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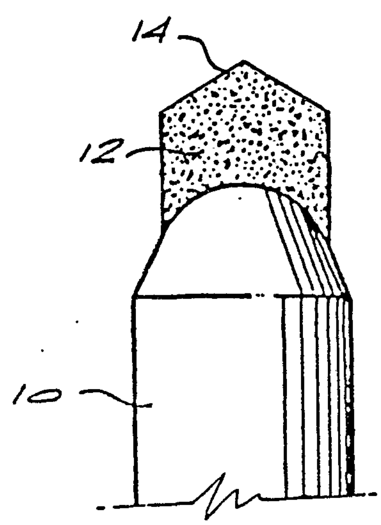
(54) **Abrasive products.**

(57) An abrasive body (12, 22) is provided which has high strength and an ability to withstand high temperatures making it suitiable as a tool insert for dressing tools and surface set drill bits. The body (12, 22) comprises a mass of diamond particles present in an amount of 80 to 95 percent by volume of the body (12, 22) and a second phase present in an amount of 5 to 20 percent by volume of the body (12, 22), the mass of diamond particles containing substantial diamond-to-diamond bonding to form a coherent skeletal mass and the second phase containing chromium and a second metal selected from the group of nickel, iron and cobalt, the chromium being in the form of the metal, chromium carbide and/or in the form of an intermetallic compound with the second metal and the second metal being in the form of the metal and/or the intermetallic compound with the chromium. The abrasive bodies (12, 22) are made under conditions of elevated temperature and pressure suitable for diamond compact manufacture.



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"ABRASIVE PRODUCTS"

BACKGROUND OF THE INVENTION

This invention relates to abrasive products.

Abrasive compacts are well known in the art and are used extensively in industry for the abrading of various workpieces. They consist essentially of a mass of abrasive particles present in an amount of at least 70 percent, preferably 80 to 90 percent, by volume of the compact bonded into a hard conglomerate. Compacts are polycrystalline masses and can replace single large crystals in many applications. The abrasive particles of compacts are invariably ultra-hard abrasives such as diamond and cubic boron nitride.

Abrasive compacts generally contain a second phase or bonding matrix which contains a catalyst (also known as a solvent) useful in synthesising the particles. In the case of cubic boron nitride, examples of suitable catalysts are aluminium or an alloy of aluminium with nickel, cobalt, iron, manganese or chromium. In the case of diamond, examples of suitable catalysts are metals of Group VIII of the Periodic Table such as cobalt, nickel or iron or an alloy containing such a metal.

As is known in the art, diamond and cubic boron nitride compacts are manufactured under conditions of temperature and pressure at which the abrasive particle is crystallographically stable.

Abrasive compacts may be bonded directly to a tool or shank for use. Alternatively, they may be bonded to a backing such as a cemented carbide backing prior to being mounted on a tool or shank. Such backed compacts are also known in the art as composite abrasive compacts.

United States Patent Specification No. 4,224,380 describes a method of leaching out a substantial quantity of the catalyst from a diamond compact. The product so produced comprises self-bonded diamond particles comprising between about 70 percent and 95 percent by volume of the product, a metallic phase infiltrated substantially uniformly throughout the product, the phase comprising between about 0,05 percent and 3 percent by volume of the product, and a network of interconnected, empty pores dispersed throughout the product and defined by the particles and the metallic phase, the pores comprising between 5 percent and 30 percent by volume of the product. Leaching may be achieved by placing a diamond compact in a hot concentrated nitric-hydrofluoric acid solution for a period of time. This treatment with the hot acid leaches out the catalyst phase leaving behind a skeletal diamond structure. The leached product is said to be thermally more stable than the unleached product.

United States Patent No. 4,124,401 describes and claims a polycrystalline diamond body comprised of a mass of diamond crystals adherently bonded together by a silicon atom-containing bonding medium comprised of silicon carbide and a carbide and/or silicide of a metal component which forms a silicide with silicon, the diamond crystals ranging in size from 1 micron to about 1 000 microns, the density of the crystals ranging from at least about 70 percent by volume up to at least about 90 percent by volume of said body, said silicon atom-containing bonding medium being present in an amount ranging up to about 30 percent by volume of said body, said bonding medium being distributed at least substantially uniformly throughout the body, the portion of the bonding medium in contact with the surfaces of the diamond crystals being at least in a major amount silicon carbide and the diamond body being at least substantially pore-free. The metal component for the diamond body is selected from a wide group of metals consisting of cobalt, chromium, iron, hafnium, manganese, molybdenum, niobium, nickel, palladium, platinum, rhenium, rhodium, ruthenium, tantalum, thorium, titanium, uranium, vanadium, tungsten, yttrium, zirconium and alloys thereof. The polycrystalline diamond body is made under relatively mild hot pressing conditions and such that diamond intergrowth will not occur.

United States Patent No. 4,151,686 describes a polycrystalline diamond body similar to that of United States Patent No. 4,124,401 save that the bonding medium is comprised of silicon carbide and elemental silicon and the density of diamond crystals in the body ranges from 80 percent by volume to about 95 percent by volume of the body. Moreover, the polycrystalline abrasive bodies of this United States patent are made under higher applied pressure conditions, i.e. applied pressures of at least about 25 kilobars.

United States Patent No. 3,234,321 describes diamond compacts having a second phase of titanium, vanadium, zirconium, chromium or silicon or an alloy of any of these metals with nickel, manganese or iron. The compacts are made by mixing the diamond particles with the metal, in powdered form, and subjecting the mixture to elevated conditions of temperature and pressure. One example uses silicon as the metal.

European Patent Publication No. 0116403 describes an abrasive body which has high strength and an ability to withstand high temperatures making it suitable as a tool insert for dressing tools and surface set drill bits. The body comprises a mass of diamond particles present in an amount of 80 to 90 percent by volume of the body and a second phase present in an amount of 10 to 20 percent by volume of the body, the mass of diamond particles containing substantial diamond-to-diamond bonding to form a coherent skeletal mass and the second phase containing nickel and silicon, the nickel being in the form of nickel and/or nickel silicide and the silicon being in the form of silicon, silicon carbide and/or nickel silicide. The abrasive bodies are made under conditions of elevated temperature and pressure suitable for diamond compact manufacture.

SUMMARY OF THE INVENTION

An abrasive body according to the invention comprises a mass of diamond particles present in an amount of 80 to 95 percent by volume of the body and a second phase present in an amount of 5 to 20 percent by volume of the body, the mass of diamond particles containing substantial diamond-to-diamond bonding to form a coherent skeletal mass and the second phase containing chromium and a second metal selected from the group of nickel, iron and cobalt. The chromium will be present in the form of the metal, chromium carbide and/or in the form of an intermetallic compound with the second metal. The second metal will be in the form of the metal and/or the intermetallic compound referred to above.

Further according to the invention there is provided a dressing tool comprising a tool shank and an abrasive body as defined above mounted in one end thereof to present a dressing edge.

Still further according to the invention there is provided a surface set drill bit comprising a rotatable body presenting at one end thereof a cutting face, the cutting face having a plurality of abrasive bodies as defined above mounted therein to present cutting edges for the face.

Still further according to the invention there is provided a method of producing an abrasive body as defined above including the steps of:

(a) placing a mass of diamond particles in a reaction vessel;

(b) placing a mass of chromium and the second metal or an alloy of chromium and the second metal in contact with the mass of diamond particles;

(c) placing the loaded reaction vessel in the reaction zone of a high temperature/high pressure apparatus;

(d) subjecting the contents of the reaction vessel to conditions of elevated temperature and pressure in the diamond stable region of the carbon phase diagram for a time sufficient to produce the abrasive body: and

(e) recovering the abrasive body from the reaction zone.

DESCRIPTION OF THE DRAWINGS

Figure 1 is a fragmentary side view of a dressing tool of the invention;

Figure 2 is a perspective view of a surface set drill bit of the invention;

Figure 3 is a perspective view of a portion of the cutting face of the bit of Figure 2.

DETAILED DESCRIPTION OF THE INVENTION

It has been found that the abrasive bodies of the invention have substantial strength due, at least in part, to the substantial diamond-to-diamond bonding which forms a coherent skeletal mass. The diamond-to-diamond bonding includes both diamond intergrowth and physical diamond-to-diamond interlocking and bonding created by plastic deformation of the diamond particles during manufacture of the body. Furthermore, the abrasive bodies have been found to be capable of withstanding a temperature of 1200°C under a vacuum of 10^{-4} Torr or better without significant graphitisation of the diamond occurring. Indeed, it has been noted that the thermal stability of the abrasive bodies of this invention is better than that of the abrasive bodies described and claimed in European Patent Publication No. 0116403. The strength of the abrasive bodies and their ability to withstand high temperatures makes them ideal as tool inserts for tools where high temperatures are generated during use thereof, as for example in dressing tools, or where high temperatures are required during manufacture of the tool, as for example in surface set drill bits.

The second phase will be uniformly distributed through the coherent, skeletal diamond mass.

The weight ratio of the chromium to the second metal will typically be in the range 90:10 to 20:80.

The abrasive bodies of the invention may take on a variety of shapes depending on the use to which they are put. Examples of suitable shapes are disc, triangular, cube and rectangular.

The abrasive bodies of the invention are manufactured, in the manner described above, using temperatures and pressures in the diamond stable region of the carbon phase diagram. The preferred conditions of temperature and pressure are temperatures in the range 1400 to 1600°C and pressures in the range 50 to 70 kilobars. These elevated conditions of temperature and pressure will be maintained for a time sufficient to produce the abrasive body. Typically, these elevated conditions of temperature and pressure are maintained for a period of 5 to 20 minutes. The chromium and the second metal may be provided in the form of a mixture or alloy or in the form of discrete layers. The chromium and second metal may be provided in the form of powders or in the form of sheets or foils.

The diamond particles used in the manufacture of the abrasive body of the invention may vary from coarse to fine particles. Generally the particles will be less than 100 microns in size and typically have a size in the range 60 to 75 microns.

High temperature/high pressure apparatus is well known in the art-see, for example, U.S. patent No. 2,941,248.

Figure 1 illustrates the use of an abrasive body of the invention in a dressing tool. Referring to this Figure, there is shown a dressing tool comprising a shank 10 having an abrasive body 12 mounted in one end thereof. The abrasive body presents a dressing edge 14. High temperatures are generated at the dressing edge 14 during use of the tool. However, it has been found that the excellent thermal stability of the abrasive body 12 enables the body to withstand these high temperatures.

Figures 2 and 3 illustrate a surface set drill bit (also referred to as a coring bit) using abrasive bodies of the invention. Referring to these Figures, there is shown a surface set drill bit comprising a rotatable core 16 having one end 18 threaded for engagement in a coring drill and a cutting face 20 at the other end thereof. The cutting face 20 comprises a plurality of cutting elements 22 firmly held in a suitable metal matrix. The cutting elements 22 each comprise triangular shaped abrasive bodies of the invention, as illustrated in greater detail in Figure 3. The triangular abrasive bodies 22 are so mounted in the cutting face 20 that the base of the triangle is located in a recess 24 and the top pointed edge 26 stands proud of the general plane of the cutting face to present a cutting edge. Located immediately behind the triangular abrasive body 22 is a support 28 made of the same metal as the cutting face. The direction of rotation of the bit is shown by the arrow.

In surface set drill bits, the cutting elements are set into the cutting face using standard high temperature infiltration techniques. The excellent thermal stability of the abrasive bodies of the invention enables them to withstand such temperatures without significant degradation thereof.

The invention is further illustrated by the following examples.

EXAMPLE 1

A mass of diamond particles (16,0 g) was placed in a tantalum cup. A disc (2,6g) of a nickel/chromium alloy was placed on top of the mass of diamonds.Thus, the weight ratio of nickel/chromium was 85:15. The nickel/chromium constituted 14 percent by weight of the contents of the loaded tantalum cup.

The loaded cup was placed in the reaction zone of a conventional high temperature/high pressure apparatus and subjected to 1500°C temperature and 55 kilobars pressure and these conditions were maintained for a period of 10 minutes. Recovered from the reaction zone was a disc-shaped abrasive body which comprised a mass of diamond particles in which there was a substantial amount of diamond-to-diamond bonding forming a coherent skeletal diamond mass and a second phase containing chromium and nickel as metals and in various combined forms uniformly distributed through the diamond mass.

CLAIMS

1.

An abrasive body (12, 22) comprising a mass of diamond particles present in an amount of 80 to 95 percent by volume of the body and a second phase present in an amount of 5 to 20 percent by volume of the body, the mass of diamond particles containing substantial diamond-to-diamond bonding to form a coherent skeletal mass and the second phase containing chromium and a second metal selected from the group of nickel, iron and cobalt, the chromium being in the form of the metal, chromium carbide and/or in the form of an intermetallic compound with the second metal and the second metal being in the form of the metal and/or the intermetallic compound with the chromium.

2.

An abrasive body (12, 22) according to claim 1 wherein the ratio of chromium to the second metal in the second phase is in the range 90:10 to 20:80 on a weight basis.

3.

An abrasive body (12, 22) according to either one of the preceding claims having a disc, triangular, cube or rectangular shape.

4.

A dressing tool comprising a tool shank (10) and an abrasive body (12) according to any one of the preceding claims mounted in one end thereof to present a dressing edge (14).

5.

A surface set drill bit comprising a rotatable body (16) presenting at one end thereof a cutting face (20), the cutting face having a plurality of abrasive bodies (22) according to any one of claims 1 to 3 mounted therein to present cutting edges (26) for the face (20).

6.

A method of producing an abrasive body (12, 22) according to any one of claims 1 to 3 including the steps of:

(a) placing a mass of diamond particles in a reaction vessel;

(b) placing a mass of chromium and the second metal or an alloy of chromium and the second metal in contact with the mass of diamond particles;

(c) placing the loaded reaction vessel in the reaction zone of a high temperature/high pressure apparatus;

(d) subjecting the contents of the reaction vessel to conditions of elevated temperature and pressure in the diamond stable region of the carbon phase diagram for a time sufficient to produce the abrasive body; and

(e) recovering the abrasive body (12, 22) from the reaction zone.

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Fig. 1

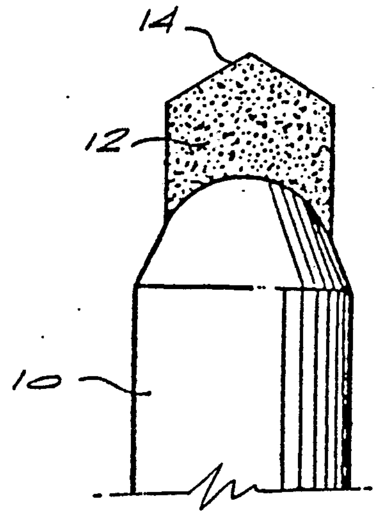


Fig. 2

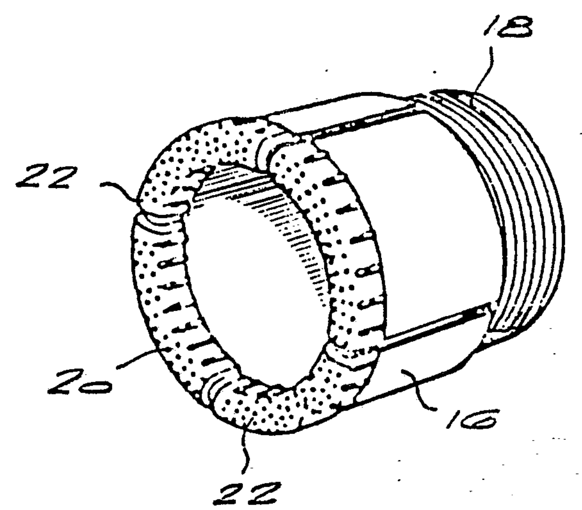
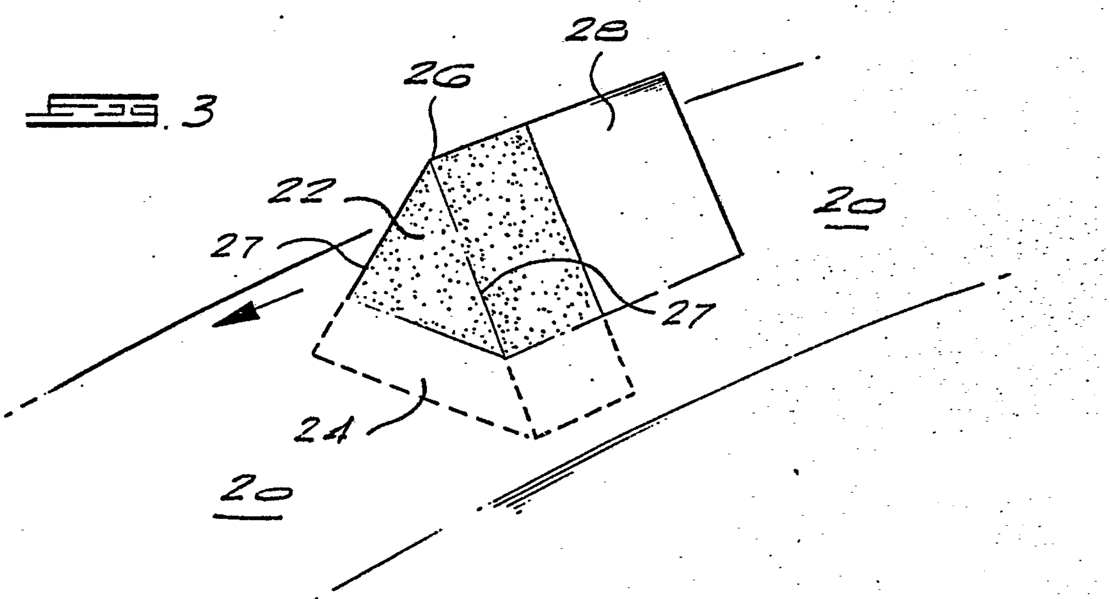


Fig. 3



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EUROPEAN SEARCH REPORT

Application number: EP 86302586.2

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)
D,X	EP - A1 - 0 116 403 (DE BEERS INDUSTRIAL DIAMOND DIVISION (PROPRIETARY) LIMITED) * Claims 1,3-6 * --	1-6	B 24 D 3/10 B 24 D 3/04 C 09 K 3/14 B 23 B 51/00 B 24 D 17/00
D,A	US - A - 4 224 380 (BOVENKERK et al.) * Claim 1 * --	1	
D,A	US - A - 4 124 401 (LEE et al.) * Claims 1,3,8,10 * --	1	
A	US - A - 4 241 135 (LEE et al.) * Claims 1,3 * --	1	TECHNICAL FIELDS SEARCHED (Int. Cl.4)
A	EP - A2 - 0 046 374 (DE BEERS INDUSTRIAL DIAMOND DIVISION (PROPRIETARY) LIMITED) * Claims 1,4,15,20 * ----	1,5	B 24 D C 09 K B 23 B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	25-06-1986	WOLF

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document