

(19) World Intellectual Property
Organization
International Bureau



(43) International Publication Date
2 December 2004 (02.12.2004)

PCT

(10) International Publication Number
WO 2004/103641 A1

(51) International Patent Classification⁷: **B24D 3/10**,
18/00, B22F 7/06, B23B 27/14

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(21) International Application Number:
PCT/IB2004/001630

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(22) International Filing Date: 20 May 2004 (20.05.2004)

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2003/3969 22 May 2003 (22.05.2003) ZA

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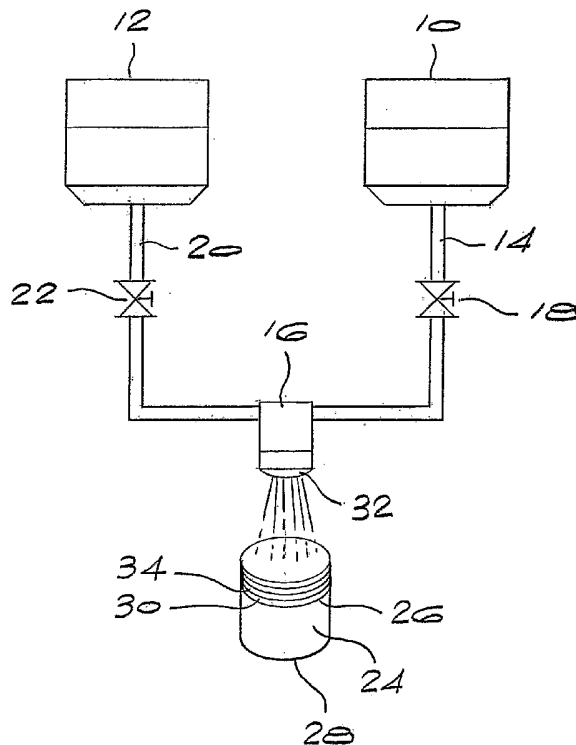
(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM,

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[Continued on next page]

(54) Title: METHOD OF MAKING A TOOL COMPONENT



(57) Abstract: A method of producing a tool component comprising a working portion of bonded abrasive particles including a non-homogeneous region. The method includes the step of providing at least two sources of a material comprising abrasive particles in a suitable binder, the materials of the sources differing from each other. The material of one source may comprise diamond or cubic boron nitride particles, whilst the material of the other source may comprise carbide particles. Alternatively, the materials of the two sources may contain the same abrasive particle, such as diamond or cubic boron nitride particles, but in different particle sizes. The materials are delivered to a zone where mixing occurs, and the mixture is applied to a surface to produce a layer of the mixed materials on the surface, typically by spraying. By controlling the quantity of material from each source which is delivered to the mixing zone, different mixtures of the two abrasives can be created. In this way, layers, e.g. one on top of the other, can be produced which differ from their neighbours in abrasive particle composition. These layers, on sintering, form non-homogeneous regions in the working portion of a tool component.



ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

METHOD OF MAKING A TOOL COMPONENT

BACKGROUND OF THE INVENTION

This invention relates to a method of making a tool component.

Abrasive compacts are used extensively in cutting, milling, grinding, drilling, boring and other abrasive operations. Abrasive compacts consist of a mass of diamond or cubic boron nitride particles bonded into a coherent, polycrystalline conglomerate. The abrasive particle content of abrasive compacts is high and there is generally an extensive amount of direct particle-to-particle bonding. Abrasive compacts are made under elevated temperature and pressure conditions at which the abrasive particle, be it diamond or cubic boron nitride, is crystallographically stable.

Diamond abrasive compacts are also known as polycrystalline diamond or PCD and cubic boron nitride abrasive compacts are also known as polycrystalline CBN or PCBN.

Abrasive compacts tend to be brittle and in use they are frequently supported by being bonded to a cemented carbide substrate or support. Such supported abrasive compacts are known in the art as composite abrasive compacts. Composite abrasive compacts may be used as such in a working surface of an abrasive tool. Where the composite abrasive compact has a thick abrasive compact layer, particularly a thick diamond compact layer, residual tensile stresses in the abrasive compact layer develop giving rise to problems in use. These stresses contribute to delamination and fracture of the compact layer in use. To minimise these problems, the interface between the abrasive compact layer and carbide substrate may be profiled and/or the composition of the compact layer varied, for example by introducing some carbide particle content in a region or regions adjacent the substrate/compact layer interface.

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Cemented carbide is used as a material for producing tool components which have an abrasiveness and hardness less than PCD or PCBN. Such tool components may consist of a homogeneous cemented carbide or a cemented carbide which varies in composition.

SUMMARY OF THE INVENTION

According to the present invention, a method of producing a tool component which comprises a working portion of bonded abrasive particles and which includes a non-homogeneous region includes the steps of providing at least two sources of a material comprising abrasive particles in a suitable binder, the materials of the sources differing from each other, delivering a quantity of the materials to a zone where mixing occurs and applying the mixed materials to a surface to produce a layer of the mixed materials on the surface. The layer of mixed materials will form at least a part of the non-homogeneous region of the working portion of the tool component. The non-homogeneous region can differ in size of abrasive particle, in the nature of the abrasive particle or in a combination thereof. The layer of the mixed materials is a green state form of the non-homogeneous region.

In one form of the invention, the material of one source comprises a mass of discrete ultra-hard abrasive particles such as diamond or cubic boron nitride in a binder. The material of the other source comprises a mass of discrete abrasive particles different to those of the material of the first source, for example carbide particles, in a binder. By controlling the quantity of material from each source which is delivered to the mixing zone, different mixtures of the two abrasives can be created. In this way, layers, e.g. one on top of the other, can be produced which differ from their neighbours in abrasive particle composition. These layers, on sintering, form non-homogeneous regions in the working portion of a tool component.

In another form of the invention, the materials of the two sources contain the same abrasive particle, but in different particle sizes. In a similar manner by controlling the quantity of material from each source which is delivered to the mixing zone, layers which differ in particle size composition from each other can be produced.

It is preferred that the mixed materials are delivered from the mixing zone in the form of a spray.

The surface to which the layer or layers of mixed material is applied may be the surface of a cemented carbide substrate producing, for example, a green state composite abrasive compact. This green state composite abrasive compact, on sintering at temperature and pressure conditions at which the abrasive particle is crystallographically stable, results in a composite abrasive compact being produced. The surface to which the layer of mixed materials is applied may be the surface of a substrate which is sacrificed leaving a green state layer or layers of mixed materials which may be sintered.

BRIEF DESCRIPTION OF THE DRAWING

The invention will now be described in more detail, by way of example only, with reference to the accompanying drawing which is a diagrammatical representation of apparatus suitable for carrying out an embodiment of the invention.

DESCRIPTION OF EMBODIMENTS

Embodiments of the invention will now be described with reference to the accompanying drawing. Referring to the drawing, there is shown apparatus comprising containers 10, 12. The containers are suitable for holding a mass of abrasive particles in a suitable binder. Examples of suitable

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binders are organic binders such as methyl or ethyl cellulose or polyvinylpyrrolidone. The abrasive particles will generally be uniformly dispersed in the binder and will be flowable. The abrasive particles of container 10 will, for example, be ultra-hard abrasive particles such as diamond or cubic boron nitride. The abrasive particles of container 12 will be different to those of container 10 and will, for example, be carbide particles. Passage 14 from container 10 leads to a mixing zone 16. Flow of material from the container 10 is controlled from valve 18. Passage 20 from container 12 leads to the mixing zone 16. Flow of material from container 12 is controlled by valve 22.

In use, a substrate 24, typically a cemented carbide substrate, is provided. The substrate is cylindrical in shape and has an upper flat surface 26 and a lower flat surface 28. A first layer 30 of mixed materials is applied to the surface 26. This is achieved by opening valves 18, 22 to a desired extent, thereby delivering material from each of the containers 10, 12 to the mixing zone 16. The materials are thoroughly mixed in zone 16 and thereafter sprayed through nozzle 32 on to the surface 26. Thereafter, a second layer 34 is applied to the layer 30. This layer will also be applied using this wet powder spraying (WPS) method, save that the proportions of material delivered from containers 10 and 12 will be varied by means of the amount delivered through the valves 18, 22. Additional layers are added to the layer 34. The compositions of these additional layers will be tailored to meet specific requirements.

The layered product is a green state product. The layers on the substrate 34 are all coherent and hold their shape. The green state product is then sintered to cause the various layers to sinter and bond to each other and the layer 30 to bond to the substrate. For example, the container 10 may contain diamond particles, in which event the container will generally contain finely particulate metal such as nickel, iron or cobalt as a mixture with the diamond particles. The container 12 may contain carbide particles. The layers 30 and 34 will generally contain a mixture of diamond particles and carbide particles in varying amounts. The outer layer or layers will

generally contain only diamond particles. The green state product will be sintered under diamond synthesis conditions and the resulting product will be a composite diamond abrasive compact. A diamond compact layer will be formed from the green state layers. The diamond compact layer of such a product will be substantially stress-free.

In an alternative embodiment of the invention, the container 10 may contain abrasive particles of a particular size and the container 12 contain the same abrasive particles but of different size. The various layers in the green state product may thus all contain the same abrasive particles but the size composition of each layer may be varied to achieve a particular objective.

It will be appreciated that by use of the method of the invention, it is possible to produce layered structures having a wide range of compositions varying from each other. Further, the illustrated embodiment has the layers one on top of the other. The method can also be used to produce layers which are vertically or otherwise disposed relative to each other.

The layered structure may be applied directly to a substrate to which it is desired to bond the layers on sintering. Alternatively, the layers may be applied to a surface, then removed from that surface and applied to a surface of a substrate to which bonding takes place.

The method of the invention may be further understood with reference to the following non-limiting Examples.

EXAMPLE 1

A cylindrical-shaped component was prepared with a WC/diamond gradient in the axial direction using the wet powder spraying (WPS) method of the invention. The starting layer of the cylinder was a 4mm layer of WC/Co. This was not prepared using the wet powder spraying method, but was rather pressed from commercially available powder at 100MPa to obtain a strong, porous support for the subsequent layer deposition. This base layer

was then strengthened further by a pre-sintering treatment under hydrogen at 600°C. The porosity of this layer was chosen to achieve a similar shrinkage behaviour to the overlying layers. The WC/Co grain composition was the same as that used in the diamond graded layers.

49 gradient layers, each of approximately 100µm thickness, with WC/diamond ratios varying in a monotonic manner were then deposited onto the WC/Co base by the WPS method. The diamond and WC particles were provided from separate containers, each in a suspension which included polyvinylpyrrolidone as binder, Lupasol P as dispersant and water. The composition ranged from 98% WC/2% diamond (by mass) in the layer immediately adjacent to the base layer to 100% diamond in the uppermost layer. The composition was altered in 2% steps by altering the flow of WC particles from one container and diamond particles from another container. In order to preserve a cylindrical shape in the component, a cylindrical mold was used for containing the sprayed layers.

As the concentration of diamond particles, which had an average particle size of about 4µm, in the suspension increased (according to the axial gradient), so the overall composition of the suspension altered. The decrease in matrix mass due to the density difference between diamond and WC/Co meant that the binder and dispersant masses had to decrease in a similar fashion. The overall water content therefore increased with respect to the dry powder weight. Each layer was dried before the subsequent layer was sprayed to prevent shrinkage problems.

The green compact was then de-binded at a sufficiently high temperature to remove the binder and dispersant phases. A high pressure, high temperature treatment was then used to sinter the green compact to produce a sintered compact. The sintered compact exhibited a marked reduction in residual tensile stresses in the abrasive compact layer.

EXAMPLE 2

A cylindrical-shaped component was prepared with a diamond grain size gradient in the axial direction using a wet powder spraying (WPS) method similar to that described in Example 1. The diamond layer immediately adjacent to the WC/Co base layer was chosen to have an average grain size of approximately 25µm, whilst the diamond layer in the uppermost layer was chosen to have an average grain size of approximately 4µm. 50 layers were deposited, each of approximately 100µm in thickness. The ratio of the two diamond grain sizes was altered in monotonic manner in 2% compositional intervals, from 100% 25µm diamond at the base surface to 100% 4µm diamond at the uppermost surface.

The mass composition of the WPS suspension did not alter significantly from the base to the top layers, as the matrix material was consistently diamond throughout. The final compact was de-binded in a similar fashion to the compact generated in Example 1, and was then treated under high pressure and high temperature to achieve a fully sintered compact with diamond to diamond bonding. The sintered compact once again provided an abrasive compact layer with a significant reduction in residual tensile stresses.

EXAMPLE 3

A cylindrical-shaped component was prepared with a gradient in diamond grain size and chemical composition in the axial direction using a wet powder spraying (WPS) method similar to that described in Example 1.

The layer immediately adjacent to the WC/Co base layer contained diamond grains of 25 µm in size and WC/Co particles of 2.5µm in size in a 75:25 (diamond:WC/Co) mass ratio. The uppermost layer contained 100% diamond material of an average of 4µm in size. The ratio of these two source compositions was altered in monotonic manner in 2% compositional

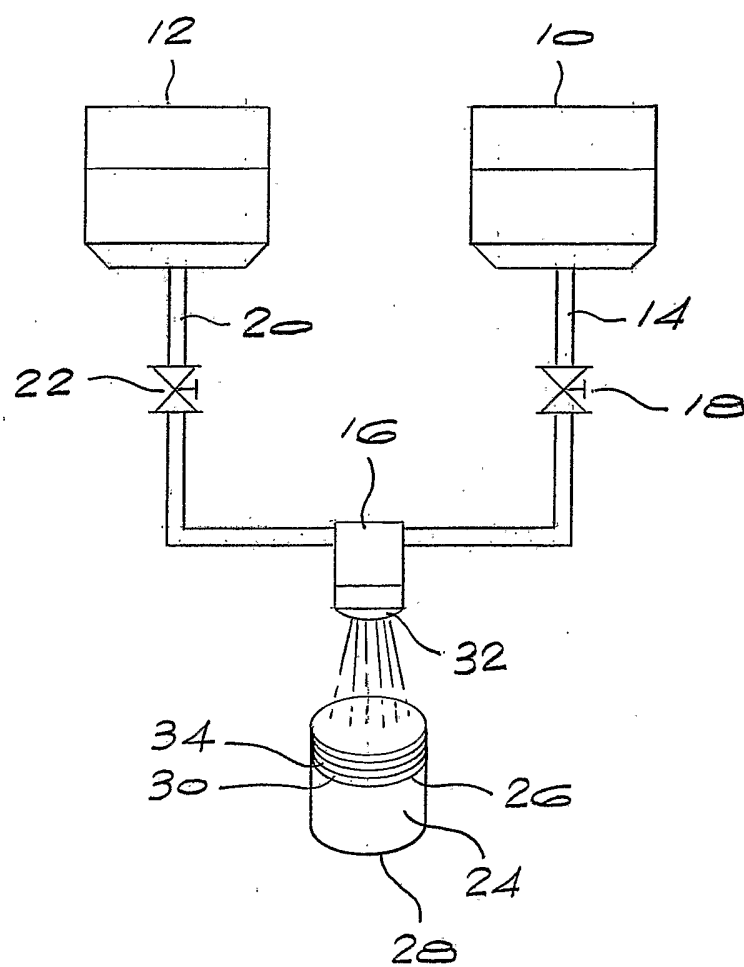
intervals, from 100% (25µm diamond/(WC/Co) mix) at the base surface to 100% 4µm diamond at the uppermost surface.

The final compact was then de-binded in a similar fashion to the compact generated in Example 1, and was then treated under high pressure and high temperature to achieve a fully sintered compact with diamond to diamond bonding. Residual tensile stresses were once again significantly reduced in the abrasive compact layer.

CLAIMS:

1. A method of producing a tool component comprising a working portion of bonded abrasive particles, which includes a non-homogeneous region, the method including the steps of providing at least two sources of a material comprising abrasive particles in a suitable binder, the materials of the sources differing from each other, delivering a quantity of the materials to a zone where mixing occurs and applying the mixed materials to a surface to produce a layer of the mixed materials on the surface.
2. A method according to claim 1, wherein the layer of mixed materials forms at least a part of the non-homogeneous region of the working portion of the tool component.
3. A method according to claim 1 or claim 2, wherein the non-homogeneous region differs in size of abrasive particle, in the nature of the abrasive particle or in a combination thereof.
4. A method according to any one of the preceding claims, wherein the layer of the mixed materials is a green state form of the non-homogeneous region.
5. A method according to any one of the preceding claims comprising first and second sources of material, the first source comprising a mass of discrete ultra-hard abrasive particles in a binder and the second source comprising a mass of discrete abrasive particles, different to those of the material of the first source, in a binder.
6. A method according to claim 5, wherein the first source of material comprises a mass of discrete diamond or cubic boron nitride particles in a binder and the second source of material comprises carbide particles in a binder.

7. A method according to any one of claims 1 to 4, comprising first and second sources of material, the materials of the two sources containing the same abrasive particle, but in different particle sizes.
8. A method according to any one of the preceding claims, wherein the mixed materials are delivered from the mixing zone in the form of a spray.
9. A method according to any one of the preceding claims, wherein the surface to which the layer or layers of mixed material is applied is the surface of a cemented carbide substrate producing a green state composite abrasive compact.
10. A method according to any one of the preceding claims, wherein the surface to which the layer or layers of mixed materials is applied is the surface of a substrate which is sacrificed leaving a green state layer or layers of mixed materials which may be sintered.
11. A method according to claim 1, substantially as herein described with reference to the accompanying drawing.
12. A method according to claim 1, substantially as herein described with reference to any one of the illustrative Examples.



INTERNATIONAL SEARCH REPORT

International Application No

IB2004/001630

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 B24D3/10 B24D18/00 B22F7/06 B23B27/14

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B24D B22F B23B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	EP 0 111 600 A (REED ROCK BIT CO) 27 June 1984 (1984-06-27) page 2, paragraphs 1,3 page 3, paragraph 2 page 5, paragraph 3 - page 13, paragraph 1 page 15, paragraph 2 page 16, paragraph 3 - page 17, paragraph 1 page 19, paragraph 3 - page 20, paragraph 3 page 22, paragraph 2 - page 24 figures 1,2,10,11 abstract ----- -/--	1-5,7,8, 10 6,9



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

° Special categories of cited documents:

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the international filing date
- *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

T later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

X document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

Y document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

& document member of the same patent family

Date of the actual completion of the international search

13 September 2004

Date of mailing of the international search report

24/09/2004

Name and mailing address of the ISA

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Eder, R

INTERNATIONAL SEARCH REPORT

International Application No

IB2004/001630

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y.	US 2002/007972 A1 (YONG ZHOU ET AL) 24 January 2002 (2002-01-24) paragraphs '0001!, '0023!, '0032! - '0034! figure 2 abstract -----	6,9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2004/001630

Box II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☒ Claims Nos.: 11, 12
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
see FURTHER INFORMATION sheet PCT/ISA/210
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box II.2

Claims Nos.: 11,12

The international search authority could not determine the scope of protection sought for claims 11 and 12.

The applicant's attention is drawn to the fact that claims relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure. If the application proceeds into the regional phase before the EPO, the applicant is reminded that a search may be carried out during examination before the EPO (see EPO Guideline C-VI, 8.5), should the problems which led to the Article 17(2) declaration be overcome.

INTERNATIONAL SEARCH REPORT

Information on patent family members

ional Application No

IB2004/001630

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
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US 2002007972	A1	24-01-2002	US 6315065 B1	13-11-2001
			CA 2305813 A1	16-10-2000
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