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(54) Insert

(57) An insert for a drill bit comprises a superhard material table secured to a carrier. A layer of a refractory metal is located between the table and the carrier. The layer of refractory metal forms part of a canister used in the formation of the superhard material table.

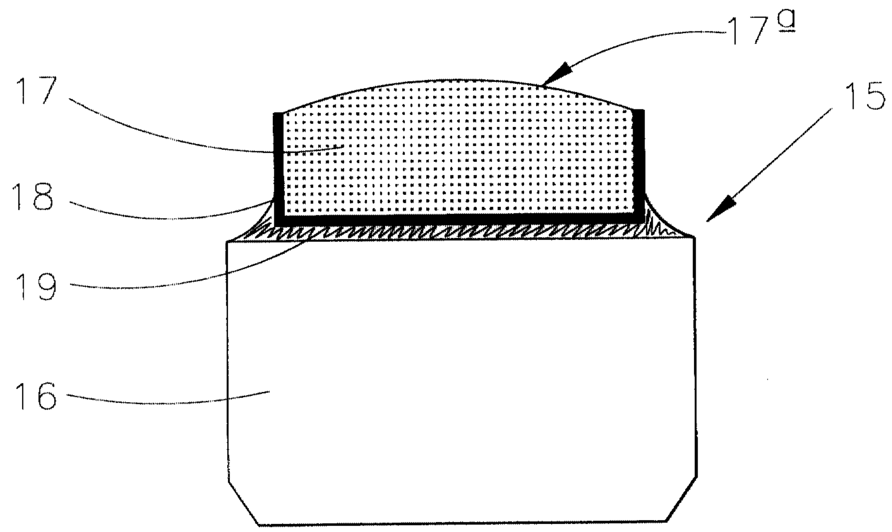

FIG.2

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Description

Field of the invention

[0001] This invention relates to an insert suitable for use as part of a rotary drill bit for drilling or coring holes in subsurface formations. Each drill bit typically has a plurality of preform inserts, each of which comprises a table of a superhard material, for example polycrystalline diamond, bonded to a substrate. The substrate is bonded or otherwise secured to a bit body forming part of the drill bit. The inserts may take the form of cutting elements of a variety of types or may be used as gauge protection inserts. Although described herein as being suitable for use as part of a drill bit, it will be appreciated that the invention may be used in other applications, for example in bearings.

Background of the invention

[0002] A typical super abrasive polycrystalline diamond (PCD) insert is manufactured by providing a quantity of monocrystalline diamond particles within a refractory metal canister. A substrate, conveniently of cobalt cemented tungsten carbide, is also located within the canister. The cobalt acts as a binder/catalyst material such that when the canister is heated to a high temperature under high pressure conditions, the cobalt within the substrate is able to infiltrate the diamond particles, promoting bonding between the particles, and hence forming polycrystalline diamond. The binder/catalyst material also bonds the polycrystalline diamond to the substrate. Although cobalt is commonly used, other binder/catalyst materials can be used in the process.

[0003] After synthesis of the polycrystalline diamond, the canister is removed from the insert and the diamond and substrate are machined to form flat surfaces for use in subsequent bonding operations. The substrate can be bonded, using a conventional bonding technique, to a carrier. The carrier may be of the same material as the substrate and may be coaxial with the substrate so as to increase the effective substrate length ready for securing to a bit body.

[0004] In order to improve manufacturing efficiency it is desirable to be able to produce several inserts during each operating cycle of the press which is used to generate the high temperature, high pressure conditions required for the formation of polycrystalline diamond. Typically, however, only two inserts can be manufactured during each cycle.

[0005] Rather than use a substrate which includes a binder/catalyst material, it is known to omit the substrate from the canister and to use a monocrystalline diamond material which has itself been mixed with a suitable binder/catalyst material. One disadvantage with this type of PCD is that, since the substrate is omitted, there is no metal surface which can be used to braze or otherwise secure the diamond to a substrate, carrier or the like for subsequent attachment to a drill bit. As diamond is not readily wettable by traditional brazing alloys, brazing of the diamond directly to a carrier is not practical. In order to secure PCDs of this type to a drill bit body of the metal matrix composite type, the PCDs may be partially embedded in the matrix material, but this technique is not suitable for use with all other types of bit body.

[0006] Where cobalt is used as the binder/catalyst, then one disadvantage associated with the manufactured polycrystalline diamond material is that it is not of high thermal stability. It is known to leach the cobalt from the manufactured polycrystalline diamond in order to improve its thermal stability and reduce the risk of fracture. It is also known to use silicon as the binder/catalyst, the silicon reacting during the diamond manufacturing process to form SiC which has a thermal expansion coefficient close to that of diamond and which does not result in the diamond being of relatively low thermal stability.

[0007] A further problem associated with the use of diamond in drill bit inserts is that, as diamond has a low coefficient of thermal expansion compared to that of the substrate to which the diamond is commonly bonded, significant stress levels are experienced at the bond between the diamond and the substrate when the diamond and substrate are heated, and the stress may give rise to the bond failing. In order to reduce this effect, it is known to provide a layer of material having an intermediate coefficient of thermal expansion between the diamond and the substrate.

Summary of the invention

[0008] It is an object of the invention to provide an insert in which the disadvantages set out hereinbefore are obviated or mitigated.

[0009] According to the present invention there is provided an insert comprising a table of superhard material secured to a carrier, and a layer of a refractory metal located between the superhard material table and the carrier, the layer of refractory metal comprising part of a refractory metal canister used in the formation of the superhard material table.

[0010] The refractory metal layer is conveniently bonded to the carrier using a bonding technique in which the layer of superhard material is cooled to avoid degradation thereof whilst a sufficiently high temperature is achieved to permit a high strength bond to be formed between the refractory metal layer and the carrier.

[0011] The superhard material is conveniently polycrystalline diamond. It may be formed using a self-sintering technique in which monocrystalline diamond particles mixed with a binder/catalyst material are subjected to high temperature under high pressure conditions. Alternatively the polycrystalline diamond may be formed using an infiltration technique wherein, during manufacture, a binder/catalyst material infiltrates monocrystalline diamond particles under high temperature, high pressure conditions from a donor substrate located within the canister. The donor substrate conveniently takes the form of a cemented tungsten carbide substrate, the cement of which includes the binder/catalyst material.

[0012] The binder/catalyst material is conveniently chosen from a group comprising cobalt, nickel, silicon and iron.

[0013] The insert may comprise a cutter intended to be mounted upon a rotary drill bit body in a position in which, upon rotating the drill bit, the cutter shears or abrades a subsurface formation and removes material therefrom. The drill bit may, for example, be a roller cone drill bit, or a rotary drag type drill bit. Alternatively, the insert may comprise a gauge insert or wear pad intended to be mounted upon a side of a bit body to reduce wear of the bit body. In either case, the carrier may comprise a post intended to be received, at least in part, within a correspondingly shaped bore or recess provided in a bit body. The post may be shaped to include location formations. Alternatively, the carrier may be of shape and dimensions to permit brazing of the insert onto a surface of a bit body, the carrier being of sufficient dimensions to provide adequate support for the table, in use, thereby reducing the risk of failure of the insert.

[0014] The wall of the refractory metal canister which forms the refractory metal layer need not be planar and may take any desired shape so that the interface between the diamond table, the refractory metal layer and the carrier can be of any desired form.

[0015] The refractory metal canister is conveniently constructed of a metal from a group comprising niobium, molybdenum and tantalum.

[0016] The invention as defined hereinbefore is advantageous in that it permits manufacturing costs to be reduced and the manufacturing process to be simplified since the manufacturing method need not include a step of completely removing the canister material, and less finishing is required. Further, where a self-sintering diamond material is used, the provision of a donor substrate can be avoided reducing the quantity of material which must be provided within the canister, and hence permitting a reduction in the size of the canister. By reducing the dimensions of the canister it may be possible to increase the number of inserts which can be manufactured during each operating cycle of the synthesis press. The invention also provides a technique whereby self-sintered diamond material can be mounted upon a carrier for subsequent mounting upon a bit body, and where the self-sintered diamond material is, for example, manufactured using silicon as the binder/catalyst material, the invention permits the use of diamond inserts of increased thermal stability.

[0017] A further advantage of the invention is that, where a refractory metal of a suitable coefficient of thermal expansion is chosen, then the refractory metal layer can act as an interlayer of thermal expansion coefficient between those of the carrier and of the diamond, thereby reducing the risk of the diamond material becoming detached.

[0018] The invention also relates to a method of manufacturing such an insert.

Brief description of the drawings

[0019] The invention will further be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1a is a side elevation of a rotary drill bit of the type including a plurality of inserts in accordance with embodiments of the invention;

Figure 1b is a view of an alternative drill bit;

Figure 2 is a diagrammatic sectional view illustrating a gauge insert in accordance with an embodiment of the invention;

Figures 3 to 7 are diagrammatic sectional views illustrating several cutters in accordance with embodiments of the invention;

Figure 8 is a diagrammatic sectional view illustrating an alternative insert; and

Figure 9 is a diagrammatic view illustrating an insert part-way through the manufacturing process.

Detailed description of the preferred embodiments

[0020] The drill bit illustrated in Figure 1a is intended for use in drilling or coring holes in subsurface formations. The drill bit comprises a machined steel bit body 10 having an end region which is provided with a plurality of upstanding blades 11. Channels 12 are defined between the blades 11, the channels 12 being supplied, in use, with drilling fluid for cleaning and cooling purposes through openings or nozzles (not shown). The bit body 10 further includes a screw threaded shank 13 arranged for connection to a drill string whereby the drill bit can be driven to rotate about its longitudinal axis.

[0021] Each blade 11 is provided, along a leading edge thereof, with a plurality of inserts in the form of cutters 14. The cutters 14 are positioned so as to abrade the surface of the formation upon rotation of the drill bit, the material abraded by the cutters 14 being carried away from the drill bit by the drilling fluid.

[0022] The blades 11 are each further provided with kickers which define a gauge region of the drill bit, gauge inserts 15 being mounted on the outer surfaces of the kickers. The gauge inserts 15 are positioned so as to co-operate with the surrounding formation material to ensure that the drill bit is positioned substantially concentrically within the borehole being drilled and to transmit side loadings to the formation. The gauge inserts 15 are intended to reduce or avoid wear of the gauge regions of the drill bit.

[0023] Figure 2 illustrates, diagrammatically, one of the gauge inserts 15. As shown in Figure 2, the gauge insert 15 comprises a carrier 16 of tungsten carbide or any other suitable material upon which is bonded a polycrystalline diamond table 17 located within part 18 of a canister of a refractory metal. The polycrystalline diamond table 17 is formed by hermetically sealing a mixture of diamond powder 21 and a suitable binder/catalyst 22, for example silicon, within a pressed refractory metal canister 23 as shown in Figure 9. The canister 23 is conveniently of two-part form comprising a base 23a or cup into which the mixture is placed, and a lid 23b which is hermetically sealed to the base 23a to prevent or restrict contamination of the mixture. The canister is 23 conveniently formed from molybdenum, niobium or tantalum. After assembly, several such canisters 23 are placed within a press designed to pressurise the mixture to a high pressure, a suitable heater being provided to achieve a high temperature. The temperature and pressure achieved are sufficient to ensure that the process produces a table 17 of polycrystalline diamond within the canister 23, the binder/catalyst promoting intergrowth between the diamond particles and bonding between the diamond and the canister 23. Clearly, as the diamond is firmly bonded to the canister 23 by the binder/catalyst material, and as the canister 23 is formed from a refractory metal, the diamond material can be secured relatively easily to a drill bit body for example as described below.

[0024] After manufacture, the lid 23b of the canister 23 is removed to expose part or all of a surface 17a of the table 17. If desired, the exposed part of the table 17 can be cleaned. The exterior of at least the part 18 of the base 23a of the canister 23 is also cleaned. After cleaning, the cleaned part 18 of the canister 23 is bonded to the carrier 16 using a conventional bonding technique. Such a technique may involve cooling the diamond table 17 whilst applying sufficient heat to the part of the carrier 16 to which the part 18 of the canister 23 is to be bonded to melt, for example, a brazing alloy 19, thereby permitting brazing of the canister 23 to the carrier 16. The temperature to which the diamond table 17 is exposed is kept sufficiently low by the cooling operation that degradation of the diamond is avoided or occurs only to a limited extent. To avoid degradation, the diamond should be kept below a temperature of about 725°C, while a temperature of around 1000°C is desirable to achieve the bond between the canister 23 and the carrier 16. It will be appreciated, from Figure 2, that the part 18 of the canister 23 located between the carrier 16 and the table 17 constitutes a layer of refractory metal.

[0025] As illustrated in Figure 2, the exposed surface 17a of the table 17 is of curved form. This is desirable in a gauge insert as the function of a gauge insert is to guide the drill bit and transmit side loadings to the formation, not to remove material therefrom. The shaping of the surface 17a may be achieved after the manufacture of the table 17 by machining. Alternatively, the lid 23b of the canister 23 may be shaped to achieve the formation of a table having this shape.

[0026] Figure 3 illustrates one of the cutters 14 of the drill bit of Figure 1. The cutter 14 illustrated in Figure 3 is structurally very similar to the gauge insert 15 of Figure 2 and is manufactured using substantially the same manufacturing technique. The main differences between the cutter 14 of Figure 3 and the gauge insert of Figure 2 are that the table 17 of the cutter 14 has a substantially planar exposed end face 17a that, in use, defines a cutting edge 17b for use in abrading material from the formation, and that as well as removing the lid 23b of the canister 23, the side walls of the base 23a thereof have also been removed. After removal of the appropriate parts of the canister 23, the remaining part 18 of the canister 23 is cleaned ready for bonding to the carrier 16 using the technique outlined hereinbefore and the exposed parts of the diamond table 17 are cleaned and polished, if desired.

[0027] The cutter 14 illustrated in Figure 4 is similar to that of Figure 3 but the diamond table 17 thereof includes a curved exposed surface 17a. The shaping of the diamond table 17 in this manner results in the cutter 14 being suitable for use in certain applications where a cutter of the type of Figure 3 may not be suitable, for example for use in drilling through harder substrates. The shape of the cutter may also be modified depending upon the type of drill bit with which it is to be used, for example the shape of the cutter may be modified if it is to be used as part of a roller cone type drill bit as illustrated in Figure 1b. Such drill bits are well known and so will not be described in detail herein. Like reference numerals have been used in Figures 1a and 1b to denote similar parts.

[0028] In addition to shaping the exposed surface(s) 17a of the diamond table 17, the surface 17c thereof which, in the finished insert, is closest to the carrier 16 may also be shaped to a desired form by appropriate shaping of the base 23a of the canister 23. As the canister 23 is formed by pressing, the shape thereof can be modified by appropriate modification of the press dies. Such shaping is advantageous in that it can improve the strength of the bond between the carrier 16 and the diamond table/canister both by forming a mechanical interlock and by increasing the surface area over which bonding takes place. Figures 5 to 7 illustrate three possible shapes for the interface between the diamond table 17 and the part 18 of the canister 23, and between the canister 23 and the carrier 16. In Figure 5, the carrier 16 is provided with a plurality of radially extending grooves 16a and the part 18 of the base of the canister 23 is shaped to conform with the carrier 16. In the arrangement of Figure 6, the carrier 16 is provided with an axially extending projection 16b, and in Figure 7 the carrier is provided with a curved end face 16c. In each case the part 18 of the canister 23 is shaped to conform with the adjacent part of the carrier 16. It will be appreciated, however, that the invention is not limited to these shapes.

[0029] As described hereinbefore, the polycrystalline diamond table 17 is conveniently formed using a self-sintering technique and using silicon as the binder/catalyst material. Such an arrangement is advantageous in that the polycrystalline diamond material formed is of good thermal stability, the insert of the invention having the advantage that such diamond material can be secured, relatively easily, to drill bits of a variety of forms. Rather than using silicon as the binder/catalyst material, cobalt or another binder/catalyst material could be used. The use of cobalt results in the diamond being of reduced thermal stability, but of sufficient stability for use in a number of applications.

[0030] The inserts according to the invention have the advantage that a layer of refractory metal is present between the diamond table 17 and the carrier 16. Provided the coefficient of thermal expansion of the refractory metal is between those of the diamond material and the carrier 16, then the layer of refractory metal acts as an interlayer reducing the risk of failure of the bond whereby the diamond is secured to the carrier and avoiding the necessity to provide a separate layer of a material having a suitable coefficient of thermal expansion therebetween.

[0031] If desired, rather than using a self-sintering technique, a donor substrate 20 may be located within the canister 23, for example as illustrated in Figure 8. The donor substrate 20 is conveniently of cemented form, for example comprising cemented tungsten carbide, the cement forming the binder/catalyst material. During the high temperature, high pressure pressing operation, the binder/catalyst material melts and infiltrates the diamond material to promote intergrowth and the formation of polycrystalline diamond, and bonding of the diamond to the donor substrate 20 and the canister 23.

[0032] The use of the donor substrate 20 increases the size of the canister 23 which must be used, and hence reduces the number of inserts which can be produced during each operating cycle of the press compared to the arrangements described hereinbefore, but still results in improvements in manufacturing efficiency as less time is spent cleaning the diamond table 17 and substrate 20 than in prior arrangements. Further, as the substrate 20 is used simply to provide the binder/catalyst used in the synthesis of the diamond, it can be relatively thin, thus the reduction in the quantity of inserts that can be synthesised may be small.

[0033] Although in the description hereinbefore only the use of silicon and cobalt as the binder/catalyst material is mentioned, it will be appreciated that other materials may be used as the binder/catalyst, for example iron or nickel or alloys thereof may be used.

Claims

1. An insert comprising a table of superhard material secured to a carrier, and a layer of a refractory metal located between the superhard material table and the carrier, the layer of refractory metal comprising part of a refractory metal canister used in the formation of the superhard material table.

2. An insert as claimed in Claim 1, wherein the refractory metal layer is bonded to the carrier using a bonding technique in which the layer of superhard material is cooled to avoid degradation thereof whilst a sufficiently high temperature is achieved to permit a high strength bond to be formed between the refractory metal layer and the carrier.

3. An insert as claimed in Claim 1, wherein the superhard material is polycrystalline diamond.

4. An insert as claimed in Claim 3, wherein the polycrystalline diamond is formed using a self-sintering technique in which monocrystalline diamond particles mixed with a binder/catalyst material are subjected to a high temperature under high pressure conditions.

5. An insert as claimed in Claim 3, wherein the polycrystalline diamond is formed using an infiltration technique wherein, during manufacture, a binder/catalyst material infiltrates monocrystalline diamond particles under high temperature, high pressure conditions from a donor substrate located within the canister.

6. An insert as claimed in Claim 5, wherein the donor substrate takes the form of a cemented tungsten carbide substrate, the cement of which includes the binder/catalyst material.

7. An insert as claimed in Claim 4, wherein the binder/catalyst material is chosen from a group comprising cobalt, nickel, silicon and iron.

8. An insert as claimed in Claim 5, wherein the binder/catalyst material is chosen from a group comprising cobalt, nickel, silicon and iron.

9. An insert as claimed in Claim 1, wherein the refractory metal layer is of non-planar form such that the interface between the table, the refractory metal layer and the substrate is non-planar.

10. An insert as claimed in Claim 1, wherein the refractory metal canister is constructed from a metal from the group comprising niobium, molybdenum and tantalum.

11. An insert as claimed in Claim 1, wherein the carrier comprises a post intended to be received within an opening provided in a bit body of a drill bit.

12. An insert as claimed in Claim 1, wherein the carrier is of dimensions sufficient to permit brazing of the insert to a surface of a bit body of a drill bit.

13. A cutter for a drill bit, the cutter comprising a table of superhard material secured to a carrier, and a layer of a refractory metal located between the table and the carrier, the layer forming part of a canister used in the formation of the table.

14. A gauge insert for a drill bit, the gauge insert comprising a table of a superhard material secured to a carrier, and a layer of a refractory metal located between the table and the carrier, the layer being part of a canister used in the formation of the table.

15. A drill bit comprising a bit body and at least one insert secured thereto, the or each insert comprising a table of superhard material secured to a carrier, and a layer of a refractory material located between the table and the carrier, the layer forming part of a canister used in the formation of the table.

16. A method of manufacturing an insert comprising the steps of forming a superhard material table within a refractory metal canister, and bonding part of the canister to a carrier.

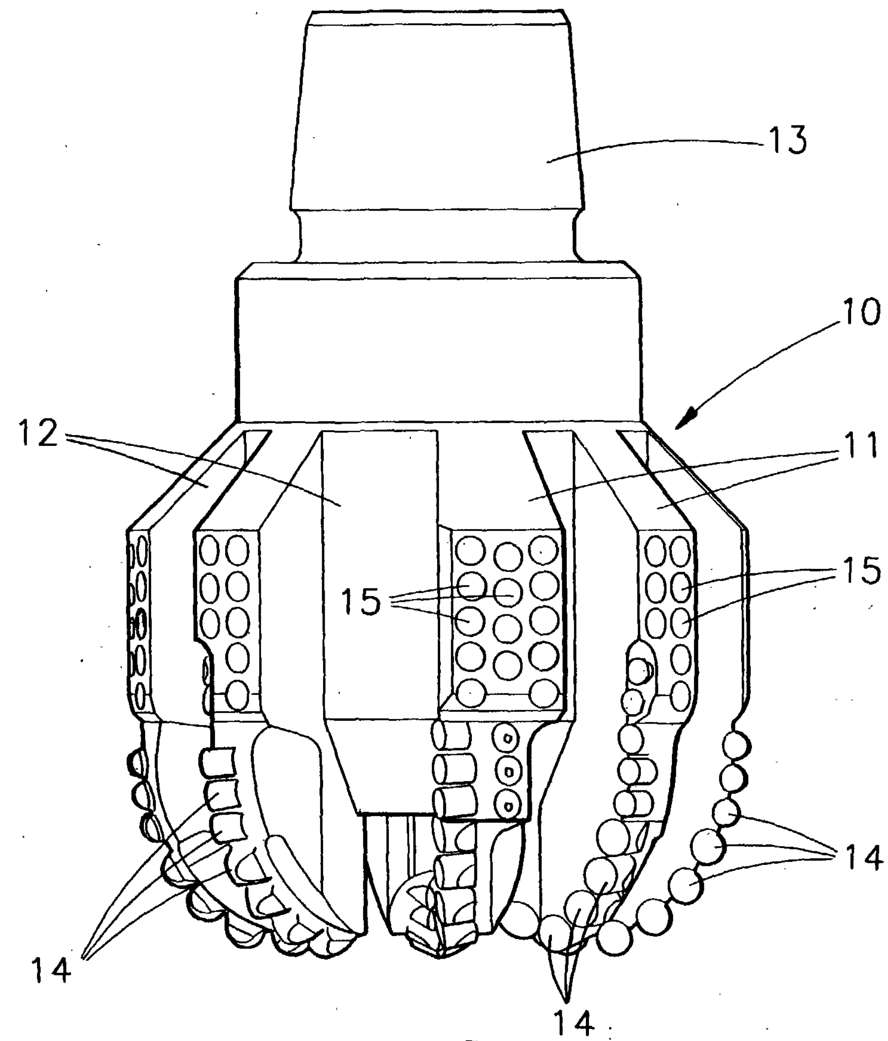

FIG.1ª

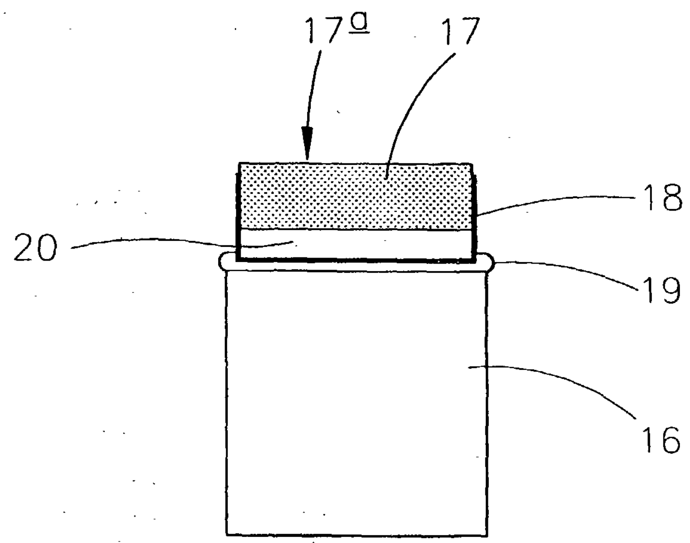

FIG.8

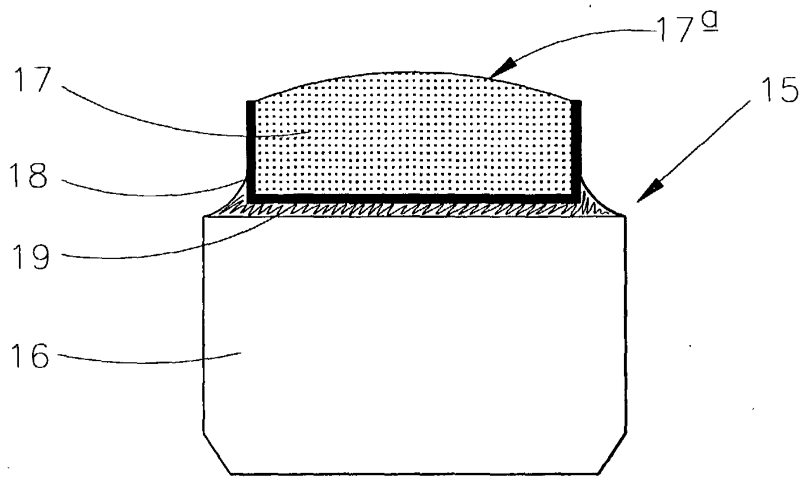

FIG.2

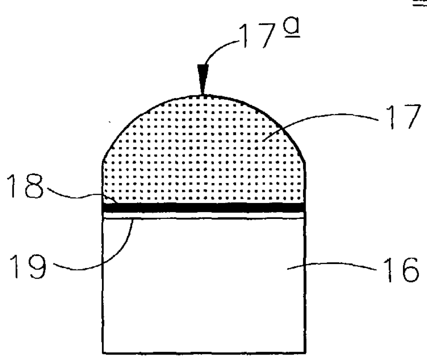

FIG.4

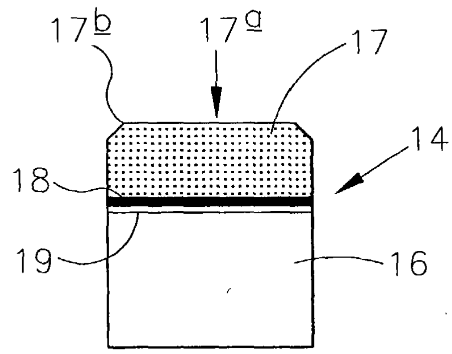

FIG.3

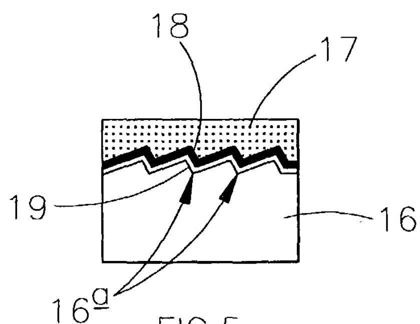

FIG.5

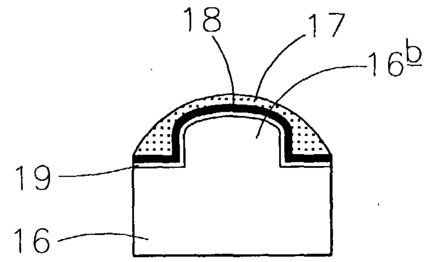

FIG.6

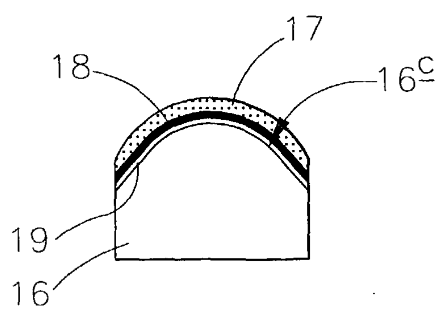

FIG.7

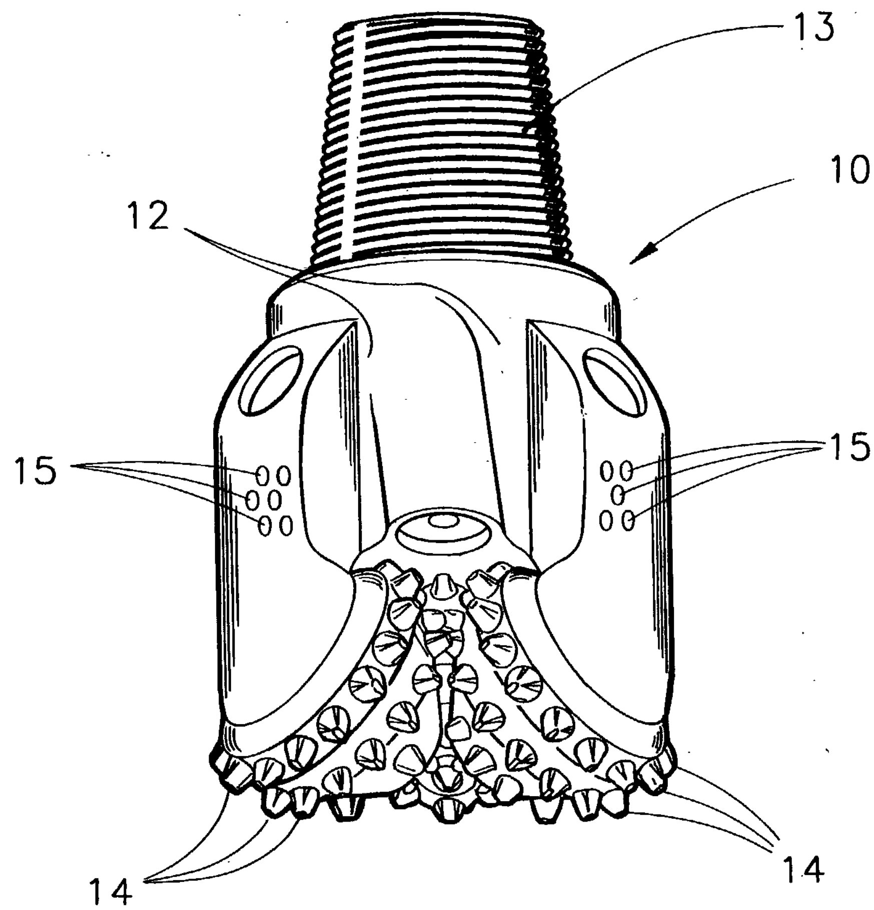

FIG. 1b

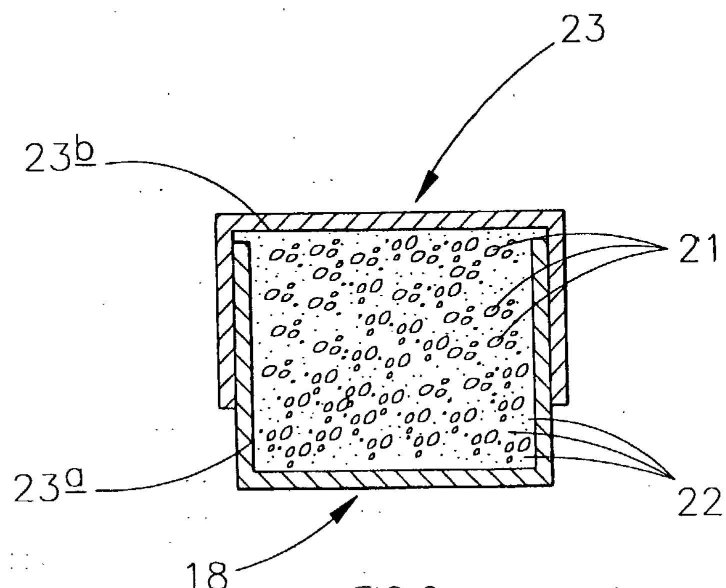

FIG. 9

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EUROPEAN SEARCH REPORT

Application Number
EP 00 31 1335

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	22 March 2001	van Berlo, A

CATEGORY OF CITED DOCUMENTS

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