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(54) **A method of drilling a substrate.**

(57) A method of drilling a substrate which contains hard rock having a compressive strength of at least 240 MPa such as reef quartzite is provided. The method involves providing a rotary drill having a rotatable core (10) mounted therein, rotating the core against the substrate and advancing the rotating core into the substrate. The rotatable core (10) comprises a working end (12) provided with a plurality of abrasive compacts (24) mounted therein and presenting cutting points (26) for the working end. The abrasive compacts (24) are arranged in a series of spaced arrays radiating out the top edge (42) of the inner vertical surface (16A) to the top edge (44) of the outer vertical surface (16). The core is rotated against the substrate in the direction of the arrow A such that the leading cutting point of each array is provided by a compact (52) located in the outermost position of the array.

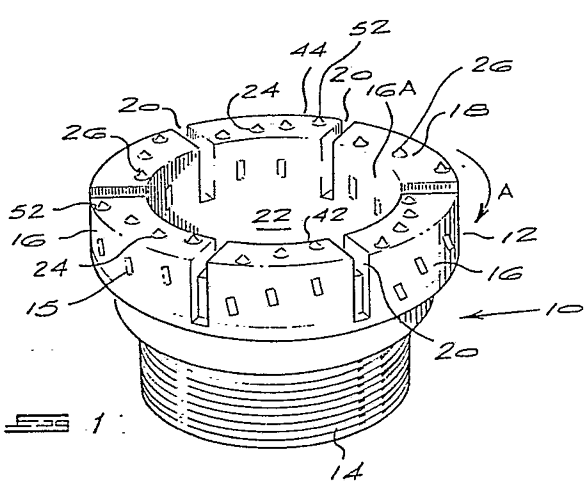

Fig. 1

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Description

"A METHOD OF DRILLING A SUBSTRATE"

BACKGROUND OF THE INVENTION

This invention relates to a method of drilling a substrate.

Rotary drills comprise a rotatable core having one end threaded for engagement in the drill and a working portion or cutting face at the other end. The working portion comprises a plurality of cutting elements firmly held in a suitable bonding matrix. The bonding matrix is usually a metal such as bronze.

The cutting elements may be made of a variety of hard material such as diamond, cemented carbide and abrasive compacts.

Abrasive compacts, as is known in the art, consist essentially of a mass of abrasive particles present in an amount of at least 70%, preferably 80 to 90%, by volume of the compact bonded into a hard conglomerate. Compacts are polycrystalline masses containing a substantial amount of direct particle-to-particle bonding. The abrasive particles of compacts are invariably ultra-hard abrasives such as diamond and cubic boron nitride.

Abrasive compacts have been widely available for many years and are described extensively in the literature. Examples of patent specifications which describe abrasive compacts are United States Patent Specifications Nos. 3,745,623 and 3,743,489 and British Patent Specification No. 1,489,130.

Diamond abrasive compacts which have a second phase containing a diamond catalyst tend to be thermally sensitive and degrade when exposed to temperatures above 700°C. Diamond abrasive compacts which are thermally stable at such temperatures are now known in the art. Examples of such compacts are described in United States Patent Specification No. 4,534,773 and British Patent Specification No. 2,158,086.

Thermally stable diamond compacts have been commercially available for over three years and have, in conjunction with other thermally sensitive diamond compacts, become an established and integral part of the drilling and mining industry. The thermally sensitive diamond compacts have shown limitations in the drilling of harder materials such as granites.

SUMMARY OF THE INVENTION

According to the present invention, there is provided a method of drilling a substrate which contains hard rock having a compressive strength of at least 240 MPa including the steps of providing a rotary drill having a rotatable core mounted therein, the rotatable core comprising a working end provided with a plurality of abrasive compacts mounted therein and presenting cutting points for the working end, the abrasive compacts being arranged in a series of spaced arrays radiating out from an inner circle to an outer circle, rotating the core against the substrate in a direction such that the leading cutting point of each array is provided by a compact located in the outermost position of the array, and advancing the rotating core into the substrate.

DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates a perspective view of a rotatable core for use in the practice of the invention;

Figure 2 illustrates a plan view of the rotatable core of Figure 1.

Figures 3 and 4 illustrate two forms of abrasive compact mounted in the working end of the rotatable core.

DETAILED DESCRIPTION OF THE INVENTION

The abrasive compact may be any known in the art, but is preferably a thermally stable diamond abrasive compact. Thermally stable diamond abrasive compacts are those compacts which are capable of withstanding a temperature of 1200°C and a vacuum of 10^{-4} Torr or better, or in an inert or reducing atmosphere without significant graphitisation of the diamond occurring. This characteristic of the compacts makes them thermally stable at temperatures exceeding 700°C in air. Examples of particularly suitable thermally stable diamond abrasive compacts are those described in U.S. Patent Specification No. 4,534,773 and British Patent Specification No. 2,158,086.

The abrasive compacts may be of any suitable shape, e.g. cube, rectangle, triangle or hexagon.

The cutting point is preferably provided by the apex of a triangular shaped cutting face of the compact which protrudes from the surface in which it is mounted.

Embodiments of the invention will now be described with reference to the accompanying drawings. Referring to Figure 1, there is shown a rotatable core 10 suitable for mounting in a rotary drill. The core 10 has a working end 12 and a threaded end 14 for engagement in the rotary drill. The working end 12 is right-circular cylindrical in shape having vertical sides 16, 16A and a substantially flat top 18. Embedded in the outer vertical side 16 are gauge stones 15. A series of grooves 20 are cut into the core and extend downwardly from the surface 18. These grooves allow cooling liquid which passes up the hollow centre 22 of the core, in use, to escape from the core.

Partially embedded in the surface 18 of the cylinder are a number of diamond abrasive compacts 24. Each compact is so embedded in the surface 18 that it presents a upwardly projecting cutting point 26. The abrasive compact may be of any suitable shape. An example of the use of a cube-shaped abrasive compact is illustrated by Figure 3, while the use of a triangular shaped compact is illustrated by Figure 4. Referring first to Figure 3, the abrasive compact 24 is so embedded in the surface 18 that it presents an exposed triangular cutting surface 28. The apex 30 of the surface provides the cutting point 26 of the embodiment of Figure 1.

In Figure 4 the compact 24 is triangular-shaped and is so mounted in the surface 18 that it presents an exposed triangular cutting surface 32, the apex 34 of which provides the cutting point 26 of the embodiment of Figure 1. The triangular shaped compact 24 is provided with a backing support 36.

The core 10 is made of a metal such as steel and the abrasive compacts 24 will be bonded therein using a suitable braze such as bronze.

The abrasive compacts are preferably thermally stable diamond abrasive compacts produced by the method described in the British Patent Specification No. 2,158,086. These abrasive compacts comprise a mass of diamond particles present in an amount of 85% by volume of the compact, and a second phase present in an amount of 15% by volume of the compact. The mass of diamond particles contain a substantial amount of diamond-to-diamond bonding to form a coherent, skeletal mass, and the second phase contains silicon in the form of silicon and/or silicon carbide.

As can be seen from Figures 1 and 2, the abrasive compacts 24 are arranged in a series of spaced arrays 40. Each array 40 radiates outward from the top of the edge 42 of the inner circular vertical side 16A to the top of the edge 44 of the outer circular vertical side 16. It will be noted that there are six arrays 40 of abrasive compacts. This number is not critical. There must be sufficient numbers of compacts and arrays to ensure that effective drilling can be achieved. It will be noted that arrays containing three compacts alternate with arrays containing four compacts. Further, the centre compact 46 of a three-array is staggered relative to its nearest centre compacts 48, 50 in the adjacent four-arrays. This staggered arrangement ensures that the entire distance between the inner circular edge 42 and the outer circular edge 44 is traversed by abrasive compacts, effective cutting is achieved.

The arrays 40 each radiate in the same direction creating a spiral effect. In use, the core 10 is rotated in the direction of the arrow A. This is important because it means that for each array the leading compact 52 is the outermost compact of each array. In use, flushing liquid is pumped through the hollow centre 22 and escapes through the grooves 20 and past the working face 18. In so doing, it carries with it swarf. With the compacts arranged in the manner set out in Figures 1 and 2, the swarf is swept away from the cutting points in the manner indicated by the dotted lines in Figure 2. This swarf is swept away without contacting or damaging a compact immediately behind it. This, it has been found, is particularly important when drilling substrates which contain hard rock having a compressive strength of at least 240 MPa, typically a compressive strength in the range 240 MPa to 400 MPa. Examples of such rocks are reef quartzite, crystalline quartzite, compact conglomerate and solid glassy quartz. These hard rock substrates are encountered, for example, in gold mining operations. If, on the other hand, the cylinder was rotated in the opposite direction, then swarf produced from any particular compact would strike a compact immediately behind it interfering with the cutting action of that compact in the drilling of these hard rock substrates.

In use, the rotatable core 10 is rotated at a high speed and contacted with the substrate to be drilled. Drilling is effected by advancing the core 10 into the substrate. It has been found that using a rotatable core as illustrated in the drawings and in the manner described above, produces very excellent drill penetration rates and tool lives when drilling reef quartzite and similar hard-to-drill formations. This is particularly so when the abrasive compact is a thermally stable abrasive compact of the type described in the above-mentioned British Patent Specification No. 2,158,086.

Claims

1. A method of drilling a substrate which contains hard rock having a compressive strength of at least 240 MPa including the steps of providing a rotary drill having a rotatable core (10) mounted therein, the rotatable core (10) comprising a working end (12) provided with a plurality of abrasive compacts (24) mounted therein and presenting cutting points (26) for the working end, the abrasive compacts being arranged in a series of spaced arrays (40) radiating out from an inner circle (42) to an outer circle (44),rotating the core (10) against the substrate in a direction such that the leading cutting point of each array is provided by a compact (52) located in the outermost position of the array, and advancing the rotating core (10) into the substrate.

2. A method of claim 1 wherein some of the compacts (46) in one array are staggered relative to their nearest neighbours (48, 50) in an adjacent array so that the abrasive compacts traverse the entire distance between the inner and outer circles.

3. A method of claim 1 or claim 2 wherein the inner circle (42) is defined by the inner top edge of the working end and the outer circle (44) is defined by the outer top edge of the working end.

4. A method of any one of the preceding claims wherein the abrasive compacts (24) are thermally stable abrasive compacts.

5. A method of any one of the preceding claims wherein the substrate contains hard rock having a compressive strength in the range 240 MPa to 400 MPa.

Fig. 2

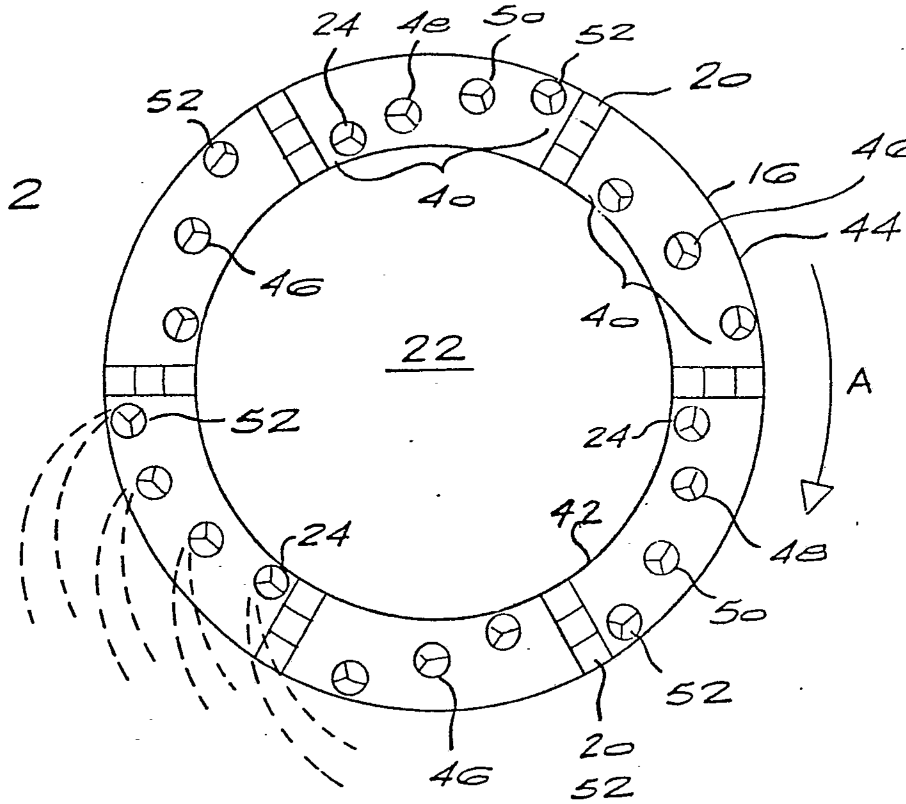


Fig. 1

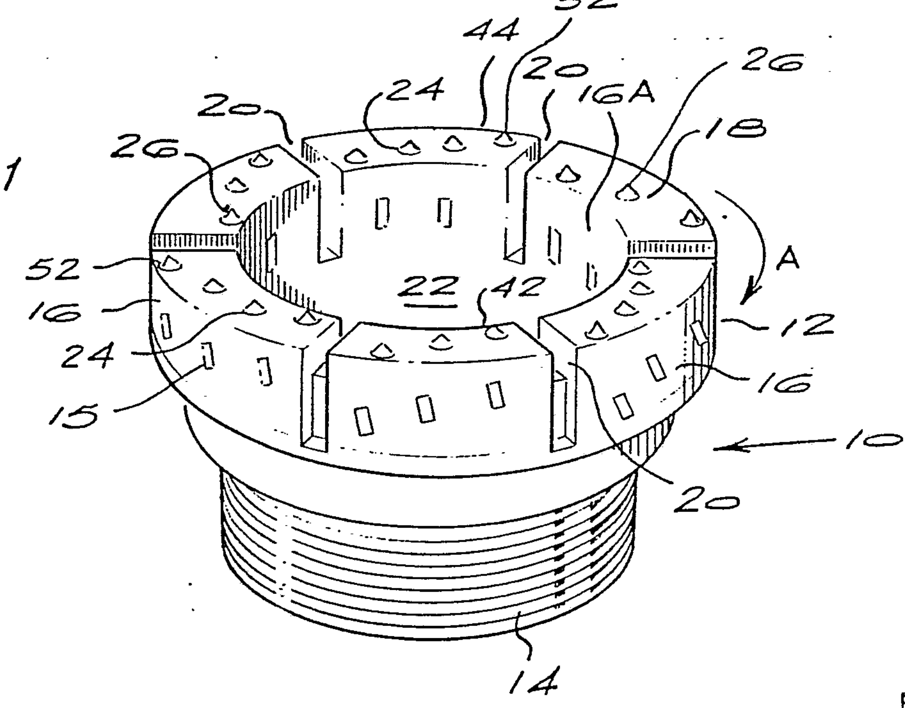


Fig. 3

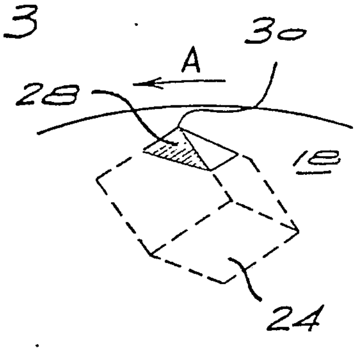
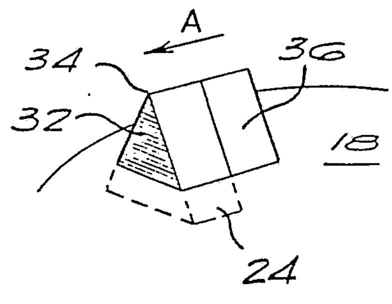


Fig. 4



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EUROPEAN SEARCH REPORT

Application Number

EP 88 30 9371

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X	EP-A-0 117 506 (CHRISTENSEN) * Page 17, line 26 - page 18; figure 8 * ---	1,3,4	E 21 B 10/48
A	EP-A-0 206 737 (DE BEERS) * Abstract; figure 1 * ---	1,3,4	
A	WORLD OIL, vol. 200, no. 7, June 1985, pages 149-154, Houston, Texas, US; A. PARK: "Coring: Part 4 - bit considerations" * Page 149, figure 1 * -----	1	
			TECHNICAL FIELDS SEARCHED (Int. Cl.4)
			E 21 B B 28 D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	10-01-1989	RAMPELMANN J.

CATEGORY OF CITED DOCUMENTS

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