using a double walled drill pipe wherein fluid such as compressed air is driven down the annular passage between the double walled drill pipe and then into the path of the fragments via passages in the teeth of the drill bit to assist in removing such fragments upwardly through the inner core of the drill pipe is described in U.S. Pat. No. 3,280,925 of N.D. Becker et al. This apparatus provides a desirable method for removing fragments in normal operations through overburden. In the case where a relatively large diameter hole is required to be drilled it has now been found that greater efficiency is obtained with the method and apparatus described below.

In the method and apparatus to be described, an impact apparatus including a double walled drill pipe useful for drilling small diameter holes can be easily adapted for producing relatively large diameter holes by casing the hole and discharging water at high pressure between the casing and the drill pipe to assist in the removal of the fragments. The new method also permits casing of the borehole simultaneously with drilling operations. The casing also prevents the walls of the borehole from collapsing during drilling operations. It must be understood, however, that a drill bit having a diameter large enough to drill the desired size of the hole is required.

It is therefore an object of this invention to provide a novel method of drilling and simultaneously casing a relatively large diameter hole in overburden.

It is another object of this invention to provide an apparatus for drilling and simultaneously casing a relatively large diameter borehole in overburden.

These objects are obtained by an improvement in a method of impact drilling and casing a large diameter borehole in overburden comprising: subjecting an annular bit body secured at the lower end of a double walled drill pipe consisting of an inner and an outer pipe in axial alignment with an annular passage therebetween and a central passage in said inner pipe to a steady axially directed force while transmitting impact energy to said body by a series of blows at a rate in excess of 500 foot pounds per blow per inch of borehole diameter on an annular cap mounted at the upper end of the drill pipe, said annular bit body having radial cutting teeth and an axial bore communicating with the central passage in the drill pipe, passages in said teeth communicating with the annular passage of the double walled drill pipe, and opening into said axial bore; passing fluid down the annular passage of the double walled drill pipe and the passages in the teeth into said axial bore and then passing said fluid and overburden fragments upwardly through the axial bore of the bit body and central passage of the drill pipe; the improvement comprising:

a. casing the borehole from the upper end of the borehole to a point immediately above the cutting teeth of said bit body with a casing having an outside diameter equal to the diameter of said borehole and sealing the upper end of the borehole between the casing and the double walled drill pipe,
b. passing liquid at relatively high pressure downwardly between the casing and the double walled drill pipe,
c. continuing the passage of liquid at relatively high pressure between the cutting teeth and into the axial bore of the bit body,
d. continuing the passage of fluid at relatively low pressure down the annular passage of the double walled drill pipe, the passages in the teeth and into the axial bore adjacent the said teeth,
e. passing the fluid and liquid upwardly through the axial bore and central passage of the drill pipe thereby assisting the removal of overburden fragments upwardly through said axial bore and central passage, and
f. subsequently withdrawing the double walled drill pipe and bit body from the borehole. These objects are also obtained by means of an apparatus comprising:

a. a double walled drill pipe having an outer diameter smaller than the diameter of the resulting borehole and capable of sustaining repeated axial blows of impact energy in excess of 500 foot pounds per inch of borehole diameter, said drill pipe consisting of an outer pipe with an inner pipe coaxially fitted therein and an annular passage therebetween and a central passage through said inner pipe,
b. an annular bit secured to the lower end of the drill pipe having radial cutting teeth and an axial bore communicating with the central passage in the drill pipe, fluid passages in said teeth in communication with the annular passage of the drill pipe and opening into said axial bore, said annular bit having a diameter at the cutting edge of said radial cutting teeth substantially equivalent to the diameter of said borehole;
c. a casing having an outside diameter equal to the diameter of said borehole and coaxially mounted over the drill pipe and drill bit from at least the upper end of said borehole to a point immediately above the cutting teeth of the bit;
d. an annular cap assembly mounted at the upper end of the drill pipe and casing, said assembly including an annular for receiving impact energy and transmitting said energy to the drill pipe drill bit and casing, means for introducing fluid down the annular passage of the drill pipe, means for discharging the effluent of the central passage of the drill pipe from the apparatus and means for introducing liquid at a pressure greater than the pressure of the fluid in the drill pipe down the space between the drill pipe and the casing;
e. a fluid tight seal between the annular cap assembly and casing and a second fluid tight seal between said assembly and drill pipe whereby fluid introduced down the annular passage of the drill pipe is discharged into the axial bore of the bit via fluid passages in said cutting teeth and liquid introduced down the space between the drill pipe and casing is discharged between the drill bit and the casing in an area immediately adjacent the teeth;
f. a fluid tight seal between the means for discharging the effluent of the said central passage and the inner pipe whereby fluid in said axial bore, liquid from the space between the drill pipe and casing and borehole fragments from said borehole may be passed upwardly through said axial bore and central passage and discharged as effluent from the apparatus.

In the drawings:

FIG. 1 is a partially schematic illustration of an axial section of the apparatus of the present invention positioned in a borehole; and

FIG. 2 is a partial cross-section of a portion of the annul cap assembly shown in FIG. 1.

The apparatus includes a double walled drill pipe 1 having an outer pipe 2 and an inner pipe 3 in axial alignment and defining an annular passage 4 therewith. An annular drill bit 5 having an axial bore 6 and depending teeth 7 is threadedly secured onto a male threaded connector welded at the lower end of the drill pipe 1. Passages 8 in the upper end of bit 5 are aligned with passages 4 of the drill pipe when the bit is threaded into position whereby fluid discharging down passage 4 of drill pipe 1 is discharged through passages 8 into drill bit chamber 9. Passages 10 in the lower portion of the drill bit communicate with chamber 9 and open into axial bore 6 in an area 11 immediately above the cutting edge of depending teeth 7 and below the marginal circumferential edge portion 12 of the body of drill bit 5.
3. The drill pipe and bit is shown positioned in a bed of overburden the upper layer of which is illustrated at 13. An anvil cap assembly 14 is shown at the upper end of the drill pipe for receiving impact from a reciprocating hammer (not shown).

The anvil cap assembly is mounted above drill pipe 1 and includes an anvil 15 mounted above a cylindrical cap 16 and a discharge passage 17 positioned in cap 16 defined at a discharge pipe 18 communicating with the central passage 20 of the drill pipe and having means for discharging the effluent from discharge pipe 18 to a sample collector (not shown) such as a cyclone separator. A reinforced area 18c on discharge pipe 18 is desirable in order to reinforce the outer bend of the pipe. This area is subjected to considerable abrasion from the borehole fragments in the effluent. The effluent includes borehole fragments passing upwardly through central passage 20 in a manner to be explained below. An elongated boss 19 which is secured to the lower end of discharge pipe 18 provides passage between the central passage 20 of drill pipe 1 and discharge passage 17. Elongated boss 19 is welded to cylindrical cap 16 at position 21. Anvil cap assembly 14 also includes a fluid chamber 22 inside cylindrical cap 16 and a fluid inlets 23 in cap 16 for delivering fluid such as air from a fluid supply source (not shown) into chamber 22. Heavy steel plate 24 is secured around the cylindrical cap 16 by welding and forms part of the anvil cap assembly. The assembly is positioned on female threaded box coupling 25 which is welded to the upper end of drill pipe 1. Box coupling 25 has a central bore and outer walls connected respectively to inner pipe 3 and outer pipe 2 with a fluid passage 26 communicating with annular passage 4 of the drill pipe. As can be seen more clearly in FIG. 2, the upper end of the box coupling is positioned in recess 27 formed between cap 16 and box 19 so that shoulder 28 formed by boss 19 at the upper end of the recess bears against the face of box coupling 25. Boss 19 is not threaded but is welded firmly in place by means of O-rings 29 and 30. Fluid passages 31 in boss 19 co-operate with fluid passage 26 in box coupling 25 when the anvil assembly is mounted in position whereby fluid such as compressed air entering chamber 22 from fluid inlet means 23 may be discharged into annular passage 4 of the drill pipe via fluid passage 26 and 31. Steel plate 24 is welded around cylindrical cap 16 so that grooves 32 in its outer edge rests on the upper edge of casing 33. A high pressure inlet 34 is positioned on plate 24 for discharging a high pressure fluid such as water into the annular space 35 between the casing and the drill pipe in the manner to be described below. Gussets 36 are positioned on plate 24 for purpose of reinforcement.

This invention also comprises an annular area 35 between the bit and the inner pipe 37 and having a conical inner wall 37 and axial bore 6 which communicates with the central passage 20 of the drill pipe. Gussets 42 are positioned in the drill bit chamber 9 to provide reinforcement in the bit against the force of impact.

The apparatus described up to this point is similar in some respects to the one described in my U.S. Pat. No. 3,280,925. In addition to the above mentioned elements of the apparatus, the double walled drill pipe 1 is centered in a casing 33 having a casing shoe affixed at the lower end, such that the lower cutting edge of the shoe 38 is just above the lower edges of the teeth 7 on bit 5. The top end of casing 33 has butts against grooves 32 in heavy steel plate 24, which is integral with the anvil cap 16. The impact of hammer blows on anvil 15 is simultaneously transmitted to drill pipe 1 and the casing 33 in such a manner that they are driven as an assembly by the impact into the borehole formation.

Water under relatively high pressure is introduced via high pressure water inlet 34 down the annular space 35 between drill pipe 1 and casing 33. A seal 39 between the two is provided to equalize the pressure difference that forces the fluid and water upwardly. Since the combination of fluid plus liquid assists in removing the fragments it enables the drill operator to obtain greater efficiency than would be obtained if fluid alone were used.

When a length of drill pipe and casing has been impacted into the ground a further length can be added in order to continue the drilling of the borehole. The water and fluid supply is shut off. The anvil cap assembly 14 is raised from its position on the drill pipe and casing. The complete assembly consisting of cylindrical cap 16, discharge pipe 18 with elongated boss 19 and plate 24 is easily lifted off as a unit. A further length of double walled drill pipe is mounted axially above drill pipe 1 having a male connector welded at its lower end in a manner shown at the lower end of drill pipe 1 for connecting the drill pipe to the female threaded connection at the upper end of drill bit 5. This further length of drill pipe is threaded by means of its male connector into box connector 25 of drill pipe 1. The upper end of the further length of drill pipe has a box connector similar to connector 25 for receiving elongated bosses.

A further length of casing is fitted onto the upper end of casing 33 and welded thereto. Casing lengths having threaded ends for connecting the lengths together may also be used and would have the added advantage of easy removal when the casing is eventually pulled back up the drill hole. The casing lengths must be so predetermined that the upper end of each casing length extends slightly above the upper end of the further length of drill pipe so that when the anvil cap assembly 14 is mounted in position an adequate seal is obtained between the cap 16 and the drill pipe as well as between plate 24 and the upper end of the casing.

A box cap assembly 14 is lowered into position on the further length of drill pipe and casing. The box connector welded to the upper end of the drill pipe is positioned in recess 27 so that shoulder 28 formed by boss 19 in recess 27 rests on the upper end of the box connector and a proper seal is obtained by means of O-rings 29 and 30. The upper end of the new length of casing abuts grooves 32 in plate 24 and a liquid seal 39 provided.

An apparatus as described above was used to drill a 19 inch diameter hole in granular soil consisting of consolidated and unconsolidated gravel. The apparatus included a drill pipe consisting of an inner and an outer pipe each of 'Inch steel. The outside diameter of the outer pipe was 9 inches and the inside diameter of the inner pipe was 6 inches leaving a 2 inch
annular passage therebetween. A casing of 1 inch steel plate having an outside diameter of 19 inches was used. Using air at a pressure of approximately 100 lbs per sq. inch down the an-
nular passage of the drill pipe and water at a pressure of ap-
proximately 400 lbs per sq. inch down the annular space be-
tween the drill pipe and the casing the 19 inch diameter hole was bored to a depth of 250 feet in approximately 40 hours.

I claim:
1. In a method of impact drilling and casing a large diameter borehole in overburden comprising: subjecting an annular bit body secured to the lower end of a double walled drill pipe consisting of an inner and an outer pipe in axial alignment with an annular passage therebetween and a central passage in said inner pipe to a steady axially directed force while transmitting impact energy to said bit body by a series of blows at a rate in excess of 500 foot pounds per blow per inch of borehole diameter on an anvil cap mounted at the upper end of the drill pipe, said annular bit body having radial cutting teeth and an axial bore communicating with the central passage in the drill pipe, passages in said teeth communicating with the annular passage of the double walled drill pipe, and opening into said axial bore; passing fluid down the annular passage of the dou-
bble walled drill pipe and the passages in the teeth into said axial bore and then passing said fluid and overburden frag-
ments upwards through the axial bore of the bit body and central passage of the drill pipe; the improvement comprising:
a. casing the borehole from the upper end of the borehole to a point immediately above the cutting teeth of said bit body with a casing having an outside diameter equal to the diameter of said borehole and sealing the upper end of the borehole between the casing and the double walled drill pipe,
b. passing liquid at relatively high pressure downwardly be-
tween the casing and the double walled drill pipe,
c. continuing the passage of liquid at relatively high pressure between the cutting teeth and into the axial bore of the bit body,
d. continuing the passage of fluid at relatively low pressure down the annular passage of the double walled drill pipe, the passages in the teeth and into the axial bore adjacent the said teeth,
e. passing the fluid and liquid upwardly through the axial bore and central passage of the drill pipe thereby assisting the removal of overburden fragments upwardly through said axial bore and central passage, and
f. subsequently withdrawing the double walled drill pipe and bit body from the borehole.
2. A method as claimed in claim 1 wherein said fluid is com-
pressed air and said liquid is water.
3. A method as claimed in claim 2 wherein said fluid is passed down the annular passage of the drill pipe at a pressure of from 50 pounds to 200 pounds per square inch and said liquid is passed downwardly between the casing and the drill pipe at a pressure of from 300 pounds to 600 pounds per square inch.
4. The method as claimed in claim 2 wherein said air is passed down the annular passage of the drill pipe at a pressure of approx-
imately 100 pounds per square inch and said water is passed downwardly between the casing and the drill pipe at a pressure of approximately 400 pounds per square inch.
5. An apparatus for impact drilling and casing a large diameter borehole in overburden comprising:
a. a double walled drill pipe having an outer diameter smaller than the diameter of the resulting borehole and capable of sustaining repeated axial blows of impact ener-
gy in excess of 500 foot pounds per inch of borehole diameter, said drill pipe consisting of an outer pipe with an inner pipe coaxially fitted therein and an annular passage therebetween and a central passage through said inner pipe,
b. an annular bit secured to the lower end of the drill pipe having radial cutting teeth and an axial bore communicat-
ing with the central passage in the drill pipe, fluid passages in said teeth in communication with the annular passage of the drill pipe and opening into said axial bore, said annular bit having a diameter at the cutting edge of said radial cutting teeth substantially equivalent to the diameter of said borehole;
c. a casing having an outside diameter equal to the diameter of said borehole and coaxially mounted over the drill pipe and drill bit from at least the upper end of said borehole to a point immediately above the cutting teeth of the bit;
d. an anvil cap assembly mounted at the upper end of the drill pipe and casing, said assembly including an anvil for receiving impact energy and transmitting said energy to the drill pipe drill bit and casing, means for introducing fluid down the annular passage of the drill pipe, means for discharging the effluent of the central passage of the drill pipe from the apparatus and means for introducing liquid at a pressure greater than the pressure of the fluid in the drill pipe down the space between the drill pipe and the casing;
e. a fluid tight seal between the anvil cap assembly and cas-
ing and a second fluid tight seal between said assembly and drill pipe whereby fluid introduced down the annular passage of the drill pipe is discharged into the axial bore of the bit via fluid passages in said cutting teeth and liquid introduced down the space between the drill pipe and casing is discharged between the casing and the casing in an area immediately adjacent the teeth;
f. a fluid tight seal between the means for discharging the ef-
fluent of the said central passage and the inner pipe whereby fluid in said axial bore, liquid from the space between the drill pipe and casing and borehole fragments from said borehole may be passed upwardly through said axial bore and central passage and discharged as effluent from the apparatus.
6. An apparatus as claimed in claim 5 wherein said annular bit has a conic inner wall defining the axial bore of the bit and wherein spaces between said teeth define passages for said liquid from the space between the drill bit and casing im-
mediately above the teeth is passed into the axial bore of the bit.
7. An apparatus as claimed in claim 6 wherein said anvil cap assembly comprises an anvil cap for mounting on the upper end of the drill pipe and having an anvil at its upper end, a fluid chamber in said cap, a fluid inlet means on said cap for introducing fluid into the fluid chamber, a discharge pipe in said chamber having an elongated boss at its lower end and secured to the inner wall of said cap for connecting the discharge pipe to the central passage of a drill pipe when said cap is mounted on said drill pipe, the upper end of the discharge pipe communicating with the exterior of said cap, passages in the elongated boss communicating with the fluid chamber of said cap and adapted for discharging fluid from said chamber to the annular passage of said drill pipe when said cap is mounted thereon, a plate secured transversely around said cap for mounting on said casing when said cap is mounted on said drill pipe and the cap means on said plate for introducing liquid down the space between said shaft and drill pipe and casing.