DIAMOND DRILL ASSEMBLY WITH BORE HOLE SUPPORT

Inventor: Choiseul J. J. Dela Gorgendiere, North Bay, Ontario, Canada

Assignee: Wheel Trueing Tool Co. of Canada, Ltd.

Filed: Dec. 22, 1970

Appl. No.: 100,759

U.S. Cl. 175/325, 175/215

Int. Cl. E21b 17/00

Field of Search 175/60, 215, 325, 323, 330, 175/244, 249, 255, 69, 70

References Cited

UNITED STATES PATENTS

3,518,398 5/1967 Owen 175/323
3,322,217 5/1967 Cook 175/323
3,155,179 11/1964 Hunt et al. 175/215
3,208,539 9/1965 Henderson 175/215
3,323,604 6/1967 Henderson 175/244


Primary Examiner—David H. Brown
Attorney—Stevens, Davis, Miller & Mosher

ABSTRACT

A diamond drill string assembly which drills a much straighter hole than heretofore and in a small size has a sleeve adjacent the drill bit which is so close to the size of the reamed hole that it is substantially supported by it. Instead of allowing the cooling and material removal fluid return to be over the outside it is between the sleeve and another member, intermediate the sleeve and the core tube, which is a shell member convoluted to provide the passageways; and the sleeve rotates in a high shear paste in the microannulus between it and the bore hole. To reduce whip still further a stabilizer sleeve is also provided above the sleeve in the string; the return flow for this stabilizer sleeve is in helical grooves along the surface. The ports allowing transfer of the flow from inside the sleeve to outside also function as wrench engagements to facilitate dismantling.

10 Claims, 4 Drawing Figures
DIAMOND DRILL ASSEMBLY WITH BORE HOLE SUPPORT

This invention relates to the drilling of bore holes. More specifically, it relates to the particular problem of drilling straight holes.

In drilling, a long unresolved problem is that of keeping the hole straight. Such holes in diamond drilling may be as little as 2 inches diameter (or somewhat less) and a steel shaft of this diameter—even if solid—is easily deflected as the hole may be made up over a thousand feet deep. A small deviation in, say 100 feet becomes much larger at 1,000 feet and, of course, each progressive 100 feet may bring further deviation. The change of direction may be as much as 5° to 10° per 100 feet. As is well known this reduces to a minimum when the drill bit enters hard strata normally; that is at right angles. Expressed alternatively, a drill bit has a tendency to change direction by digging itself into hard bedding planes so as to achieve eventually a normal intersection; that is one at right angles. Of course, rock strata do not necessarily run horizontally and indeed the direction in which they run is not known and therefore the direction which the hole will take cannot easily be predicted. This deviation is particularly bad when drilling alternate hard and soft formation, as is also well known.

Theoretically an obvious solution is to support the drill bit for a short length immediately rearwardly of the drill, as illustrated in U.S. Pat. No. 1,172,139. In practice this is not done as may be seen in any sales pamphlet. The drill string is always some 0.070 foot on the diameter less than the diameter over the diamonds, so that the water returns by flowing through the 0.035 inch wide annulus between the outside diameter of the drill string and the bore hole. The reason is that, when adjacent the drill, spiral return grooves do not work as some particles and water escape and score and wear the diameter between the grooves rapidly so that support for the drill bit is lost after a few feet have been drilled.

As a practical method in the field the solution to the problems mentioned are partly obtained by what is called controlled drilling; this is a technique developed through long experience and requires the operator to deduce the type of material actually being bored at any instant and the change from one to another as they occur. This is done through monitoring of water pressure and adjusting the rate of travel (or “feed”) of the bit and the pressure on the bit. That is to say, the drill string weight does not fall on the bit as the depth of the hole increases. Typical loading for average strata (neither granite rock nor soft shale) is 1,200 psi and the known control techniques, of course, reduce the pressure when penetrating soft strata although the feed is usually increased. These methods are, of course, expensive as operators must be highly skilled and depth drilled per bit is limited to about 20 feet per bit since otherwise the diamonds become polished and therefore, they do not cut so well. This leads to higher bit pressure and masks information. However, even the most expensive holes leave much to be desired in the way of straightness.

These problems are particularly aggravated when drilling small holes for core samples. It goes without saying that economics favor drilling small holes in order to obtain samples but, of course, a long shaft is much more flexible and liable to deviation in, say, a 2 inch diameter than say a 4 inch diameter.

It is, therefore, an object of this invention to provide a drill which will make holes much straighter than heretofore. It is also an object to provide a new and improved water flow apparatus in such a drilling device, and particularly for the smaller sizes.

The invention may best be understood by reference to the drawings which illustrate a typical prior art device together with a drill bit which overcomes the disadvantages of the prior art.

FIG. 1 shows a prior art drilling device adapted from a typical sales leaflet and shows general construction by a part elevation past section view and includes arrows showing liquid flow patterns.

FIG. 2 shows corresponding views of a drilling device which overcomes the disadvantage of the prior art device and again shows the cooling liquid flow pattern;

FIG. 3 shows a cross section illustrating in detail the assembly of a convoluted shell, core and sleeve to clarify how the flow between sleeve and core in FIG. 2 occurs; it is somewhat enlarged over the dimensions of FIG. 2.

FIG. 4 is a perspective view, partially broken away, of the drilling device of the present invention.

FIG. 1 needs little explanation. The cooling liquid flows down the inside of the drill string in the inner annulus between the outside diameter 2 of the core lifter 4 and the core lifter casing 5 and the inside diameter 6 of the drill shank 8 and washes away the debris formed by the drill bit 10 and returns to the drill head by way of the annulus between the outside diameter 12 of the drill shank 8 and the surrounding rock 14. This annulus is usually of the order of 0.035 radial width as mentioned above, and typical water flow is 3 to 5 gallons per minute. Pressure to achieve this flow fluctuates depending upon the material of the strata being bored.

There is thus an unsupported length which, bearing in mind the additional factors of heat, vibration, inhomogeneity of the material being drilled leads to the typical deviation conditions of holes of between 5° to 10° per 100 feet for alternate hard and soft layered strata.

By contrast FIG. 2 illustrates that the support is achieved adjacent the drill and that the flow pattern has now been changed, both “go” and “return” flows being within the outer sleeve of the assembly. This outer sleeve 16 is to all intents and purposes, supported by the rock formation which has just been drilled. It will, of course, be understood by those skilled in the art that there is what might be termed a micro-annulus between the outside diameter 18 of this sleeve 16 and the rock formation 14 being drilled. This micro-annulus is of the order of 0.002 inches radial thickness in hard rock formation and is, in practice, (I believe) filled with a stiff paste of small particles into which water is attracted by capillary action. Thus, the hollow shank 8 of the prior art has been replaced by a sleeve 16 in bearing contact with the hole face and a shell body 20.

The water for cooling the bit and for removing the cuttings flows downwardly through four channels 22 broached in the shell body 20. These channels are spaced around the core lifting device 4 as opposed to the previous flow axially along the inner annulus and
3,712,392

may best be seen in the cross section of FIG. 3. However, they are also indicated on FIG. 2 by the space between the dotted line in the section of item 20 and the outer diameter 2 of the core lifting device 4.

After contacting the diamond bit 10, from inside, the water flows round the end when boring is taking place back round the outside of the diamond bit to the reaming ring 24. This reaming ring 24 has four longitudinal grooves 26 in it; these are partly shown in the elevation and indicated again by a dotted line in the section. It is silver soldered to shell body 20.

To give an illustration of how little space is available, the core diameter (which must be as large as possible for assay purposes) in one size is 1 1/16 inches and the bored hole is 1 57/64. The core lifting device has an outside diameter of 1 9/32 which is just cleared by the shell inner land diameter 28 of 1.312 to 1.310 inches.

The bit gauge itself is 1.870 to 1.880 inches diameter but, of course, it does not cut accurately to size; that is, the hole is larger in some formations than the drill. Moreover, the size of the bit will change and does not hold gauge properly. The reaming ring on the other hand cuts accurately particularly in hard rock providing it is kept sharp since it removes only a small amount of material. I prefer to use a reaming ring in which the diamonds are set oversize and lapped to 1.895 inches diameter to within very close limits, to provide excellent concentricity; the end face is a stop for the thread of bit 10.

Return flow back through such a reaming ring is by way of the four recesses 26 and thence into a slurry collector groove 30. This groove reduces abrasive erosion of the metal by the slurry of hard particles in water because it assists even distribution of returning liquid in the four passageways 32 formed between external channels 34, milled in the shell body 20, and the internal diameter 36 of sleeve 16. These return passageways are shown properly in the sections of both FIGS. 2 and 3; the resulting convoluted cross section of the shell 20 formed by adjacent broached and milled channels 22, 34 for the "go" and "return" passageways can be clearly seen in FIG. 3.

The length of the sleeve is 5 1/2 inches exclusive of the 3/4 inch long castellations 38 which mate with the driving dogs 40 of the shell 20; and in the size illustrated above the internal diameter 36 of the sleeve at 1.691 ± 0.001 inches and the outside diameter 42 of the shell 20 at 1.689 ± 0.001 inches ensure proper sealing and support of the sleeve by the outer portions of the convolutions of the shell 20 beneath. In fact, I prefer to lap these parts together to avoid ovality.

After flowing upwardly within the passageways 32 the liquid sludge leaves the sleeves by ports 44 into an annulus 46; this annulus is formed by reducing the sleeve diameter to (in the example given) 1.835 so as to give an annulus of 0.030 inches wide with the bore hole diameter of 1.895; this is actually the reaming ring diameter—the actual annulus width will be about the 0.035 inches.

Another feature of this assembly is that these passageway-to-borehole-annulus transfer ports are used as wrench engagements. It is frequently difficult to unscrew the threads to replace the bits and a pipe wrench cannot be used on sleeve 16 without destroying its function; so the transfer ports 44 assist in disassembly by providing engagements for a special wrench (not shown) in order to avoid pipe wrenches on carefully machined parts. The sleeve itself may be replaced by unscrewing the shell sleeve assembly 20, 16, 20 from the stabilizer 48 and inserting a stepped or tapered hub into the bore of the shell 20 (which at the upper end is, of course, round and does not have any channels in it) and then drawing off the sleeve by means of a screw jack acting on extensions 38 between the dogs 40 in the manner of a gear puller.

Before leaving the sleeve 16 it should be mentioned that this is made to an outside diameter of 1.893 inch to give theoretically a 0.001 inch micro-annulus with the bore wall. In point of fact I prefer to turn it to an outside diameter between 1.880 and 1.881 inches in AISI 4140 steel and then I hard chrome plate it (to minimize wear) to a depth of 0.006 inches which brings the diameter up to 1.892 and 1.893 inches.

The stabilizer 48 acts to brace the drill string end over a longer length than is practical for the sleeve 16 alone, and I attach it to the shell assembly by square threads 50 which are so terminated that sleeve 16 is trapped between one end of the stabilizer 48 and the lands of dogs 40 on the shell 20.

This stabilizer increases as shown at 52 from (to quote figures for the sizes given above) 1.835 to 1.890 inches (above the hard chrome plate) and has helical grooves 54 to allow the liquid sludge to pass round the outside of the stabilizer as it continues to flow upwardly. A small amount of it may pass over the surface but the small clearance between the bore wall and the cylindrical (of the periphery reduces vibration and whip at the drill bit. The stabilizer outside diameter continues at this diameter (1.890 inches) for 4 inches length then reduces back to 1.835 to give the usual annulus. This is not shown as it is clear to those skilled in the art.

Beneath this reduced diameter the stabilizer accommodates an internal square thread so that it can accommodate an outer tube; I prefer to make an adaptor outer tube like a standard tube 56 but 12 inches shorter so that my adaptor, stabilizer, shell and sleeve assembly can be substituted for a standard drill bit and outer tube.

A test was conducted near Webbwood, Ontario. The formation on this property was most conducive to deviation, inclined at near vertical planes with continuous hard and soft bands of diorite, diabase, quartz and impure quartzite. The following log of acid tests will serve to show bore deviation comparison:

<table>
<thead>
<tr>
<th>Hole No.</th>
<th>AW4</th>
<th>Collared at 62°</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>170°</td>
<td>5°</td>
<td>New guide sleeve started</td>
<td></td>
</tr>
<tr>
<td>250°</td>
<td>5°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>330°</td>
<td>5°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>400°</td>
<td>5°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>500°</td>
<td>5°</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sleeve

<table>
<thead>
<tr>
<th>Depth</th>
<th>Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>600°</td>
<td>50°</td>
</tr>
<tr>
<td>700°</td>
<td>41°</td>
</tr>
<tr>
<td>800°</td>
<td>40°</td>
</tr>
<tr>
<td>900°</td>
<td>28°</td>
</tr>
</tbody>
</table>

Worn

<table>
<thead>
<tr>
<th>Depth</th>
<th>Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000°</td>
<td>14°</td>
</tr>
<tr>
<td>1200°</td>
<td>9°</td>
</tr>
<tr>
<td>1400°</td>
<td>10°</td>
</tr>
<tr>
<td>1500°</td>
<td>10°</td>
</tr>
</tbody>
</table>

Hole stopped

Thus, only when the sleeve was worn was there any appreciable departure from the intended direction; at 800 feet the applicant's shell was removed and a stan-
dard shell as known in the prior art was replaced because the deviation was so small other factors were suspected of influencing the results. Such results are typical in that deviation is reduced, if a driller uses the same degree of care in drilling with both types, from 5° to 10° per 100 feet to within 1° or 2° per 100 feet of hole drill.

While there has been shown and described what is at present considered the preferred embodiment of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention as defined by the appended claims.

I claim:

1. A drill string assembly comprising, at the distal end an inner tube core lifter subassembly having a cylindrical outer surface; a drill bit subassembly, and a reaming ring; a sleeve having a substantially unbroken cylindrical outer surface having an outer diameter just smaller than the hole normally cut by the reaming ring so as to inhibit return flow of cooling fluid between the bore hole and the sleeve outside surface, the cylindrical outer surface also having such a length to diameter ratio as to assist in maintaining the direction of the drill bit;
passageway providing means cooperating with the sleeve inner periphery and the core lifter cylindrical outer surface; said passageway providing means having such a cross section as to cooperate with the sleeve inner periphery and the core lifter cylindrical outer surface so as to allow passage of fluid towards the drill bit and to allow separate return flow therefrom; and means releasably securing together the upper portion of the drill string, said sleeve, said passageway providing means and said drill bit, so that they rotate together.

2. A drill string as claimed in claim 1 and further comprising above the cylindrical sleeve and secured thereto, a stabilizer sleeve of generally cylindrical form but broken by helical grooves, the outside diameter of the cylinder being just less than that of the sleeve so as to allow fluid to return over the outside of the stabilizer by way of the grooves but to assist the sleeve in main-