

[54] DIAMOND DRILLS

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[30] Foreign Application Priority Data

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[51] Int. Cl..... E21b 17/10, E21c 9/00

[58] Field of Search 175/320, 323, 324, 325,
175/330, 332, 333, 403, 404, 408; 308/4 A,
4 B, 4 C

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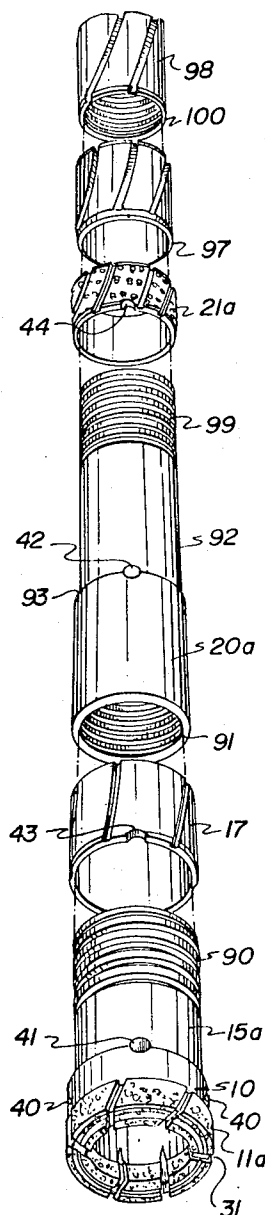
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[57] ABSTRACT

A drilling section for diamond drills consisting of a drill bit and a reamer wherein the direction of the drill hole is controlled by the provision of cylindrical surfaces behind the cutting portion of the bit and the reamer, such cylindrical surfaces having a diameter which is slightly less than that of the cutting portion and the reamer. The outer surfaces of the drill assembly including the cutting portion of the bit and the core bar may be provided with spiral grooves to assist the circulation of water.

10 Claims, 7 Drawing Figures



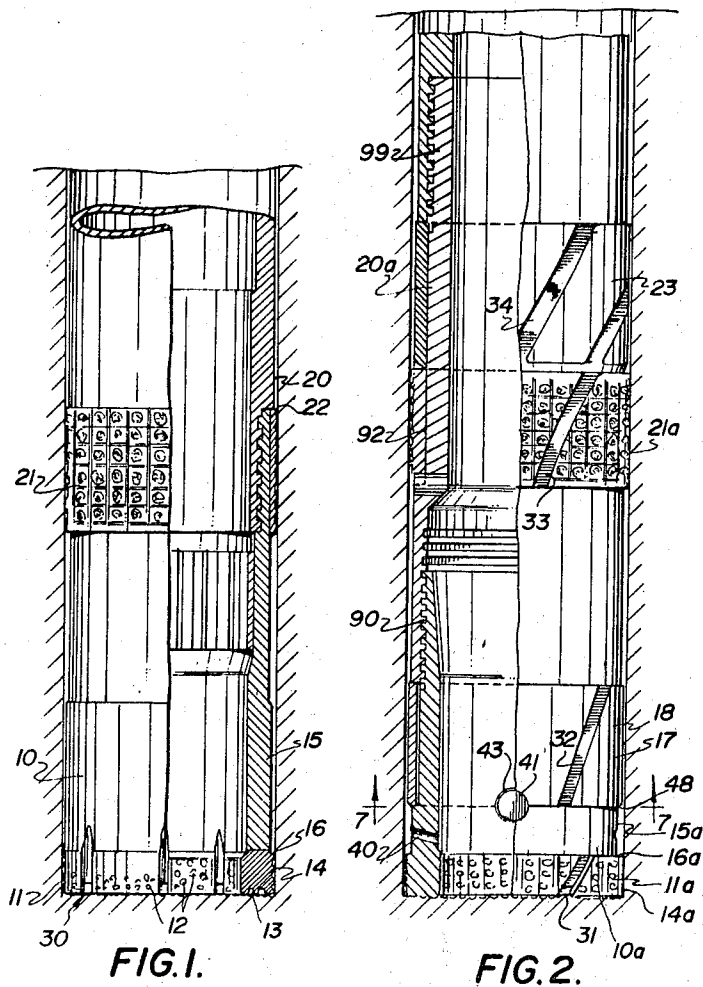


FIG. 1.

FIG. 2.

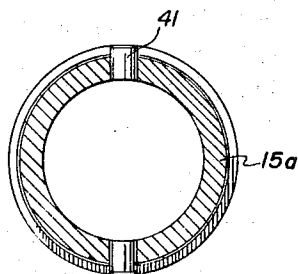


FIG. 7.

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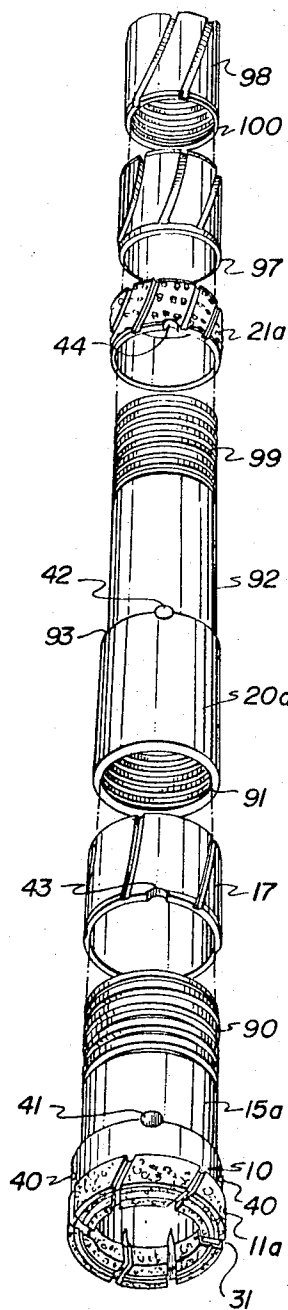


FIG. 4.

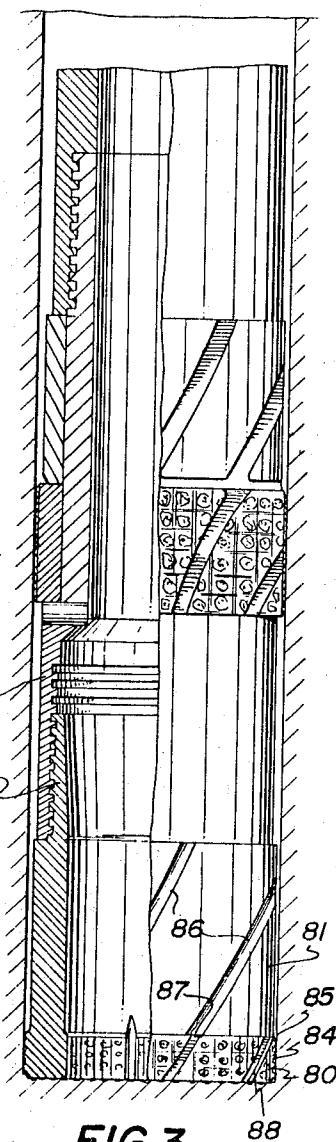


FIG. 3.

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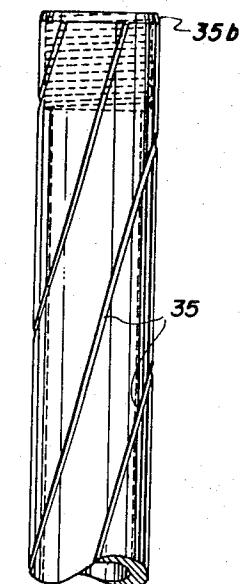
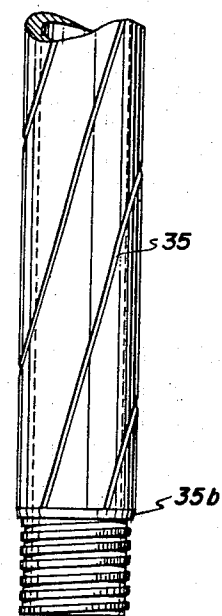


FIG. 5

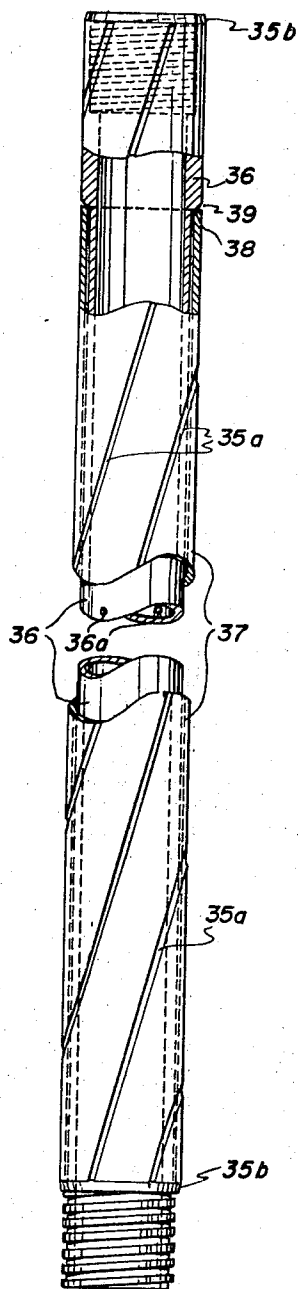


FIG. 6.

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DIAMOND DRILLS

BACKGROUND OF THE INVENTION

This invention relates to diamond drills and more particularly to an improved structure for the drilling sections of diamond drills which affords an improved control over the direction of the drill hole in the course of drilling operations.

DESCRIPTION OF THE PRIOR ART

Conventionally the drilling section of a diamond drill is screw-threadably mounted to the end of the lowest core rod of a drill string and comprises a diamond drill bit with an annular cutting portion at its head and a reaming shell with a cylindrical cutting surface spaced from the bit by a number of inches. Usually the bit is a screw-threadably mounted on the reaming sleeve, the reaming sleeve is threadably mounted at its other end in the end of the lowermost core rod. The screw-threads have an orientation which is such that the various screw-threaded attachments all tend to be tightened by the rotary motion of the drill during operation. Several varieties of drill section assembly are available and in common use, some of which have the female screw-threaded portions facing upwardly and other of which have the female screw-threaded portions facing downwardly. To allow for easy withdrawal of the drill string and reinsertion thereof as well as to provide for a reasonable wear life of the cutting portions of the drilling assembly, these cutting portions are made with an outer diameter which is larger than the diameter of the core rod and the other components of the drill assembly, thus providing an annular shoulder immediately behind the cutting surface of both the bit and the reamer. The depth of this shoulder may vary slightly from one make and quality of bit and reamer to another but generally speaking it is of the order of from about forty to about fifty one thousandths of an inch. The presence of this annular shoulder makes it possible for the cylindrical cutting surfaces of the bit and the reamer to move sideways in any direction by an amount equivalent to the depth of the annular shoulder. Where a rock formation being drilled is uniform the result is that the diameter of the hole is slightly larger than the outer diameter of the bit and the reamer. However, when the rock formation being drilled is not uniform the tendency will be for the drilling assembly to continually move in the direction of least resistance away from the axis of the drill string with the result that instead of travelling in a straight line the drilling assembly describes a curved path often ending up, in deep holes, several hundred feet away from the axis of the drill string at the surface. The foregoing problem has always been a serious one for diamond drillers and mine developers because it gives an inaccurate location for the rock formations which show up in the core recovered at the surface and can result in substantial financial losses due to shaft sinking and underground development work being carried out in the wrong location.

SUMMARY OF THE INVENTION

My invention has as its principal object the provision of a drilling section which minimizes or eliminates the tendency of the drilling section to depart from the intended drill hole axis.

According to my invention I provide a section of cylindrical surface behind the cylindrical cutting surface of the bit and behind the cylindrical cutting surface of the reamer which closely approximates the cylindrical cutting surfaces in outer diameter, leaving the drilling assembly free to move sideways no more than from about one one-thousandth of an inch, to about ten one-thousandths of an inch.

According to one embodiment of my invention these surfaces may be provided by mounting a sleeve made of wear-resistant material behind the cutting surfaces of the bit and the reamer, such sleeves having an outer diameter of from about one one-thousandth to about ten one-thousandths of an inch less than the outer diameter of the bit and the reamer. In such cases it will be convenient to have a series of such sleeves of diminishing outer diameter which are interchangeable so that as the outer diameter of the bit and the reamer is diminished by wear a sleeve of one diameter may be exchanged for one of a lesser diameter to maintain the outer diameter of the sleeve actually in use the appropriate amount less than the outer diameter of the bit and the reamer that is desired.

According to a still further embodiment of my invention the surfaces may be formed as an integral part of the bit or the reamer, the material of the portions of the bit and the reamer forming such surfaces being made of a material calculated to wear at the same rate as the cylindrical cutting surface of the bit and/or the reamer.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention and its operation will be described in greater detail with reference to the accompanying drawings wherein,

FIG. 1 is a side elevation partly in section showing a currently used conventional drilling section in operation in a drill hole.

FIG. 2 is a side elevation partly in section of a drilling section according to the invention in operation in a drill hole wherein the invention is executed by means of sleeves mounted behind the cutting surfaces of the bit and the reamer.

FIG. 3 is a side elevation partly in section of a diamond drill bit having an integrally formed cylindrical surface behind the cylindrical surfaces of the cutting portion thereof in accordance with one embodiment of the invention.

FIG. 4 is an exploded perspective view of the drill according to the invention of the kind illustrated in FIG. 2.

FIG. 5 is a side elevation of one preferred type of core bar for connection to the drill section according to the invention.

FIG. 6 is a side elevation partly in section of another preferred core bar embodying a replaceable sleeve, and

FIG. 7 is a right cross section along plane 7—7 of FIG. 2.

SUMMARY OF PREFERRED EMBODIMENTS

Referring more particularly to the drawings, in the conventional drilling section illustrated in FIG. 1, there is a bit 10 which is formed with the annular cutting portion 11, which portion has diamonds 12 embedded in it which become exposed as the material of the cutting portion 11 wears to provide an annular cutting face 13

generally perpendicular to the axis of the bit and a cylindrical cutting surface 14 coaxial with the axis of the bit. The cylindrical cutting surface 14 is of larger diameter than the shank portion 15 of the bit providing an annular shoulder 16 between the cutting portion 11 and the shank portion 15. Conventionally, when the bit is new the depth of the shoulder 16 is of the order of forty to fifty one-thousandths of an inch. As the bit operates, the cutting surfaces 13 and 14 are subject to wear, and the depth of the shoulder 16 will gradually diminish until at some stage the bit is worn out and must be replaced.

Referring now more particularly to FIGS. 2 and 4 of the drawings, (wherein like numerals indicate like parts) the drilling section according to the invention shown in FIGS. 2 and 4 differs from the conventional one shown in FIG. 1 by the presence of the sleeve 17 surrounding the shank 15a of the bit 10a presenting an outer cylindrical surface 18 of almost the same diameter as that of the cutting portion 11a of the bit.

In FIG. 1 the reaming shell 20 carries the cylindrical cutting surface 21 which has a diameter the same as that of the cutting portion 11 of the bit 10 providing a shoulder 22 behind the cylindrical cutting surface 21 which shoulder is comparable to the shoulder 16 of the bit 10.

In the drilling section illustrated in FIG. 2 the cylindrical cutting surface 21a is followed by a sleeve 23 mounted on the reaming shell 20a which has a slightly smaller outer diameter than the cutting surface 21a.

As will be seen by comparing FIGS. 1 and 2, when the diamond drill is in operation the cutting surfaces 11 and 21 of the conventional drilling section illustrated in FIG. 1 are free to cut into the side walls of the drill hole an amount corresponding to the depth of the shoulders 16 and 22. The depth of these shoulders is appreciable, particularly when the drill and reamer are new, and may be as much as forty to fifty one-thousandths of an inch. If the drill is drilling in a geological stratum where conditions are such that the cutting section is being urged continually in the same direction, as the cut progresses and the length of the drill string introduces the necessary element of flexibility, the tendency will be for the bit and reamer to move laterally towards the side of the hole to which the drilling forces urge them until further cutting action of the cutting surfaces 11 and 21 of the bit and reamer respectively is prevented by the bearing against the side of the hole of the cylindrical surface 15 of the bit shank. Under the above conditions as the drilling advances the axis of the drill bit will depart more and more from the original axis.

By comparison, in the arrangement shown in FIG. 2 under similar conditions the sideways cutting action of the cylindrical cutting surfaces 11a and 21a is limited by the difference in diameter of those cutting surfaces and the cylindrical surfaces 18 and 23 of the sleeve according to the invention which is only of the order of one to ten one-thousandths of an inch. Thus while the tendency of the cutting section to be urged away from the intended axis of the drill may remain unchanged, the amount by which the drill bit can actually be deflected laterally is only a very small fraction of the amount by which the conventional drill bit is illustrated in FIG. 1 may be deflected laterally under similar conditions.

The restraint against lateral deflection provided by the cylindrical surfaces 18 and 23 has the effect of

lengthening the radius of any curved path which drilling conditions may tend to impose upon the drilling section so that the drill must travel a much longer distance than would be the case with a conventional bit before any significant change in direction of the bit can take place.

In the conventional drill bit illustrated in FIG. 1 it will be observed that the annular cutting portion 11 is provided with a number of slots 30 extending radially and axially and giving to the cutting portion 11 a castellated configuration. The purpose of the slots 30 is to permit water to circulate from the interior of the bit to the annular space above the cutting portion 11 between the shank 15 and the side of the drill hole. Water circulation in and about the drilling section is most important since it is necessary to keep the mud produced by the cutting action of the bit in fluid condition to prevent the occurrence of a condition known as "mudding" which causes the string to become stuck in the hole, resulting in costly shut down and retrieval procedures and in some cases even loss of the hole or damage to the equipment caused by "burning" due to excess friction. In normal operation five hundred feet of drilling will produce between about one and one and one-half tons of cuttings which must be circulated out of the hole by water pumped down the string from the surface. When the pump stops however, circulation ceases and the cuttings settle very rapidly causing the bit to "mud" almost immediately.

I have found that this situation can be materially improved by forming the cutting portion of the bit with slots 31 which are inclined both radially and axially away from the direction of rotation at a pitch of approximately 15°. In the embodiment illustrated in FIGS. 2 and 4 there are six such slots equidistantly spaced about the cutting portion 11 but this number is arbitrary, other suitable numbers being 8, 10 or 12. The inclination of the slots 31 creates a pumping action when the drill is being rotated which causes water circulation to continue even if the pump stops. This pumping action is assisted by the formation in the outer surface of the sleeve 17, the reamer 21a and the sleeve 23 of the spiral grooves 32, 33 and 34 respectively, which may suitably be the same in number as the slots 31 in the cutting portion of the bit with a similar pitch of approximately 15°. The pitch of the spiral grooves can vary substantially within the range of from about 15° to about 60°. As is well known, drilling conditions vary greatly and rock formations which contain clays and talcous materials produce very different flowability conditions than rock formations having a larger primary crystal structure. For this reason, when drilling certain types of rock formation it may be found that an increased pitch in the spiral grooves will improve the circulation and a selection of any particular pitch is a matter to be determined on the basis of the skill and experience of a particular drill operator having regard to the characteristics of the particular rock formations in which he is operating. Suitably, these grooves 32, 33 and 34 may have a depth of 0.031 inch and a width of from 3/32 inch to 3/16 inch, although the actual dimensions are not critical.

A still further improvement in circulation may be achieved by the employment of a preferred form of core bar such as those illustrated in FIGS. 5 and 6.

FIG. 5 illustrates a solid walled core bar in which there are six spiral grooves 35 formed in the outer sur-

face of the bar, the bar itself being otherwise similar in all respects to a conventional core bar and being made in sections of from about two to about five feet in length.

The embodiment illustrated in FIG. 6 consists of a cylindrical body 36 formed to accommodate a sleeve 37 which rests against a shoulder 38 formed in the body 36, the shoulder being formed with the annular groove 39. The sleeve 37 is provided with six spiral grooves 35a similar to grooves 35 on the embodiment shown in FIG. 5.

The spiral grooves 35 and 35a may be six in number as illustrated or they may vary in number as may appear appropriate in any particular case. In operation they exert a pumping action on the fluid between the outer walls of the drill string and the side of the drill hole assisting circulation towards the surface. Because of the difficulty of ensuring an exact match between the ends of the grooves on successive lengths of the core bar the ends of the bars are chamfered as at 35b to a maximum depth of about 1/64 inch for a maximum length of approximately 1/4 inch, thus providing a space for circumferential flow of water and ensuring that the water flowing out of one of the spiral grooves of a lower section of core rod will be able to find its way into a spiral groove of the next higher section of core rod. Optionally, the embodiment illustrated in FIG. 6 may be provided with a pair of diametrically opposed holes 36a in the body 36 and situated substantially midway along the length of the body 36 permitting water from the interior of the bar to enter the space between the sleeve 37 and the body 36 and thus tending to keep fine dirt and grit from entering.

An additional feature of the embodiment illustrated in FIGS. 2 and 4 is the presence of two generally radial holes 40 communicating between the interior of the bit and the outside of the bit just behind the cutting section 11a. These holes 40 function to supply water from the inside of the bit to the area of the cutting surfaces particularly during start up and in incipient "mudding" conditions to prevent burning.

Also illustrated in FIGS. 2 and 4 is the use of pins 41 and 42 to prevent the sleeve 17 and the reamer 21a from rotating with respect to the shanks on which they are seated. In respect to each sleeve that is to be held by such pins, two are required which should be directly opposite to each other. The pins 41 and 42 are press fitted into holes formed in the shank. They are suitably ground flush with the inner surface of the shank on which they are mounted and extend about one-sixteenth of an inch proud of the outer surface of the shank over which the sleeve 17 is positioned. Round slots 43 and 44 are formed respectively in the leading edge of the sleeve 17 and the reamer 21a which, on assembly of the drilling section, mate with the proud portion of the pins 41 and 42 respectively. The provision of the pins 41 and 42 and the holes into which they fit makes the section on which they are located the weakest section in the whole assembly. It is desirable that the weakest section be just behind the front of the bit so that if the drill muds or burns failure will occur as close to the end of the bit as possible, leaving the core and core engaging elements which are usually contained within the reaming shell intact and capable of being withdrawn from the hole. Failures which occur higher up on the string are much more costly in terms of the time required to remedy the situation and in terms of

the possibility of having to abandon the hole being drilled.

To assemble the drilling section illustrated in FIG. 2 reference is had to FIG. 4.

In assembling the drilling section the sleeve 17 is fitted over the shank 15a of the bit 10a until it fits against the shoulder 48 and the pins 41 are home in the slots 43. The reaming shell 20a is then screw-threaded onto the screw-threaded portion 90 of the bit 10a until its annular front surface 91 snugly engages the rear annular surface of the sleeve 17. The reaming sleeve 21a may then be slid over the shank portion 92 of the reaming shell 20a until the front face of the reamer 21a engages the shoulder 93 and the pins 42 are snugly home in the slots 44. The sleeve 23 is then fitted over the shank 92 behind the reaming sleeve 21a and is caused to slide forward until its front face 97 is in snug engagement with the rear face of the reaming shell 21a. The forward end of a core rod 98 (which as illustrated in FIG. 4, is of the kind illustrated in FIG. 5) is threadably engaged with the screw-threaded portion 99 of the shank 92 and screwed home until snug engagement is achieved between the front face 100 of the core rod 98 and the rear face of the sleeve 23, whereby both the sleeve 23 and the reaming sleeve 21a are held firmly in position. The drilling section is now completely assembled and ready for use in the usual manner. If, during use, one or more parts of the drilling section need to be replaced due to wear or other causes, it is a simple matter whenever the drill has been withdrawn from the hole, to detach the bit from the reamer shell or the reamer shell from the core rod, or both, for purposes of substituting replacement parts or, where the wear gauge indicates that the outer diameter of the cutting portion 11a of the bit or that of the reaming shell 21a has been reduced sufficiently, to allow replacement of either or both of the sleeves 21a and 23 with sleeves of smaller outer diameter. For purposes of determining the reduction in outer diameter of the cutting surfaces due to wear I prefer to use a series of go no-go ring gauges calibrated at one-thousandth inch intervals, the set covering the whole range of diameters between that of a new bit and reamer shell and that of a bit and reamer shell which have reached the end of their useful life. It will be appreciated that the actual range of diameters of the gauge set will depend upon the calibre of the drill being used.

As will be seen, the cutting portion 11a has a larger diameter than the shank 15a, there being a shoulder 16a between the cylindrical cutting surface of the cutting portion 14a and the outer cylindrical surface of the shank 15a. The height of the shoulder 16a on a new bit is conventionally of the order of forty to fifty one-thousandths of an inch and its purpose is to permit adequate clearance between the shank of the bit and the core rods of the string and to provide a practical wear life for the drill bit. It will be appreciated that in use the cylindrical cutting surface 14a will gradually wear until its diameter approaches that of the outer surface 15a of the shank and that by the time the shoulder 16a entirely disappears the useful life of the bit will be over. The thickness of the sleeve 17 is such that it projects radially outwardly from the outer surface 15a of the bit shank by an amount which is just slightly less than the height of the shoulder 16a. Preferably the height of the shoulder 48 between the leading end of the sleeve 17 and the cylindrical surface 15a of the shank will be one

one-thousandth to ten one-thousandths of an inch less than the height of the shoulder 16a, depending on local conditions. The sleeve 17 is formed of hard wear-resistant metal such as tungsten steel and in practice a set of such sleeves will be available to an operator having outer diameters ranging in one one-thousandth of an inch increments from one which is one one-thousandth of an inch less than the outer diameter of a new bit to one which is one one-thousandth of an inch less than the outer diameter of a bit during the last stages of its useful life.

In operation each time the drill string is pulled to recover the core the diameter of the cutting surface 14a of the bit will be measured with a gauge and if the wear which has taken place has reduced the diameter of the cutting surface to within less than one one-thousandth of an inch of the diameter of the sleeve 17, the sleeve 17 will be replaced with a similar sleeve having the next lowest diameter. Thus, it is contemplated that throughout the drilling of a core hole the outer diameter of the sleeve 17 will be maintained at a selected value of from one one-thousandth of an inch to ten one-thousandths of an inch less than the diameter of the cutting surface 14a, the selected value being determined by local conditions. It is important that the annular end surfaces of the shell 17 be machined smooth to minimize cracking or splitting of the ring during operation.

An alternative embodiment of the invention as it pertains to a diamond drill bit is illustrated in FIG. 3 wherein instead of employing a replaceable sleeve to provide a cylindrical surface behind the cutting surface of the bit which is of comparable but slightly less diameter than the cutting surface of the bit, the drill bit itself is specially formed to provide such a surface and the wear characteristics of the metal from which the shank portion of the bit is formed is selected so that the cylindrical surface behind the cutting surfaces of the bit will wear at the same rate as the cylindrical cutting surface of the bit. Thus, as illustrated in FIG. 3, the drill bit consists of a castellated annular cutting portion 80 and the shank portion 81 with the threaded rear portion 82 adapted to connect with a reamer shell 83. In this case, however, the shank portion 81 of the drill bit is formed from material adapted to wear at the same rate as the cylindrical cutting surfaces 84 of the cutting portion 80 and the height of the shoulder 85 between the cutting portion 80 and the shank portion 81 is one one-thousandth to about ten one-thousandths of an inch. Once again the shank portion 81 is formed with spiral grooves 86, each one of which originates at its forward end in a slot 87 between the slanted castellations 88 of the cutting portion 80.

As is well known, diamonds used in diamond drilling are of different grades and accordingly the hardness of the material used for the shank 81 of the bit will be selected having regard to the grade of diamond embedded in the cutting portion 80. The higher the grade of the diamond the harder the metal selected.

The specific embodiments illustrated in FIGS. 2-7 of the drawings are used to illustrate all of the preferred refinements which may be associated to advantage with drilling sections embodying the unique direction controlling sleeve members of the invention which are situated immediately behind the cutting surface of the drill assembly. It is to be emphasized that all of these features are optional and that the sleeves or cylindrical surfaces may be employed to advantage with any con-

ventional type of diamond drill assembly, both in standard drilling equipment and in wire drilling equipment. Accordingly it is to be understood that the embodiments illustrated are for purposes of illustration only and that the invention is not limited to any such specific embodiment or otherwise than having regard to the appended claims.

What I claim as my invention is:

1. A diamond drill bit assembly comprising a diamond drill bit having an annular cutting portion at the front end thereof and a cylindrical shank extending rearwardly therefrom and having a lead portion adjoining and of a diameter less than said cutting portion and a screw-threaded trailing portion of further reduced diameter engageable with a reaming shell; and a guide sleeve formed of wear resistant material dimensioned to be received upon said trailing portion and be held thereon during operation by the forward end of said reaming shell in screw-threaded engagement with said trailing portion, retainer means in said shank co-operating with said guide sleeve to prevent rotation thereof relative to said shank, said guide sleeve having an outer diameter which is of the order of from about one one-thousandth of an inch to about ten one-thousandths of an inch less than the outer diameter of said annular cutting portion.

2. A diamond drill bit as defined in claim 1 wherein means are provided establishing communication for circulation of water between the interior of the bit and the exterior of the bit immediately behind said annular cutting portion.

3. A diamond drill bit assembly as defined in claim 1 wherein reaming shell has a screw-threaded lead portion engageable with said diamond drill bit and a screw-threaded trailing portion of reduced diameter engageable with a core rod; a reaming sleeve having an outwardly facing cylindrical cutting face, said reaming sleeve being engageable upon said trailing portion of the reaming shell at the forward end thereof; retaining means in said reaming shell co-operating with said reaming sleeve to prevent relative rotation thereof; and a second guide sleeve engageable upon said trailing portion of the reaming shell behind said reaming sleeve whereby said reaming sleeve and said second guide sleeve may be secured in position on said trailing portion by the forward end of a core rod screw-threadably connected with said trailing portion of the reaming shell, the outer diameter of said second sleeve guide being of the order of from about one one-thousandth of an inch to about ten one-thousandths of an inch less than the outer diameter of said reaming sleeve.

4. A diamond drill bit assembly as defined in claim 3 wherein said guide sleeve on said bit, said reaming sleeve, and said second guide sleeve are provided with spiral grooves in the outer surfaces thereof having a pitch direction which is the same as the direction of rotation of said diamond drill bit assembly during operation thereof.

5. A diamond drill bit assembly as defined in claim 3 wherein said guide sleeve on said bit, said reaming sleeve, and said second guide sleeve are provided with spiral grooves in the outer surfaces thereof having a pitch direction which is the same as the direction of rotation of said diamond drill bit assembly during operation thereof and wherein said drill bit assembly is screw-threadably mounted at the forward end of a drill string comprising sections of core bar having a plurality

of spiral grooves in the outer surface thereof having a pitch direction which is the same as the direction of rotation of said diamond drill bit assembly during operation thereof.

6. A diamond drill bit assembly as defined in claim 5 wherein the ends of all components on which there are spiral grooves are circumferentially cut away to slightly reduced diameter to provide a space for circumferential flow of water.

7. A diamond drill bit assembly as defined in claim 5 wherein said spiral grooves are 1/64 inch deep and 3/16 inch wide.

8. A diamond drill bit assembly as defined in claim 1, wherein said annular cutting portion and said guide sleeve define spiral grooves in their outer cylindrical surfaces said grooves having a pitch direction which corresponds to the direction of rotation of said drill bit assembly in operation.

9. A diamond drill bit assembly as defined in claim 8 further comprising a reamer sleeve carried on said reaming shell and a second guide sleeve formed of wear resistant material carried on and fixed to rotate with said reaming shell immediately axially behind said reamer sleeve and having an outer diameter which is of the order of from about one one-thousandth of an inch to about ten one-thousandth of an inch to about ten one-thousandth of an inch less than the outer diameter of said reamer sleeve.

10. A diamond drill bit assembly as defined in claim 9 wherein the outer cylindrical surfaces of said reamer sleeve and said second guide sleeve define spiral grooves having a pitch direction the same as that of said spiral grooves on said annular cutting portion and said first-mentioned guide sleeve.

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