

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
30 August 2007 (30.08.2007)

PCT

(10) International Publication Number
WO 2007/098036 A1

(51) International Patent Classification:
B24D 18/00 (2006.01) **B24D 7/00** (2006.01)

(21) International Application Number:
PCT/US2007/004107

(22) International Filing Date:
15 February 2007 (15.02.2007)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0603277.5 17 February 2006 (17.02.2006) GB

(71) Applicant (for all designated States except US): **3M INNOVATIVE PROPERTIES COMPANY** [US/US]; 3M Center, Post Office Box 33427, Saint Paul, MN 55133-3427 (US).

(72) Inventor; and

(75) Inventor/Applicant (for US only): **LE NORMAND, Jean** [FR/FR]; Boulevard de L'Oise, F-95006 Cergy Pontoise Cedex (FR).

(74) Agents: **BIESTERVELD, Daniel, D.** et al.; 3M Center, Office of Intellectual Property Counsel, Post Office Box 33427, Saint Paul, MN 55133-3427 (US).

(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, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

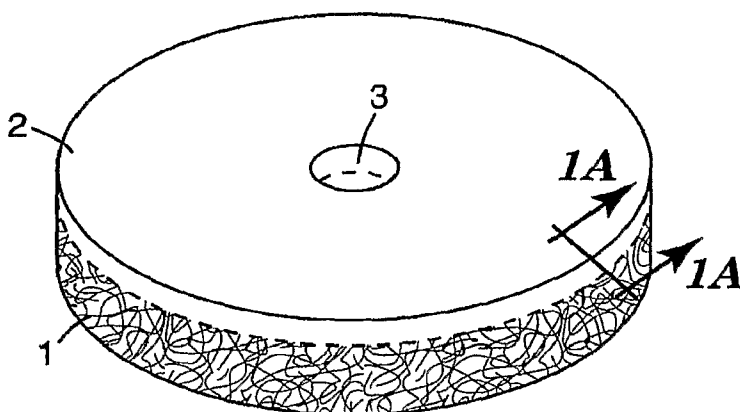
(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, 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.

(54) Title: AN ABRASIVE ARTICLE HAVING A BACKING, SUITABLE FOR ATTACHMENT TO A ROTATABLE SHAFT, AND PREPARATION THEREOF



(57) Abstract: A method is described for making an abrasive article comprising an abrasive part (1) and a backing (2) fixed to the abrasive part to provide for attachment of the abrasive article at a central location (3) to a rotatable shaft of a driven tool, wherein the abrasive part (1) comprises a substrate having abrasive characteristics. The method comprises placing a restricting layer (6) adjacent the abrasive part (1), injecting molten polymeric material onto the restricting layer, the restricting layer causing the polymeric material to spread over the abrasive part, and allowing the polymeric material to cool while remaining in contact with the abrasive part to form the backing (2).

WO 2007/098036 A1

**AN ABRASIVE ARTICLE HAVING A BACKING, SUITABLE FOR
ATTACHMENT TO A ROTATABLE SHAFT, AND PREPARATION THEREOF**

FIELD

The present invention relates to an abrasive article comprising an abrasive part fixed to a backing, suitable for attachment to a rotatable shaft, and to its preparation.

BACKGROUND

Abrasive articles are available in many different grades, from coarse grades suitable for sanding or grinding, to very fine grades suitable for polishing or cleaning.

Abrasive articles of the kind having an abrasive part fixed to a backing are known. An example is a Scotch-Brite™ Clean and Strip disc available from 3M Company of St. Paul, Minnesota, USA. This disc has a Scotch-Brite™ disc glued to a separate backing, and has a central bore permitting the article to be attached to the rotatable shaft of an abrading tool. The backing is made from impregnated fibre glass or a plastic material such as nylon. A metal ring can be inserted in the bore in the backing to strengthen the backing for mounting to the abrading tool. The Scotch-Brite™ disc is attached to the backing by an adhesive which is then cured in an oven. It is known to stick labels to the backing.

An alternative method involves making the separate backing by injection moulding. The subsequent procedure is then the same, namely gluing the backing to the Scotch-Brite™ disc, curing the glue and applying a label.

Another abrasive article of this type is an abrasive flap disc also available from 3M Company. The flap disc has a plurality of flaps made of coated abrasive material. The flaps are arranged in a slanted arrangement so that they overlap one another and are then resin bonded to a separately-made backing. The backing provides a means of attachment to a driven tool and also provides a support for the flaps as well as imparting rigidity to the article.

The production of these abrasive articles requires a number of steps and a variety of raw materials. This makes the production process time consuming.

The invention has been made with these points in mind.

Another abrasive article not having a backing can be made by the method taught in WO 2005/115716. This method involves placing particles of abrasive agglomerate (abrasive particles held together in a pellet by a binder) in a mould, placing a screen over the agglomerates and injecting thermoplastic resin into the mould. The screen ensures the agglomerates remain in the desired place, rather than being displaced by the injected resin. The resin surrounds the agglomerates such that the agglomerates are embedded in the resin.

SUMMARY OF THE INVENTION

According to a first aspect of the invention, there is provided a method of making an abrasive article comprising an abrasive part and a backing fixed to the abrasive part to provide for attachment of the abrasive article at a central location to a rotatable shaft of a driven tool, wherein the abrasive part comprises a substrate having abrasive characteristics, the method comprising placing a restricting layer adjacent the abrasive part, injecting molten polymeric material onto the restricting layer, the restricting layer causing the polymeric material to spread over the abrasive part, and allowing the polymeric material to cool while remaining in contact with the abrasive part to form the backing.

Preferably, the polymeric material is a thermoplastic material.

In the invention, the backing is fixed directly to the abrasive part by the polymeric material. This is achieved by contacting the abrasive part with the polymeric material while the polymeric material is molten, and allowing the polymeric material to cool. The polymeric material of the backing therefore becomes integrally formed with the abrasive part. The invention does not require the use of a separate adhesive to fix the backing to the abrasive part.

In this way, the invention reduces the required raw materials and production steps compared with known articles of this type, since it is not necessary to form different components separately and then fix them together. The materials used are also readily available and, particularly when a thermoplastic material is used for the backing, are comparatively inexpensive. The invention is therefore cost effective, simple and has a low

cycle time. The restricting layer is permeable to the molten polymeric material. It encourages the polymeric material to spread over the abrasive part while allowing molten polymeric material to contact the abrasive part. This is particularly preferred when the abrasive part is made of non-woven fibres as discussed below.

5 In the absence of a restricting layer, polymeric material may not spread evenly to form the backing as intended. In the case in which the abrasive part is made of non-woven fibres, the polymeric material may, in the absence of a restricting layer, preferentially penetrate into the non-woven material, particularly in the region where the polymeric material is injected, rather than build up to form the backing. In embodiments having a non-porous
10 abrasive part, it can also be beneficial to use a restricting layer. With non-porous abrasive parts, polymeric material may preferentially stick to the non-porous material in the region where polymeric is injected, thus hindering or possibly preventing spreading of the polymeric material over the whole of the abrasive part.

15 The restricting layer advantageously ensures that polymeric material spreads substantially evenly over the surface of the abrasive part before the polymeric material penetrates into or adheres to the abrasive part, and limits the penetration of polymeric material into the abrasive part.

20 The restricting layer is preferably a mesh, also known as a scrim. The mesh may have a mesh opening of up to 1000 micrometers, and the filaments of the mesh may be composed of a plastic material such as polyamide or polypropylene, an organic material such as cotton or linen, or a metal such as steel.

The purpose of the backing is to provide a means of support for the abrasive part and/or a means for attachment to a rotatable shaft of a driven tool such as a grinder, sander or polisher. The backing can also provide the abrasive part with increased rigidity or strength.
25 The backing may be substantially co-extensive with the abrasive part or, at least, have a substantially similar radial extent to that of the abrasive part. However, the backing may be slightly smaller than the abrasive part, or slightly larger than the abrasive part so as to provide an overhang or flange.

In one embodiment, in which the abrasive part comprises a support made of non-woven fibres, the molten polymeric material penetrates into interstices between the fibres, fixing the backing to the abrasive part. Non-woven abrasive materials typically comprise a uniform lofty web of continuous three-dimensionally autogenously bonded filaments, which may be impregnated with an adhesive binder and may contain a multitude of abrasive grains or granules dispersed throughout the web. The thickness, length and composition of the filaments and the type of adhesive binder and abrasive particles may be selected depending upon the intended application of the abrasive product. Webs of that type are disclosed, for example, in US 2,958,593, US 4,227,350, US 5,928,070 and US 6,302,930. An example of a non-woven abrasive material is the product commercially known as Scotch-BriteTM abrasive material, available from 3M Company of St. Paul, Minnesota, USA.

In another embodiment, the abrasive part is non-porous (for example it may be made of a coated abrasive material) the molten polymeric material of the backing adhering to the abrasive part. Coated abrasive articles generally comprise a substrate, which is often non-porous, to which a plurality of abrasive particles are bonded by suitable bond systems. Various coated abrasives are known to the person skilled in the art.

The abrasive part may be a disc. Alternatively, the abrasive part comprises a plurality of abrasive elements in a disc-like arrangement. The abrasive elements can be substantially planar flaps, each having a part which is fixed to the backing. Typically, the flaps extend obliquely away from the backing and the plane of each flap extends radially outwardly. Optionally, at least one of the abrasive elements can be made of a first material, such as non-woven fibres, and at least one of the abrasive elements can be made of a second material, such as a non-porous material. The two kinds of abrasive elements may be arranged to alternate.

These embodiments of the invention are advantageous since they can economically provide flap discs.

The abrasive article may have an aperture/thread formed generally at its centre for receiving a rotatable shaft which is mountable to a driven tool.

The method of making the abrasive article may further comprise the steps of providing a mould having first and second mould plates which together define a mould cavity, placing said abrasive part in the mould cavity, placing the restricting layer on the abrasive part, and injecting molten polymeric material into the mould cavity to form the backing.

- 5 Preferably, one of the mould plates is formed with a channel through which the molten polymeric material is injected.

In some embodiments of the invention, a predetermined amount only of molten polymeric material is injected.

- 10 If a thermoplastic material is used to form the backing, the selection of one suitable for a given use from the range available will be apparent to those skilled in the art. The material is selected so that it will have a suitable viscosity at the injection temperature, generally 200 to 280°C. Exemplary thermoplastic materials include thermoplastic polyether ester elastomer block copolymers comprising hard (crystalline) segments of polybutylene terephthalate and soft (amorphous) segments based on long-chain
15 polymether glycols commercially available from DuPont under the trade name HYTREL; polyamides such as nylon 66 e.g. commercially available from LATI Industria Termoplastica S.p.A. under the trade name LATAMID and polyolefins, such as polyethylene and polypropylene. The thermoplastic material may optionally contain filler and/or reinforcing fibres.

- 20 The injected material need not, however, be a thermoplastic material: other polymeric materials suitable for injection moulding could be used including thermoset materials and blocked epoxy resins.

- Suitable injection moulding machines for use in the invention are well known and may have vertical or horizontal orientations. A vertical orientation moulding machine provides
25 an advantage since it facilitates controlling of the spread of the molten polymeric material. Suitable injection moulding machines are commercially available from Arburg GmbH under the trade name ALLROUNDER. Horizontal injection moulding machines are widely available and may also be used. As described below, in some cases the machine

selected should be capable (following adaptation if necessary), of injecting only a specific, predetermined, amount of molten polymeric material.

Embodiments of the invention will now be described, by way of example only, with reference to the following drawings in which:

5 Figure 1 is a diagrammatic perspective view of an abrasive article according to one embodiment of the invention;

Figure 1A is an enlarged cross-section on the line 1A-1A of Figure 1;

Figure 2 is a diagrammatic section through a mould used to make the article of Figure 1; and

10 Figure 3 is a perspective view of another abrasive article according to the invention.

The abrasive article of Figure 1 has an abrasive part 1 fixed to a backing 2. The abrasive part 1 is a disc of non-woven abrasive material, for example the above-mentioned Scotch-Brite™ abrasive material, and the backing 2 (which is also generally disc-shaped and of substantially the same diameter as the abrasive disc 1) is made of injection moulded thermoplastic material. The article has a bore 3 generally through its centre so that it can be mounted to a rotatable shaft and can then be used on a rotary tool. The article is made by placing the disc 1 in a mould cavity defined by first 4 and second 5 mould plates, as shown in Figure 2. A restricting layer, or scrim 6, is placed over the disc 1, the mould is closed and a pre-selected amount of molten thermoplastic material is injected through a channel 7 in the first mould plate 4. Molten thermoplastic material fills the space 9 in the cavity and is allowed to cool, thus forming a backing 2 which, as described in greater detail below, is fixed to the disc 1. During the moulding operation, a suitably-shaped pin 5A on the second mould plate 5 projects into the central aperture in the abrasive disc 1 to prevent the injected thermoplastic material from entering the bore.

25 The scrim 6 is a mesh of Sefar™ Nitex™ 06-850/53 monofilament open mesh fabric composed of polyamide 6. The mesh opening is 850 micrometers, the filament has a diameter of 305 micrometers, and the fabric has a thickness of 555 micrometers. The

fabric is available from Sefar AG, Filtration Division, Moosstrasse 2, CH-8803, Rueschlikon, Switzerland.

The scrim causes the molten thermoplastic material to spread over the disc 1 before it penetrates substantially into the non-woven material. Without the scrim, it has been found
5 that molten thermoplastic material may preferentially penetrate into the surface of the disc in which case it does not fill the full space 9 in the cavity to form a satisfactory backing.

While the scrim 6 encourages the thermoplastic material to spread over the abrasive part 1, it also allows thermoplastic material to pass through the scrim and penetrate into the non-woven material of the disc, filling the some of the interstices 10 in the disc. Therefore,
10 upon cooling, the thermoplastic material forms integrally with the abrasive part, such that the backing is fixed to the disc as illustrated in the cross-sectional detail of Figure 1A.

As an additional aid to improving the distribution of the thermoplastic material over the surface of the disc 1, several injection channels may be provided in the mould plate 4 rather than the single channel 7 as illustrated.

15 When the completed abrasive article has been removed from the mould cavity, the bore 3 is formed in the backing by removing the thermoplastic material that covers the central aperture in the abrasive disc 1.

In a moulding process as described above with reference to Figs. 2, the amount of thermoplastic material that is injected into the space 9 in the mould cavity can be
20 controlled by means of a suitable valve (not shown) located in the channel 7 of the mould. The channel 7 is connected to a suitable supply of molten thermoplastic material under pressure so that, if the valve is opened for a predetermined interval of time, a predetermined amount of the thermoplastic material will be injected into the space 9, sufficient to form the backing 2 and to penetrate, to the desired extent, into the abrasive
25 material of the disc 1. The process thus differs from a conventional injection moulding process in which the injection of molten thermoplastic material into the mould would continue until the mould cavity has been filled. The process may, nevertheless, be carried out using a conventional injection moulding machine suitably-adapted for the purpose although, because the mould cavity is never filled with the injected thermoplastic material,

it is not actually essential for the mould to be closed. Through the use of such a process, it can be ensured that the injected thermoplastic material does not permeate throughout the abrasive material of the flaps 1 and, because the abrasive material is not subjected to the high pressures normally generated in the mould cavity of an injection moulding machine, the risk of structural damage to the abrasive material is minimized.

The valve used to control the amount of thermoplastic material injected into the space 9 of the mould cavity may be of any suitable type, one being an electromagnetically-controlled needle valve known for use in sprueless injection moulding. A suitable valve is an electromagnetic needle valve available, under the trade name "Z 1081" from HASCO Hasenclever GmbH + Co KG of Lüdenscheid, Germany. The opening of the valve can be controlled by the injection machine itself.

Another abrasive article in accordance with this invention can be seen in Figure 3. This article is a flap disc which comprises a plurality of abrasive elements 11 formed of a coated abrasive material which is non-porous. The abrasive elements are generally planar, rectangular flaps arranged in a circle to form a disc, with each flap being fixed to a backing 12 made of injection moulded plastic. The backing 12 is also generally disc-shaped. The flaps 11 extend generally radially outwards in the disc, with their planes making an oblique angle with the backing, and with adjacent flaps overlapping each other. The inner side edges of the flaps 11 define a central opening, aligned with a bore 13 in the backing 12 for receiving a rotatable shaft for attachment to a rotary tool.

As already mentioned, the backing 12 is generally disc-shaped, to correspond to the arrangement of the flaps 11. The backing 12 provides a support for the flaps and imparts rigidity to the abrasive article. Although the backing is substantially co-extensive with the arrangement of flaps, it does not fully cover the flaps. Accordingly, the outer edges of the flaps are not covered by the backing.

The method of making the flap disc of Figure 3 is similar to the method of making the abrasive article of Figure 1. The individual flaps are placed in the mould cavity formed by two mould plates and arranged in a circle (not shown). A scrim is placed on the arrangement of flaps to stop the molten thermoplastic material sticking to the flaps in the region where the plastic material is injected before it has spread out over the flaps.

The mould is closed and molten thermoplastic material is injected through a channel formed in the first mould plate. In this case, because the flaps 11 are non-porous, it is not necessary to pre-select the amount of material that is injected. Molten thermoplastic material is injected to fill the space in the mould cavity and is allowed to cool, thus forming a backing. The molten thermoplastic material adheres to the surface of the flaps, thus forming the backing integrally with the flaps.

When the completed flap disc has been removed from the mould cavity, the bore 13 is formed in the backing by removing thermoplastic material covering the central aperture in the circular arrangement of flaps 11.

The invention can cover various alternatives not described here. For example, the abrasive part and/or backing can have various different shapes and sizes, and can be made of other suitable materials.

The backing, for example, need not be circular but could, as an alternative, comprise several arms that extend from the centre over the abrasive part in the shape of a star: the arms will typically have a similar radial extent to that of the abrasive part. The backing need not be flat as shown in the drawings but could have any shape known to be suitable for products of this type and capable of being formed by an injection-moulding process: as an example, the backing could have a generally dome-shaped central region surrounding the shaft-receiving aperture 3, 13.

An alternative form of the abrasive part could, for example, comprise a plurality of flaps of abrasive material positioned vertically and arranged in a ring with a major face of one flap positioned adjacent a major face of another flap. In that case, the injection-moulded backing would be attached to the upper edges of the flaps.

Different features of the different embodiments can be used in combination as appropriate.

CLAIMS

1. A method of making an abrasive article comprising an abrasive part and a backing fixed to the abrasive part to provide for attachment of the abrasive article at a central location to a rotatable shaft of a driven tool, wherein the abrasive part comprises a substrate having abrasive characteristics, the method comprising placing a restricting layer
5 adjacent the abrasive part, injecting molten polymeric material onto the restricting layer, the restricting layer causing the polymeric material to spread over the abrasive part, and allowing the polymeric material to cool while remaining in contact with the abrasive part to form the backing.
- 10 2. A method as claimed in claim 1, wherein the backing is substantially co-extensive with the abrasive part.
3. A method as claimed in claim 1 or claim 2, wherein the abrasive part further comprises a plurality of abrasive particles bonded to the substrate.
4. A method as claimed in any one of the preceding claims, wherein said substrate
15 comprises non-woven fibres, the molten polymeric material penetrating into interstices between the fibres, which fixes the backing to the abrasive part.
5. A method as claimed in claim 4, in which a predetermined amount only of polymeric material is injected onto the restricting layer.
6. A method as claimed in claim 1 or claim 2, wherein said substrate is non-porous,
20 the molten polymeric material of the backing adhering to the abrasive part.
7. A method as claimed in claim 6, wherein the abrasive part is a coated abrasive material.
8. A method as claimed in any one of the preceding claims, wherein the restricting layer is a mesh.
- 25 9. An abrasive article comprising an abrasive part including a substrate to which a plurality of abrasive particles are bonded, and a backing made of injected polymeric

material, the backing being fixed directly to the abrasive part by the method of any one of the preceding claims.

5

10

15

1/2

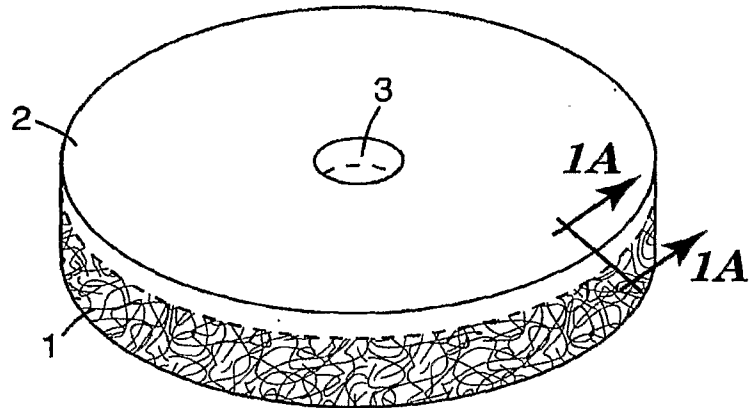


Fig. 1

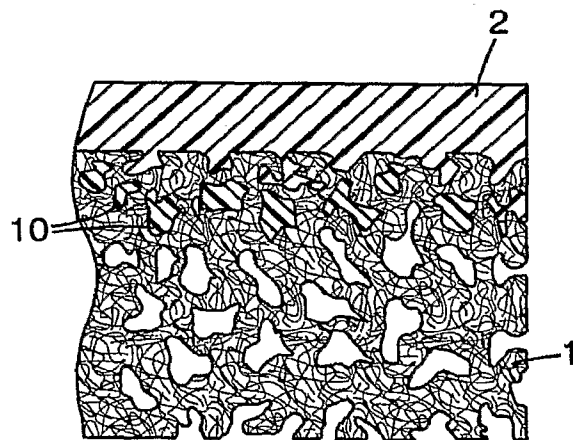


Fig. 1A

2/2

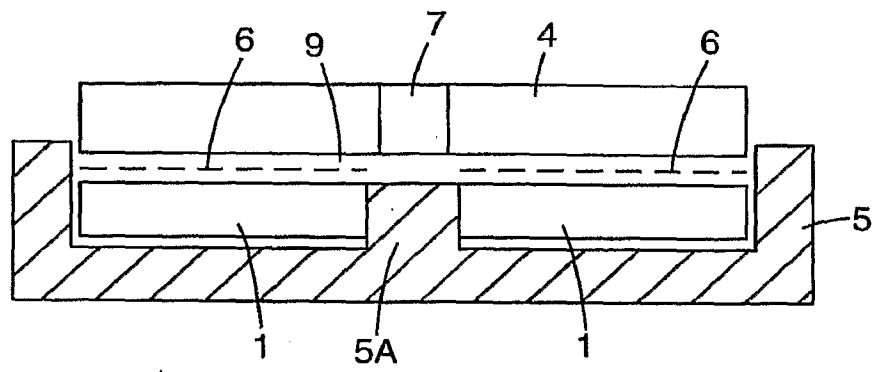


Fig. 2

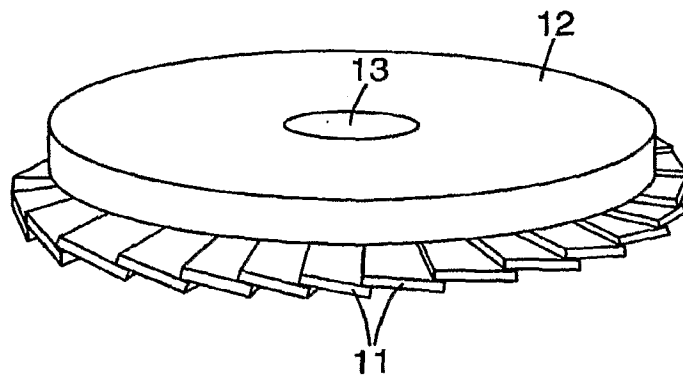


Fig. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2007/004107**A. CLASSIFICATION OF SUBJECT MATTER****B24D 18/00(2006.01)i, B24D 7/00(2006.01)i**

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 8: B24D 18/00

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

Korean Utility Models and applications for Utility Models since 1975

Japanese Utility Models and applications for Utility Models since 1975

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

eKIPASS (KIPO internal) "abrasive", "backing", "polymeric"

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 11-320423 A (SUMITOMO 3M LTD.) 24 NOVEMBER 1999 See Abstract; Figures 1 and 2	1-9
A	EP 0790880 B1 (NORTON COMPANY) 23 FEBRUARY 2000 See Claims 1, 2 and Figures 1 and 2	1-9
A	US 2001/0011108 A1 (3M INNOVATIVE PROPERTIES COMPANY) 2 AUGUST 2001 See Paragraph [0033] - Paragraph [0048]; Figure 1	1-9
A	KR 10-2002-0095941 A (HYUNG-RAE JO) 28 DECEMBER 2002 See Figure 1	1-9

☐ Further documents are listed in the continuation of Box C.☒ See patent family 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 application or patent 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 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

25 JULY 2007 (25.07.2007)

Date of mailing of the international search report

25 JULY 2007 (25.07.2007)

Name and mailing address of the ISA/KR

Korean Intellectual Property Office
920 Dunsan-dong, Seo-gu, Daejeon 302-701,
Republic of Korea

Facsimile No. 82-42-472-7140

Authorized officer

PARK, TAE WOOK

Telephone No. 82-42-481-5451



INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2007/004107**Box No. 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.:
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:
3. ☒ Claims Nos.: 4, 8, 9
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. 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 and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2007/004107

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 11-320423 A	24 NOVEMBER 1999	NONE	
EP 0790880 B1	23 FEBRUARY 2000	AU 3278695 A1 BR 9509602 A AT 189871 E CA 2203427 C CN 1081111 C CZ 9701308 A3 DE 69515180 C0 FI 971965 A JP 09-512756 A KR 10-1997-0706944 A NZ 291602 A RU 2139786 C1 US 5525100 A WO 9614964 A1	6 JUNE 1996 16 SEPTEMBER 1997 15 MARCH 2000 23 MAY 2000 20 MARCH 2002 13 AUGUST 1997 30 MARCH 2000 7 MAY 1997 22 DECEMBER 1997 1 DECEMBER 1997 22 SEPTEMBER 1997 20 OCTOBER 1999 11 JUNE 1996 23 MAY 1996
US 2001/0011108 A1	2 AUGUST 2001	NONE	
KR 10-2002-0095941 A	28 DECEMBER 2002	NONE	