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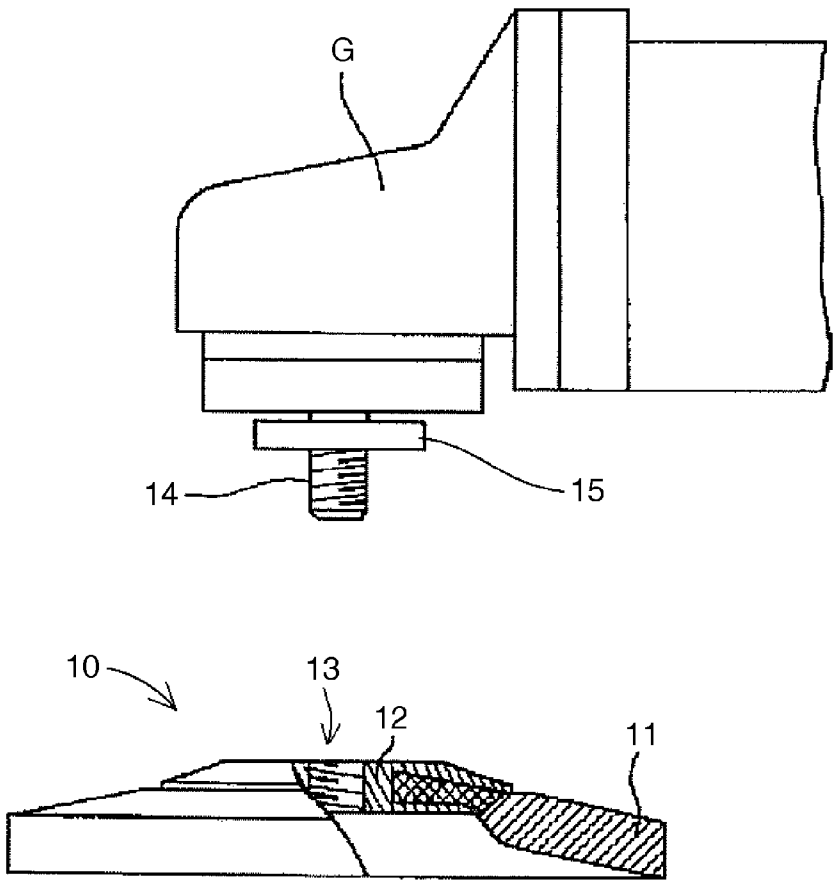
[Continued on next page]

(54) Title: ABRASIVE DISC



(57) Abstract: To provide an abrasive disc which has a small size in the thickness direction and, therefore, can grind objects easily even if they are narrow portions or side walls of grooves and which has a strength enough for resisting the force applied during grinding. Means for Solution. An abrasive disc which comprises a disc-shaped laminate comprising a layer of a nonwoven abrasive material, a layer of a reinforcing fabric connected to one side of the layer of the nonwoven abrasive material, a central opening, an almost flat front surface and an almost flat back surface; and a grinder-mounting resin portion, the grinder-mounting resin portion being formed integrally with the disc-shaped laminate by insert-molding a resin at the peripheral portion of the central opening in the disc-shaped laminate.

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ABRASIVE DISC

Field of Invention

[0001] The present invention relates to abrasive discs, particularly to abrasive discs to be used while being mounted to the output shafts (rotating shafts) of disc grinders.

Background

[0002] Japanese Patent Laid-Open Publication No. H11(1999)-320423 discloses an abrasive disc in which a grinder-mounting resin portion and a nonwoven abrasive material are formed integrally. In Fig. 1, a partial sectional side view of this abrasive disc 10 is shown. The abrasive disc of Fig. 1 has an umbrella-shaped nonwoven abrasive material 11 and a grinder-mounting resin portion 12 with a central opening. The grinder-mounting resin portion 12 is connected, at its outer peripheral portion, with the inner peripheral portion of the nonwoven abrasive material 11.

[0003] The grinder-mounting resin portion 12 has a grinder-mounting hole 13 and the inner peripheral wall of the grinder-mounting hole has screw threads so as to function as a nut. An output shaft 14 of a disc grinder G is screwed into the grinder-mounting hole 13 with a washer 15 and the like, so that the abrasive disc 10 is fixed to the disc grinder G.

[0004] This abrasive disc does not need to use a backup pad during grinding. It, therefore, is light and compact and excels in drive energy efficiency, workability, etc.

[0005] In this abrasive disc, however, the nonwoven abrasive material 11 is shaped like an umbrella and the grinder-mounting resin portion 12 projects in the mounting direction. Therefore, the size in the thickness direction is not

reduced so much as compared with the case where a backup pad is used. Therefore, a wide work space is needed during a grinding operation and it is difficult to grind narrow portions or side walls of grooves.

[0006] Further, the grinder-mounting resin portion 12 has a large radius, and the connecting portion which grasping the nonwoven abrasive material 11 occupies about 1/2 of the diameter of the nonwoven abrasive material 11. If the connecting portion is wide, the amount of the nonwoven abrasive material which can be used for grinding work will be small, resulting in a somewhat short working life of the abrasive disc.

[0007] If the shape of the nonwoven abrasive material 11 is only made flat in order to lessen the size in the thickness direction, the strength of the abrasive disc will be insufficient and the abrasive disc may be broken due to grinding stress. Further, if the radius of the grinder-mounting resin portion 12 is reduced, the width of the connecting portion with the nonwoven abrasive material 11 will be narrower and, therefore, the connecting portion may be separated due to grinding stress.

[0008] On the other hand, Japanese Translation of PCT International Application No. 10-511749 and Japanese Patent Laid-Open Publication No. H5(1993)-229071 disclose methods for connecting a nonwoven fabric and a reinforcing fabric. Laminats prepared by such methods are excellent in strength to dynamic loads and are used as products for surface finishing.

Summary of the Invention

[0009] The present invention intends to solve the aforementioned existing problems. An object of the present invention is to provide an abrasive disc

which has a small size in the thickness direction and, therefore, can grind objects easily even if they are narrow portions or side walls of grooves and which has a strength enough for resisting the force applied during grinding.

Means for Solving Problems

[0010] The present invention provides an abrasive disc which comprises:

a disc-shaped laminate comprising a layer of a nonwoven abrasive material, a layer of a reinforcing fabric connected to one side of the layer of the nonwoven abrasive material, a central opening, an almost flat front surface and an almost flat back surface; and

a grinder-mounting resin portion, the grinder-mounting resin portion being formed integrally with the disc-shaped laminate by insert-molding a resin at the peripheral portion of the central opening in the disc-shaped laminate. This can attain the above-mentioned object.

[0011] The abrasive disc of the present invention has a small size in the thickness direction and, therefore, can grind objects easily even if they are narrow portions or side walls of grooves. Moreover, it has a strength enough for resisting the force applied during grinding.

Brief Description of the Drawings

[0012] Fig. 1 is a partial sectional side view of a conventional abrasive disc.

Figs. 2a and 2b are a sectional view and a front view showing one example of the constitution of the abrasive disc of the present invention.

Fig 3 is a sectional view showing one example of the constitution of the abrasive disc of the present invention.

Fig. 4 is a sectional view showing one constitution example of a

laminate of a nonwoven abrasive material and a reinforcing fabric used in the present invention.

Detailed Description

[0013] Abrasive Disc

Fig. 2 shows one example of the constitution of the abrasive disc of the present invention. Fig. 2 (a) is a sectional view and Fig. 2 (b) is a front view.

[0014] This abrasive disc has a disc-shaped laminate 1 and a grinder-mounting resin portion 2. The disc-shaped laminate 1 is an article prepared by making a nonwoven abrasive material 3 and a reinforcing fabric 4 overlapped and connecting them. The disc-shaped laminate 1 has a front surface and a back surface, both of which are almost flat, and has a central opening 5. The grinder-mounting resin portion 2 is integrally formed at the peripheral portion of the central opening. The grinder-mounting resin portion 2 has a grinder-mounting hole 6 and the inner peripheral wall of the grinder-mounting hole 6 has screw threads so as to function as a nut.

[0015] The abrasive disc of the present invention has a disc-shaped laminate 1 in which a reinforcing fabric 4 has been connected with a nonwoven abrasive material 3. The reinforcing fabric 4 is a stretch resistant woven fabric and it exhibits a low stretch value when being drawn. Therefore, the disc-shaped laminate 1 has an increased tensile strength and rigidity in comparison with the nonwoven abrasive material 3. For this reason, the abrasive disc of the present invention can withstand grinding stress even if it is not molded in an umbrella-like form.

[0016] Further, the reinforcing fabric 4 also increases the strength of the

central opening 5 of the disc-shaped laminate. This results in increase in the force connecting to the grinder-mounting resin portion. Therefore, in the abrasive disc of the present invention, separation in the connecting portion will not occur during grinding even if the radius of the grinder-mounting resin portion 2 is made small.

[0017] For example, when the outer diameter of the abrasive disc is from about 75 to about 125 mm, the outer diameter of the grinder-mounting resin portion 2 may be around the same as the outer diameter of the washer of a grinder. Typically, it is about 20 to about 40 mm in diameter, for example about 30 mm.

[0018] Further, the front surface and the back surface of the abrasive disc of the present invention are almost flat. Therefore, two abrasive discs may be laminated and connected together back-to-back. The two abrasive discs may be connected by adhering exposed surfaces of the reinforcing fabrics 4 each other, with an appropriate binder. Fig. 3 is a sectional view showing one example of the constitution of the abrasive disc. The abrasive disc has a front surface and a back surface both as abrasive faces. It can grind facing side walls such as both side walls of a groove in a single grinding operation.

[0019] Nonwoven abrasive material

The nonwoven abrasive material is an abrasive material prepared by using a nonwoven fabric as a base material and fixing abrasive particles to the surface of fibers forming the nonwoven fabric with a binder. Nonwoven abrasive material is used for removing corrosions, defects, burrs and the like in the surfaces of articles made of metal, wood, plastics or the like or finishing surfaces into desired conditions.

[0020] The nonwoven fabric comprises a lofty web made of suitable synthetic fibers such as nylon and polyester. The nonwoven fabric preferably is capable of withstanding the temperatures at which impregnating resins and adhesive binders are cured without deterioration. The fibers of the nonwoven fabric are preferably tensilized and crimped and also may be continuous filaments formed by a spunbond process such as that described in United States Patent No. 4,227,350, for example. Fibers which are satisfactory for use in the nonwoven fabric are between about 20 mm and about 100 mm and preferably between about 40 mm and about 65 mm in length and have a denier ranging from about 1.5 to about 500 and, preferably, from about 15 to about 100.

[0021] The nonwoven fabric is readily formed on a "Rando webber" machine commercially available from Rando Machine Company, New York or may be formed by other conventional carding processes. Where a spunbond-type nonwoven material is employed, the filaments may be of substantially larger diameter, for example, up to 2 mm or more in diameter. The use of larger diameter fibers permits the employment of relatively large abrasive particles in the finished article. Useful nonwoven fabrics preferably have a weight per unit area of at least about 100 g/m^2, and more preferably about 250 g/m^2. Relatively less amounts of fiber within the nonwoven fabric will provide articles having somewhat shorter working life. The foregoing fiber weights typically will provide a nonwoven fabric, before needling or impregnation, having a thickness from about 6 mm to about 75 mm, and preferably about 25 mm. Commercially available nonwoven fabrics suitable for use in the invention include those identified in the examples provided below.

[0022] The nonwoven fabric may optionally be further reinforced and

consolidated by needle tacking, a treatment which mechanically strengthens the nonwoven fabric by passing barbed needles therethrough. During this treatment, the needle pulls fibers of the nonwoven fabric together with the needle and passes through the nonwoven fabric. Therefore, when the needle is pulled, each aggregate of fibers of the nonwoven fabric moves in the thickness direction of the nonwoven fabric. The amount or degree of needle tacking may include the use of about 8 to about 20 needle penetrations per square centimeter of fabric surface when 15 × 18 × 25 × 3.5 RB, F20 6-32-5.5B/3B/2E/L90 needles commercially available from Foster Needle Company, Manitowoc, Wisconsin are used. Needle tacking is readily accomplished by use of a conventional needle loom which is commercially available from, for example, Dilo, Inc., North Carolina.

[0023] Following the optional needle tacking step, the nonwoven fabric is impregnated either with a resin-abrasive slurry or a resin binder (e.g., without abrasive particles) depending upon the required strength of the finished article. The nonwoven fabric is thoroughly saturated with the resin-abrasive slurry or the resin binder using any of a number of conventional application techniques, such as spray coating, dip-coating, or roll coating using a two-roll coater. The resins preferred for use in coating the nonwoven fabric are those which, after curing, will be relatively hard and which will provide firm bonding of the constituent fibers to one another. Specific examples of resins that are useful in the present invention include phenolic resins, aminoplast resins having pendant α,β-unsaturated carbonyl groups, urethane resins, epoxy resins, ethylenically unsaturated resins, acrylated isocyanurate resins, urea-formaldehyde resins, isocyanurate resins, acrylated urethane resins,

acrylated epoxy resins, bismaleimide resins, fluorine-modified epoxy resins, and combinations thereof. Catalyst and/or curing agents may be added to the binder precursor to induce and/or eliminate polymerization. Preferably, the binders used in the present invention are phenolic resins such as resole and novolac resins, described in Kirk-Othmer, Encyclopedia of Chemical Technology, Third Edition, Volume 17, pages 384-399, 1981, issued by John Wiley and Sons, New York, incorporated by reference herein. Resole phenolic resins are made from an alkaline catalyst and a molar excess of formaldehyde, typically having a molar ratio of formaldehyde to phenol between about 1.0:1.0 and 3.0:1.0. Novolac resins are prepared under acid catalysis and with a molar ratio of formaldehyde to phenol less than 1.0:1.0. Commercially available phenolic resins suitable for use in the present invention include those known under the trade designations "Durez" and "Varcum," commercially available from Occidental Chemicals Corporation (N Tonawanda, New York); "Resinox," commercially available from Monsanto Corporation; and "Arofene" and "Arotap," both commercially available from Ashland Chemical Company.

[0024] Each of the front and/or the back of the nonwoven fabric is coated with the aforementioned resin binder which may include any abrasive particles. Abrasive particles can also be applied in a separate step after the application of the resin binder to the nonwoven fabric. Abrasive particles suitable for use herein are preferably of 24 grade or finer, such as those normally used for finishing operations. Suitable abrasive particles include aluminum oxide including ceramic aluminum oxide, heat-treated aluminum oxide and white fused aluminum oxide; silicone carbide, alumina zirconia, diamond, ceria, cubic boron nitride, garnet, flint, emery and combinations of the foregoing.

Additionally, abrasive agglomerates can be used such as those described in United States Patent Nos. 4,652,275 and 4,799,939, the disclosures of which are incorporated herein by reference.

[0025] Reinforcing fabric

The reinforcing fabric is a woven stretch resistant fabric which exhibits a low stretch value when being pulled. The stretch value is preferably less than about 20%, and more preferably less than about 15%. Nonlimiting examples of suitable materials for use as the reinforcing fabric in the articles of the invention include thermobonded fabrics, knitted fabrics and stitch-bonded fabrics.

[0026] One aspect of the present invention is use of a reinforcing fabric composed of woven fabric having openings. Where nylon 6 is used, the reinforcing fabric is preferably composed of plain weave fabric having openings between the warp and fill yarns of about 0.10 mm^2. A plain weave fabric having 16 warp yarns and 16 fill yarns per inch (e.g., 16 x 16) of 840 denier nylon 6,6 yarns and having a fabric weight of 149 g/m^2 (4.4 $oz./g^2$) is most preferred for use with a nylon 6 polymer. Such a material is commercially available from Highland Industries of Greensboro, North Carolina.

[0027] Other materials may be used such as those made of polyester, cotton, animal hair, other polyamides, and the like. Preferably, at least one layer of woven stretch resistant reinforcing fabric is included within the disc-shaped laminate. The dimensional strength may be enhanced by use of other layers (not shown) of the fabric.

[0028] Disc-shaped laminate

A disc-shaped laminate is obtained by cutting a nonwoven abrasive

material and a reinforcing fabric into a circular shape, providing central openings therein, and laminating and connecting them. Alternatively, the nonwoven abrasive material and the reinforcing fabric may be laminated and connected and then cut into a circular shape, followed by forming a central opening. The method for connecting the nonwoven abrasive material and the reinforcing fabric is not limited particularly. For example, they may be stuck together using a suitable adhesive. Alternatively, they may be connected by the methods disclosed in patent document 2 or 3.

[0029] A particularly preferable method for connecting the nonwoven abrasive material and the reinforcing fabric is one disclosed in patent document 2. This method connects a reinforcing fabric and a nonwoven abrasive material by putting the reinforcing fabric on the nonwoven abrasive material, applying a resin liquid from an exposed surface of the reinforcing fabric, making the resin liquid permeate the reinforcing fabric and the nonwoven abrasive material, and then solidifying the resin liquid.

[0030] Fig. 4 is a sectional view showing the structure of a laminate of a nonwoven abrasive material and a reinforcing fabric connected by the method disclosed in patent document 2. In this laminate, the nonwoven abrasive material 3 and the reinforcing fabric 4 are laminated and a resin layer 7 is disposed on an exposed surface of the reinforcing fabric 4. The resin layer 7 has a flexible low-friction surface 7a and a portion 7b which passes openings (interstitial spaces) present in the reinforcing fabric 4, runs along the border plane between the nonwoven abrasive material 3 and the reinforcing fabric 4, and encapsulates constituent fibers of the nonwoven abrasive material 3.

[0031] Preferably, the resin is applied as a hardenable coatable composition

in the form of a viscous fluid, and typically in a molten state. With the application of pressure, the coatable composition will be extruded through the openings in the reinforcing fabric 4 into the nonwoven abrasive material 3. In this manner, the molten resin flows around the major surface of the nonwoven abrasive material 3 and encapsulates fibers. The resin is then hardened in a known manner to form a reinforcing, thick, continuous resin layer 7, forming an outer surface of the article. Preferably, the resin is applied and hardened without significant penetration through the remainder portion of the nonwoven abrasive material 3.

[0032] The resin layer 7 generally has a Shore D hardness of from about 60 to about 90, and preferably from about 70 to 80. When the hardness of the resin layer 7 is less than about 60 in Shore D, bending of the abrasive disk under working load becomes large, and the abrasive efficiency becomes poor. Whereas when the hardness of the resin layer 7 is more than about 90 in Shore D, brittleness of the abrasive disk becomes high, and it becomes easy to break during abrasive work.

[0033] Preferably, the constituent resin of the resin layer 7 is a melt extruded resin, which may contain compatible fillers, pigments, reinforcing fibers, antioxidants, and the like. Suitable melt extrudable resins include thermoplastic resins such as nylons, polyesters, polypropylene, ethylene/vinyl acetate copolymers, and acrylic acid/butadiene/styrene copolymers. Thermoplastic elastomers such as ionomers, polyesters, polyurethanes, and polyamide ethers are also suitable melt extrudable resins. The resin layer can be formed from the polymerization of liquid reactants in the coatable composition described above and, useful reactive resin systems include

thermal or radiation cured urethane, polyester and epoxy resins.

[0034] Grinder-mounting resin portion

It is preferable that the grinder-mounting resin portion be formed integrally with a laminate by insert-molding a resin at the peripheral portion of the central opening in the disc-shaped laminate. Insert molding is a method which includes putting an insert member (in this case, the disc-shaped laminate) in a mold, then pouring a molten resin, and solidifying the resin while encapsulating the insert member therein, thereby forming an integrated composite material.

[0035] The disc-shaped laminate is lofty and contains interstitial spaces between its constituent fibers. Therefore, in the outer peripheral portion of the grinder-mounting resin portion, the grinder-mounting resin portion and the disc-shaped laminate are connected through penetration of the resin of the grinder-mounting resin portion into interstitial spaces between constituent fibers of the disc-shaped laminate and solidification of the resin during the insert-molding. Specific operations are substantially the same as those of the method disclosed in patent document 1. It should be noted that the mold used is modified in shape so that the grinder-mounting resin portion does not project in the mounting direction and becomes flat along both the front surface and the back surface of the disc-shaped laminate.

[0036] The grinder-mounting resin portion is preferably formed of hard thermoplastic resin, examples of which include ABS, nylons and polyester resins. A particularly preferable thermoplastic resin is nylon 6,6. In order to reinforcing the inner peripheral wall with screw threads, etc., glass fibers may be mixed with the resin. The content of glass fibers is from about 10 to about

60% by weight, and preferably about 45% by weight.

[0037] The grinder-mounting resin portion formed has a tensile strength of from about 150 to about 250 MPa, for example, about 220 MPa, and a bending strength of from about 220 to about 340 MPa, for example, about 300 MPa, as physical properties under the dry circumstance and the ambient temperature. The thickness of the grinder-mounting resin portion is adjusted to almost the same as that of the disc-shaped laminate. Typically, it is from about 2 to about 15 mm, for example, about 5 mm.

CLAIMS

1. An abrasive disc which comprises:

a disc-shaped laminate 1 comprising a layer of a nonwoven abrasive material 3, a layer of a reinforcing fabric 4 connected to one side of the layer of the nonwoven abrasive material, a central opening 5, an almost flat front surface and an almost flat back surface; and

a grinder-mounting resin portion 2, the grinder-mounting resin portion being formed integrally with the disc-shaped laminate 1 by insert-molding a resin at the peripheral portion of the central opening in the disc-shaped laminate 1.

2. An abrasive disc which comprises two abrasive discs according to claim 1, wherein these abrasive discs are laminated and connected together back-to-back.

3. The abrasive disc according to claim 1 or 2, wherein in the outer peripheral portion of the grinder-mounting resin portion 2, the grinder-mounting resin portion and the disc-shaped laminate has been connected through penetration of the resin of the grinder-mounting resin portion 2 into interstitial spaces between constituent fibers of the disc-shaped laminate and solidification of the resin during the insert-molding.

4. The abrasive disc according to any one of claims 1 to 3, wherein the grinder-mounting resin portion 2 has a grinder-mounting hole 6 and the inner peripheral wall of the grinder-mounting hole has screw threads so as to

function as a nut.

5. The abrasive disc according to any one of claims 1 to 4, wherein the disc-shaped laminate 1 is one in which the reinforcing fabric 4 and the nonwoven abrasive material 3 have been connected by applying a resin liquid from an exposed surface of the reinforcing fabric 4, making the resin liquid permeate the reinforcing fabric 4 and the nonwoven abrasive material 3, and then solidifying the resin liquid.

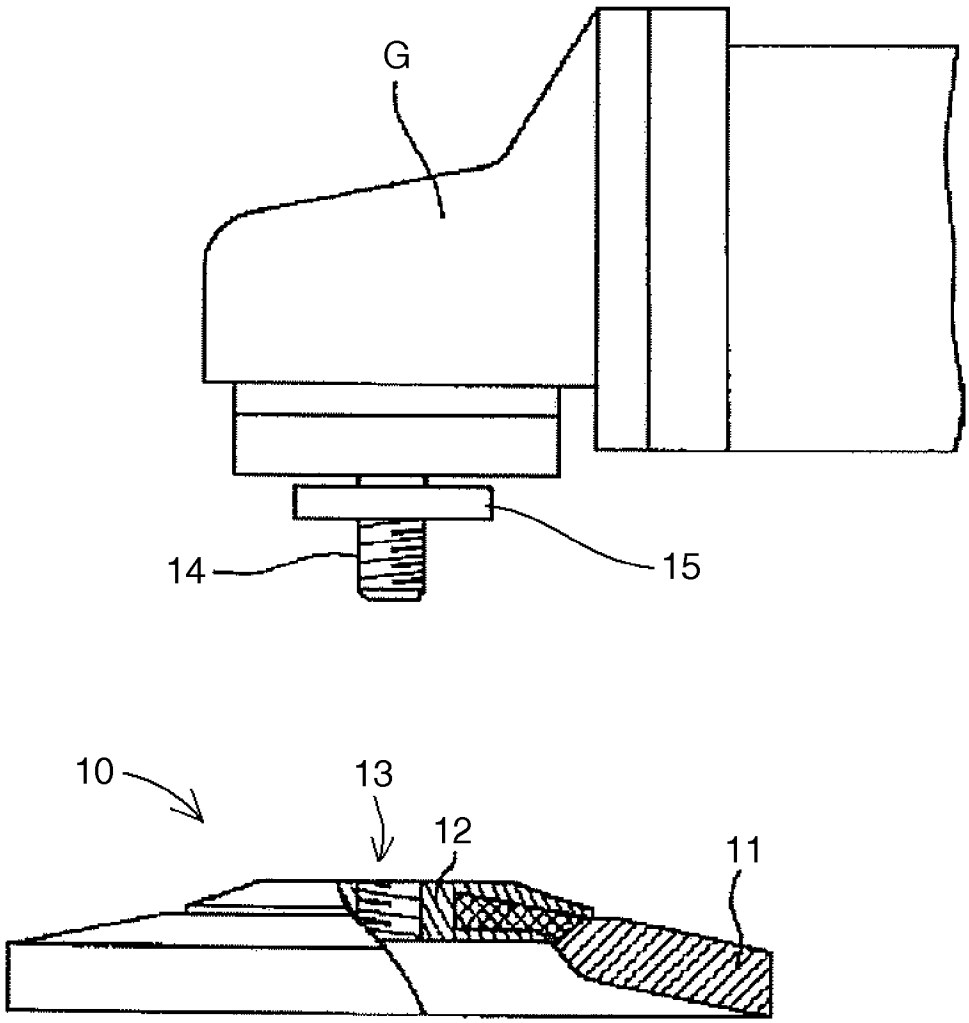

Fig. 1

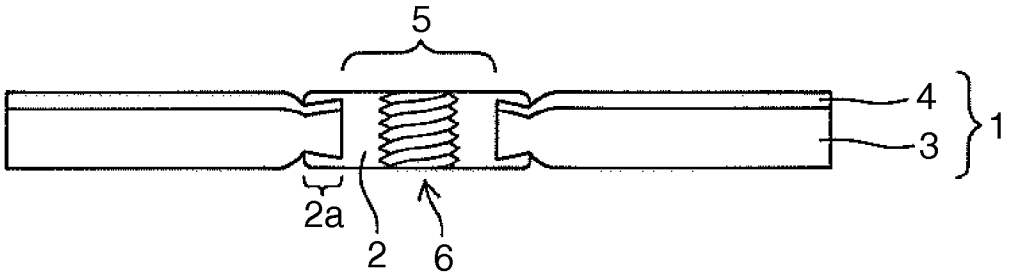

Fig. 2a

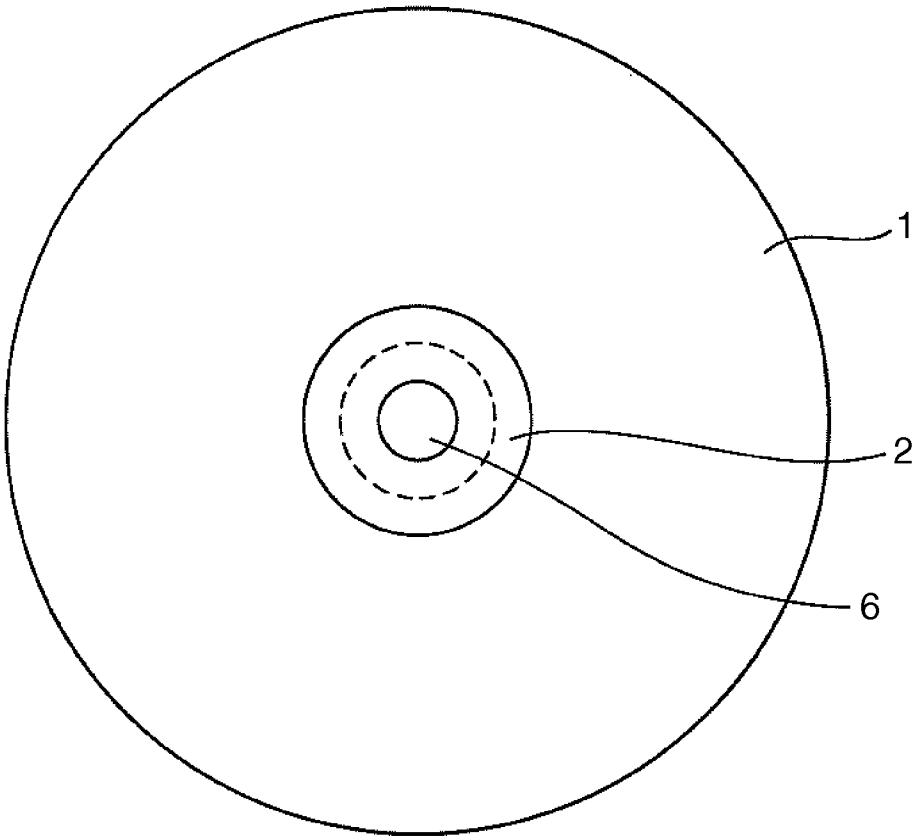

Fig. 2b

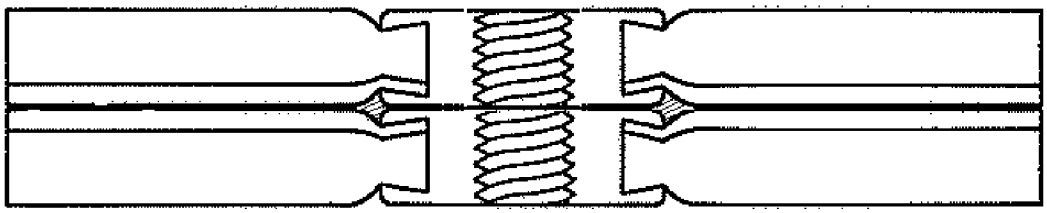

Fig. 3

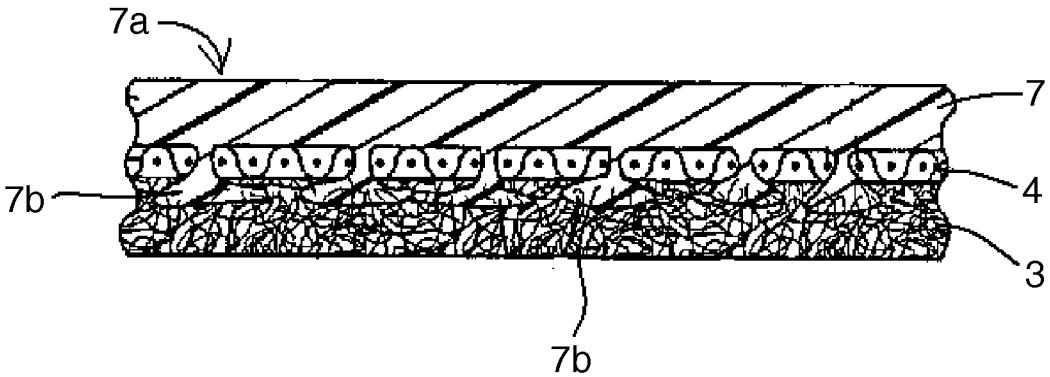

Fig. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2007/071189

A. CLASSIFICATION OF SUBJECT MATTER

B24D 7/00(2006.01)i, B24B 23/00(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 A47L 25/00, B24B 1/00,9/02, B24D 3/34, 11/00, 17/00, 13/04, B44D 5/00

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) & keywords: abrasive, disc, resin, nonwoven, layer, fabric

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6,261,156 B1(DAVID E. JOHNSON et. al.) 17 July 2001 see Column 5, Line 11 - Column 12, Line 24; Figure 3.	1-5
A	US 6,863,596 B2(PETER J. FRITZ et. al.) 08 March 2005 see Column 3, Line 55 - Column 5, Line 60, Figure 3.	1-5
A	US 3,991,526 B(BURTON E. FRANK et. al.) 16 November 1976 see Column 3, Line 50 - Column 4, Line 61; Figures 1-3.	1-5
A	US 6,638,144 B2(BRUCE A. SVENTEK et. al.) 28 October 2003 see Column 6, Line 55 - Column 8, Line 24; Figure 1.	1-5
A	US 5,996,167 A(THOMAS E. CLOSE) 07 December 1999 see Column 4, Line 42 - Column 5, Line 3; Figure 2.	1-5
A	US 5,876,470 A(GERALD R. ABRAHAMSON) 02 March 1999 see Column 2, Line 62 - Column 3, Line 26; Figure 2.	1-5

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:

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Date of the actual completion of the international search	Date of mailing of the international search report
19 NOVEMBER 2007 (19.11.2007)	**19 NOVEMBER 2007 (19.11.2007)**

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2007/071189

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 6,261,156	17-07-2001	None	
US 6,863,596	08-03-2005	CN1511077	07-07-2004
		EP1390177 A1	25-02-2004
		JP16527390 A	09-09-2004
		KR1020040003003 A	07-01-2004
		WO2002096603 A1	05-12-2002
US 3,991,526	16-11-1976	AU1382576 A1	17-11-1977
		CA1052577 A1	17-04-1979
		DE2621176 A1	25-11-1976
		ES447498 A5	16-08-1977
		FR2310838 B1	29-08-1980
		GB1533029 A	22-11-1978
		IT1061905 A	30-04-1983
		JP51137997 A	29-11-1976
		SE7605028 A	13-11-1976
		ZA7601832 A	30-03-1977
US 6,638,144	28-10-2003	None	
US 5,996,167	07-12-1999	EP861138 A1	02-09-1998
		US6251002 B1	26-06-2001
		WO9718059 A1	22-05-1997
US 5,876,470	02-03-1999	BR9810853 A	25-07-2000
		CA2296522 A	11-02-1999
		CN1265699 A	06-09-2000
		DE69807900 C0	17-10-2002
		EP1007599 A1	14-06-2000
		JP14506084 A	26-02-2002
		KR1020010022321 A	15-03-2001
		WO9906500 A1	11-02-1999