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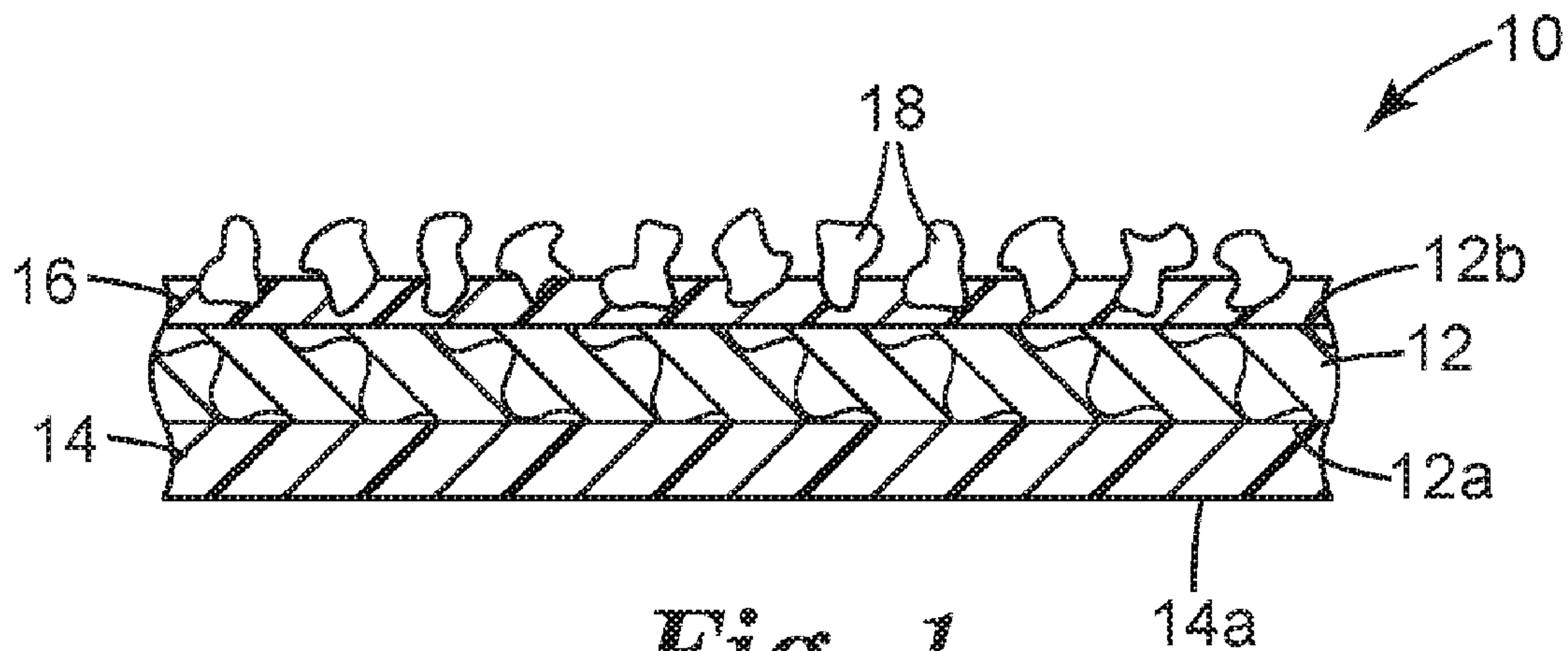


Fig. 1

(57) **Abrégé/Abstract:**

The present disclosure generally relates to abrasive articles for abrading a work surface such as, for example, flexible sheet-like abrasive articles, as well as methods of making and using such abrasive articles. Some embodiments of the abrasive articles include an improved, more heat resistant non-slip coating or layer.

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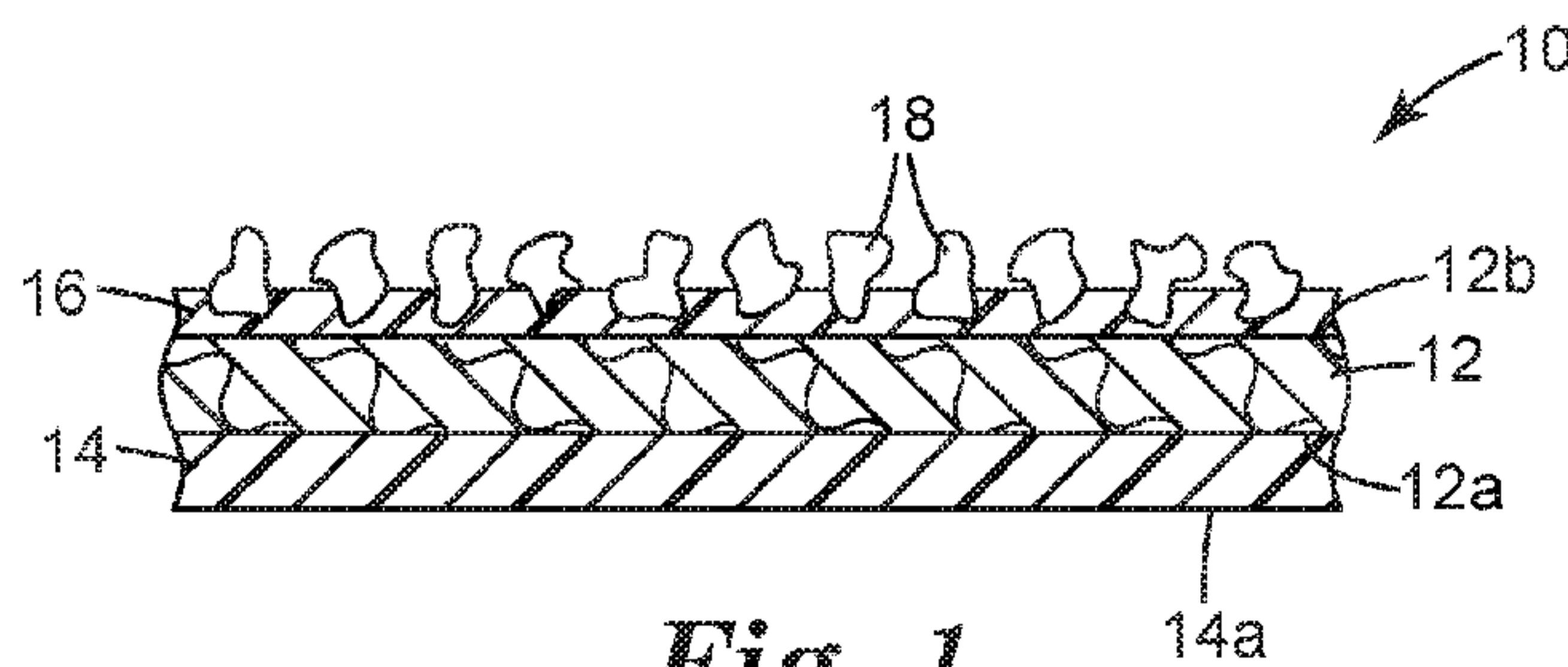


Fig. 1

(57) Abstract: The present disclosure generally relates to abrasive articles for abrading a work surface such as, for example, flexible sheet-like abrasive articles, as well as methods of making and using such abrasive articles. Some embodiments of the abrasive articles include an improved, more heat resistant non-slip coating or layer.

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SANDPAPER WITH NON-SLIP COATING LAYER

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Technical Field

The present disclosure generally relates to abrasive articles for abrading a work surface such as, for example, flexible sheet-like abrasive articles, as well as methods of making and using such abrasive articles.

Background

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Sheet-like abrasive articles are commonly used in a variety of sanding operations including, for example, hand sanding of wooden surfaces. In hand sanding, the user holds the abrasive article directly in his or her hand and moves the abrasive article across the work surface. Sanding by hand can, of course, be an arduous task.

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Sheet-like abrasive articles include, for example, conventional sandpaper. Conventional sandpaper is typically produced by affixing abrasive material to a relatively thin, generally non-extensible, non-resilient, non-porous backing (*e.g.*, paper). The thin, flat, slippery nature of conventional sandpaper backing materials makes conventional sandpaper difficult to grasp, hold, and maneuver. Because of the slippery nature of conventional sandpaper, to hold a sheet of sandpaper securely, a user will grasp the sheet of sandpaper between his or her thumb and one or more of his or her remaining

20 fingers. Holding the sandpaper in this manner is uncomfortable, can lead to muscle cramps and fatigue, and is difficult to maintain for an extended period of time. In addition, the thumb is typically in contact with the abrasive surface of the sandpaper, which can irritate or damage the skin. Also, because the thumb is positioned between the sandpaper and the work surface, grasping the sandpaper in this manner interferes with the sanding operation. That is, due to the position of the thumb, a portion of the sandpaper

25 abrasive surface is lifted away from the work surface during sanding. Because the lifted portion is not in contact with the work surface, the full sanding surface of the sandpaper is not utilized, and the effectiveness of the sandpaper is, therefore, diminished.

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During hand sanding, a user often applies pressure to the sandpaper using his or her fingertips. Because of the thin nature of the backing materials used in conventional sandpaper, the finger pressure is concentrated in the regions where the finger pressure is applied. This, in turn, causes the sandpaper to wear and/or load unevenly, and can produce an uneven sanding pattern on the work surface.

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Some sandpaper can be used in either wet or dry environments. In wet environments, common applications include filler sanding, putty sanding, primer sanding and paint finishing. A particular problem encountered with certain sandpaper in wet environments is the tendency for sheet-like article to curl. Curling of the abrasive article can be a significant nuisance to the user. A similar effect can also occur when abrasive articles are stored in humid environments. To mitigate curling, abrasive sheets are sometimes preflexed in the manufacturing process, but this is generally ineffective in preventing curling during use.

Conventional sandpaper is typically sold in standard size sheets, such as 9 x 11 inch sheets. To make sandpaper easier to use, users often fold the sandpaper, thereby producing smaller sheets that are easier to handle. Folding the sandpaper, however, produces a jagged edge, and also weakens the sandpaper along the fold line. During the rigors of sanding, the weakened fold line may tear, thereby
5 resulting in premature failure of the sandpaper.

To resolve at least some of the above-identified concerns, 3M Company developed sandpaper that has a non-slip surface. Such sandpaper is described in, for example, US Patent No. 8,662,962. The commercial product, 3M No-Slip Grip™ Advanced Sandpaper, provides at least some of the following advantages: improved handling, ease of use, comfortable use, relatively easy and inexpensive to
10 manufacture, improved cut, improved durability, and produces finer scratches than a comparable sheet of sandpaper.

Summary

The inventors of the present disclosure learned that some users place sheets of sandpaper (or portions thereof) on power sanding tools. In some instances of high-speed use on power tools, the non-slip coating on the sandpaper can soften or melt, sticking to the power tool. The inventors of the present
15 disclosure sought to formulate an improved no-slip grip coating that provides added heat resistance without significantly compromising the advantages of the existing non-slip sandpaper.

The present disclosure provides a sheet of sandpaper comprising (1) a backing layer having opposed first and second major surfaces, (2) an adhesive make coat directly on the first major surface, (3)
20 abrasive particles at least partially embedded in the make coat, thereby defining an abrasive surface, and (4) a non-slip layer on the second major surface, the non-slip layer comprising (a) a dimer acid polyamide, (b) an elastomer, and (c) a tackifying agent.

Advantageously, this configuration provides a coated abrasive that displays superior curl-resistance and improved overall cut and finish performance as compared with prior art abrasive articles.
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Brief Description of Drawings

The present disclosure will be further described with reference to the accompanying drawings, in which:

FIG. 1 is a cross sectional view of a sheet of sandpaper according to the disclosure;

FIG. 2 is a perspective view of a second embodiment of the disclosure; and

FIG. 3 is a photograph of various Examples during a Wet Curl test.

Layers in certain depicted embodiments are for illustrative purposes only and are not intended to absolutely define the thickness, relative or otherwise, or the location of any component. While the above-identified figures set forth several embodiments of the disclosure, other embodiments are also
35 contemplated, as noted in the discussion. In all cases, this disclosure presents the disclosure by way of

representation and not limitation. It should be understood that numerous other modifications and embodiments can be devised by those skilled in the art, which fall within the scope and spirit of the principles of the invention.

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Detailed Description

Referring now to the drawings, FIG. 1 shows a cross-section of a sheet-like abrasive article 10, such as a sheet of sandpaper, comprising a flexible backing layer 12 having opposed first 12a and second 12b major surfaces, a flexible non-slip coating layer 14 on the backing layer first major surface 12a, an adhesive make coat layer 16 on the backing layer second major surface 12b, and a plurality of abrasive particles 18 at least partially embedded in the make coat layer 16. The abrasive article 10 may be provided in, for example, a stack of individual sheets, or in roll form, wherein the abrasive article 10 may have an indefinite length.

As used herein, the expression “sheet-like” refers generally to the broad, thin, flexible nature of the abrasive article 10. As used herein, the expression “coating” refers generally to at least a single layer of generally flowable material, such as a liquid or a solid powder that can be applied directly to a surface. A coating, therefore, does not include a separate sheet of material laminated to a surface. As used herein, the expression “layer” refers generally to the non-slip material forming a discrete stratum on top of the backing layer 12 (*i.e.*, the non-slip material does not soak through the entire thickness of the backing layer 12).

In one end use application of the disclosure, the sheet-like abrasive article 10 may be used for hand sanding a work surface, such as a wooden surface or work piece. That is, the abrasive article 10 may be used to remove material from a surface by contacting the abrasive article 10 directly with one’s hand (*i.e.*, without the aid of a tool, such as a sanding block) via the non-slip coating layer 14, and subsequently moving the abrasive article 10 against the work surface. It will be recognized that the present disclosure may also be used with manually-operated sanding tools and sanding blocks, or with power tools.

The backing layer 12, the non-slip coating layer 14, the adhesive make coat layer 16, and the abrasive particles 18 are each described in detail below.

30

Backing 12

Suitable materials for the backing layer 12 include any of the materials commonly used to make sandpaper including, for example, paper, cloths (cotton, polyester, rayon) polymeric films such as thermoplastic films, foams, and laminates thereof. The backing layer 12 will have sufficient strength for handling during processing, sufficient strength to be used for the intended end use application, and the ability to have the non-slip coating 14 and make coat 16 applied to at least one of its major surfaces.

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In some embodiments, the backing layer 12 is formed of paper. In some embodiments, paper is a desirable material for the backing layer 12 because it is readily available and is typically low in cost. Paper backings are available in various weights, which are usually designated using letters ranging from “A” to “F”. The letter “A” is used to designate the lightest weight papers, and the letter “F” is used to designate the heaviest weight papers. As explained more fully below, the present disclosure allows any weight paper to be used without experiencing the drawbacks associated with conventional sandpaper backings noted above.

In the illustrated embodiment, the backing layer 12 is continuous. That is, the backing layer 12 does not contain holes, openings, slits, voids, or channels extending there through in the Z-direction (*i.e.*, the thickness or height dimension) that are larger than the randomly formed spaces between the material itself when it is made. The backing may also contain openings (*i.e.*, be perforated), or contain slits. In some embodiments, the backing layer 12 is generally non-extensible. As used herein, the term “non-extensible” refers to a material having an elongation at break of no greater than about 25%. In some embodiments, the material has an elongation at break of no greater than about 10%. In some embodiments, the material has an elongation at break of no greater than about 5%.

In certain embodiments, such as when the backing layer 12 is formed of paper, the backing layer 12 may be relatively thin, and typically has a thickness of no greater than about 1.5 mm, no greater than about 1 mm, or no greater than about 0.75 mm. In such embodiments, the backing layer 12 is generally not resilient. The backing layer 12 may also be porous or non-porous. In another embodiment, such as when the backing is a foam material, the backing layer may be somewhat thicker. For example, in embodiments having a foam backing layer, the backing layer may have a thickness of at least about 2 mm, at least about 5 mm, or at least about 10 mm.

The backing layer 12 may also be formed of a cloth material or film, such as a polymeric film. Cloth materials are desirable because they are generally tear resistant and are generally more durable than paper and film materials. In addition, cloth backings tolerate repeated bending and flexing during use. Cloth backings are generally formed of woven cotton or synthetic yarns that are treated to make them suitable for use as a coated abrasive backing. As is the case with paper backings, cloth backings are available in various weights, which are usually designated using a letter ranging from “J” to “M” with the letter “J” designating the lightest weight cloth, and the letter “M” designating the heaviest weight cloths.

Suitable film materials for the backing layer 12 include polymeric films, including primed films, such as polyolefin film (*e.g.*, polypropylene including biaxially oriented polypropylene, polyester film, polyamide film, cellulose ester film). In one suitable implementation of the present disclosure, the backing layer 12 includes a polyurethane, such as those described in US Publication No. 2017/0043450 (Graham et al.), including at least one thermoplastic polyurethane (TPU). In some embodiments, the backing may comprise a single thermoplastic polyurethane or a combination of thermoplastic polyurethanes. One suitable class of polyurethanes is aromatic polyether-based polyurethanes, particularly thermoplastic polyether-based polyurethanes. In some embodiments, the thermoplastic polyether-bases

polyurethanes are derived from 4,4'-methylenedicyclohexyl diisocyanate (MDI), a polyether polyol, and butanediol.

Non-Slip Coating Layer 14

5 In some embodiments, the sandpaper 10 includes a non-slip coating layer 14, which defines a non-slip, or slip resistant, outer surface 14a of the sandpaper 10. “Non-slip” or “slip resistant” coatings, layers, or materials refer to coatings, layers, or materials that tend to increase the coefficient of friction of the backing layer surface to which the non-slip material is applied. That is, if the surface of the backing layer 12a to which a non-slip coating layer is applied has a coefficient of friction of “x” prior to when the coating is applied, and the coating - as applied to the surface of the backing - provides a surface that has a coefficient of friction that is greater than “x”, then the coating is a “non-slip” coating. Or stated another way, if the coating tends to increase the coefficient of friction of the backing surface to which it is applied, then the coating qualifies as a “non-slip” coating.

15 In one embodiment, the non-slip coating layer 14 has an average peak static coefficient of friction of at about 1 gram, at least about 1.25 grams, or at least about 1.5 grams when measured according to ASTM D 1894-08 (Standard Test Method for Static and Kinetic Coefficients of Friction of Plastic Film and Sheeting) at 23°C using an IMASS slip/peel tester (SP2000, commercially available from Instrumentors Inc., Strongsville, Ohio), and/or an average kinetic coefficient of friction of at least about 0.75 grams, at least about 1 gram, or at least about 1.25 grams

20 The non-slip coating layer 14 is provided on the first major surface 12a of the backing layer 12 opposite the make coat 16 and abrasive particles 18. The non-slip coating layer 14 outer surface 14a may have no tack, or have a low level of tackiness. Tack or tackiness as used herein refers to the stickiness or adhesive properties of a material. Non-tacky refers to a material that does not possess any degree of stickiness or adhesive properties, whereas tacky materials possess some degree of stickiness or adhesive properties. Non-tacky materials may possess a high coefficient of friction, therefore also making non-tacky materials useful as non-slip coatings.

25 If the non-slip coating is tacky, it is desirable that it have a low level of tackiness. By low level of tackiness, it is meant that the non-slip coating has an average tack level, as measured by ASTM D2979-01 (Standard Test Method for Tack of Pressure-Sensitive Adhesives Using an Inverted Probe Machine) using a ten (10) second dwell time, and a probe removal speed of one (1) cm/s, of no greater than about 200 grams, no greater than about 250 grams, no greater than about 300 grams, and no greater than about 350 grams. It is desirable that the material used to form the non-slip coating layer 14 bond directly to the backing layer 12. If the non-slip material does not form an effective bond with the backing layer, the backing layer 12 may be primed to allow the non-slip material to form a more effective bond with the backing layer 12.

35 In one embodiment, the non-slip coating 14 is slightly tacky, and has an adhesion to itself that is less than the cohesive strength of the non-slip coating itself, and further has an adhesion to itself that is

less than the “two-bond” adhesive strength. As is known to those skilled in the art, the “two-bond” adhesive strength is the adhesive strength between the non-slip coating 14 and the backing layer 12 to which the non-slip coating layer is applied. Thus, when the non-slip coating 14 is folded over onto itself, the respective non-slip surfaces that come into contact can be released again without experiencing
5 cohesive failure of the non-slip layers, and without having the non-slip layer 14 detaching from the backing layer 12.

In another aspect, the non-slip coating provides a surface that may be repeatably bonded to itself. In another somewhat related aspect, the non-slip coating 14 may be repositionable. As used herein, “repositionable” refers to a non-slip coating that allows repeated application, removal, and reapplication
10 to and from itself or a surface without damage to the non-slip coating or the surface.

In addition, it is desirable that the adhesion of the non-slip coating layer 14 to itself not build significantly over time. As such, if the abrasive article 10 is folded over onto itself such that the non-slip coating layer 14 contacts itself, the abrasive article 10 may later be readily unfolded by separating the non-slip coating layers 14 without damaging the non-slip coating 14 or the backing layer 12.

Suitable materials for the non-slip coating layer 14 include, for example, elastomers. Suitable elastomers include: natural and synthetic rubbers such as synthetic polyisoprene, butyl rubbers, polybutadiene, styrene-butadiene rubber (SBR), block copolymers such as Kraton rubber, polystyrene-polyisoprene-polystyrene (SIS) rubber, styrene-butadiene-styrene (SBS) rubber, nitrile rubber (Buna-N rubbers), hydrogenated nitrile rubbers, acrylonitrile butadiene rubber (NBR), chloroprene rubber,
15 polychloroprene, neoprene, EPM rubber (ethylene propylene rubber), EPDM rubber (ethylene propylene diene rubber), acrylic rubber, polyacrylic rubber, silicone rubber, ethylene-vinyl acetate (EVA), polyvinyl acetate (PVA), and other types of elastomers such as thermoplastic elastomers, thermoplastic vulcanizates such as Santoprene thermoplastic rubber, urethanes such as thermoplastic polyurethane, and thermoplastic olefins.

Such rubber materials may further include a tackifying agent. Exemplary tackifiers include, for example, C5 and C9 tackifiers. Exemplary commercially available tackifiers include Wingtack type tackifier resins, available from TOTAL Cray Valley, Exton, PA.

The non-slip coatings of the present disclosure further include a dimer acid polyamide. In some embodiments, the dimer acid polyamide assists in providing heat resistance to the non-slip coating or
30 layer. Dimer acids can be obtained by the polymerization of C18-acids such as oleic and linoleic acids, and are often environmentally friendly chemical reagents with characteristics of being biodegradable. Polyamides can be prepared by melt-polycondensation reactions using dimer acids and different diamines as raw materials. The dimer acid-based polyamides synthesized possess advantages of being soluble in many solvents, biodegradable, flexible and demonstrating good hot melt adhesion. Formulations and synthesis techniques of dimer acid-based polyamides can be found, for example, in U.S. Patent Nos.
35 3,377,303 (Peerman et al.) 3,483,237 (Peerman et al.); 5,085,099 (Jaeger); 5,138,027 (Van Beek); and 5,455,326 (Parker)

In some embodiments, the non-slip coating or layer includes between about 20% and about 55% by weight of dimer acid polyamide. In some embodiments, the non-slip coating or layer includes between about 25% and about 50% by weight of dimer acid polyamide. In some embodiments, the non-slip coating or layer includes between about 30% and about 45% by weight of dimer acid polyamide. In some
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embodiments, the non-slip coating or layer includes greater than about 20% by weight of dimer acid polyamide or greater than about 25% by weight of dimer acid polyamide, or greater than about 30% by weight of dimer acid polyamide, or greater than about 35% by weight of dimer acid polyamide, or greater than about 40% by weight of dimer acid polyamide. In some embodiments, the non-slip coating or layer includes less than about 55% by weight of dimer acid polyamide or less than about 50% by weight of
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dimer acid polyamide or less than about 45% by weight of dimer acid polyamide or less than about 40% by weight of dimer acid polyamide or less than about 35% by weight of dimer acid polyamide.

In some embodiments, the dimer acid polyamide is present in a ratio of between about 70:16 and about 31:55 (dimer acid polyamide: SIS block copolymer). Exemplary commercially available dimer acid polyamides include UNIREZ resins, available from Kraton Corporation, Houston, TX.

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In some instances, the non-slip coating on the sandpaper may soften or melt and stick to the power tools, and potentially ruining the power tool. It is desirable that the coating have a low hot melt adhesion to address this issue without significantly compromising the advantages of a non-slip sandpaper. To this end, a test method was developed to measure the relative hot melt adhesion of compounded formulations to a steel surface. Please see the Relative Hot-Melt Adhesion Test Method description
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below. It is desirable that the relative hot-melt adhesion (according to this test method) generate an axial force at 80°C below -18 Newtons, preferably in the range -15 Newtons to -5 Newtons.

The tackiness of such elastomeric non-slip coating layers may be adjusted by adding fillers, such as calcium carbonate, to the material.

In one aspect, the non-slip coating layer may have a glass transition temperature of at least about -
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80 degrees Celsius (°C), at least about -70°C, and at least about -65°C, and a glass transition temperature of no greater than about -5°C, no greater than about -15°C, and no greater than about -25°C. In a more specific aspect, the non-slip coating layer 14 is formed of an aqueous solution that forms a coating layer having a glass transition temperature of at least about -80 degrees Celsius (°C), at least about -70°C, and at least about -65°C, and a glass transition temperature of no greater than about -5°C, no greater than
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about -15°C, and no greater than about -25°C.

Commercially available materials suitable for producing elastomeric non-slip coating layers include Butofan NS209, a carboxylated styrene-butadiene anionic dispersion available from BASF Corporation, Florham Park, New Jersey, and Hystretch elastomeric dispersions V-29, V-43, and V-60 available from Lubrizol Corporation, Wickliffe, Ohio. Ethylene-vinyl acetate (EVA) dispersions may
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also be used.

Suitable materials for producing the non-slip coating layer 14 also include acrylates and acrylic polymers. In addition, suitable materials for producing the non-slip coating layer 14 include pressure

sensitive adhesives, such as acrylic adhesives - which may or may not include a tack modifying ingredient - repositionable adhesives, or hot melt acrylic adhesives. Depending on the particular composition, and depending on the degree of processing (for example, the degree of polymerization), such hot melt acrylic adhesives can be produced with a variety of physical characteristics including both tacky and non-tacky characteristics.

The particular thickness of the non-slip coating layer 14 may vary depending on, for example, the material selected to form the non-slip coating layer 14, and depending on the intended end use application for the abrasive article 10. For example, a non-slip coating layer 14 formed of rubber or urethane base material may have a thickness of at least about 0.1 mil (2.5 micrometers), at least about 1 mil (25 micrometers), and at least about 10 mils (254 micrometers), and a thickness of no greater than about 50 mils (1270 micrometers), no greater than about 30 mils (762 micrometers), and no greater than about 25 mils (635 micrometers). A non-slip coating layer 14 formed of an acrylic polymer coating, on the other hand, may be thinner, and may have a thickness of at least about 0.1 (2.5 micrometers), at least about 0.5 (12.7 micrometers), and at least about 1 mil (25.4 micrometers), and a thickness of no greater than about 2 mils (50.8 micrometers), no greater than about 5 mils (127 micrometers), and no greater than about 10 mils (254 micrometers).

A non-slip coating layer 14 formed from a dried styrene-butadiene rubber dispersion or a dried latex dispersion may have a coating weight of at least about 1 gram/square meter (g/m^2) (0.24 grains/24 square inch (grains/24 in²)), at least about 3 g/m^2 (0.72 grains/24 in²), or at least about 4 g/m^2 (0.96 grains/24 in²), and a coating weight of no greater than about 20 g/m^2 (4.8 grains/24 in²), no greater than about 15 g/m^2 (3.6 grains/24 in²), or no greater than about 12 g/m^2 (2.9 grains/24in²).

In one embodiment, a suitable non-slip coating layer 14 may be produced using a pressure sensitive adhesive by coating a polymerizable pressure sensitive adhesive composition onto the backing layer 12, and then polymerizing the pressure sensitive adhesive composition to produce a non-slip coating layer having the desired properties, or by coating a repositionable pressure sensitive adhesive onto the backing layer 12.

In a specific embodiment, the pressure sensitive adhesive is an acrylic hot melt adhesive that may be produced by, for example, providing a polymerizable liquid monomer mixture in a sealed pouch formed of, for example, ethylene vinyl acetate (EVA), at least partially polymerizing the liquid monomer mixture by, for example, exposing the liquid monomer mixture to actinic radiation (*e.g.*, ultraviolet light), blending the partially polymerized liquid with the EVA material used to form the pouch, thereby forming a coatable pressure sensitive adhesive composition, and coating the pressure sensitive adhesive composition onto a backing layer 12. After the pressure sensitive adhesive composition has been coated onto the backing layer 12, the non-slip layer 14 is formed by further polymerizing the pressure sensitive adhesive to form a non-slip coating layer having the desired characteristics, such as a coating layer having a low level of tack, or no tack.

The degree of additional polymerization may vary, and will depend, for example, on the desired properties of the non-slip layer 14. Further polymerization may be accomplished by, for example, exposing the pressure sensitive adhesive to additional UV light or by thermal polymerization in an amount sufficient to reduce the level of tack of the pressure sensitive adhesive to the desired level.

5 A suitable polymerizable liquid monomer mixture may include, for example, a mixture of 2 ethyl hexyl acrylate, butyl acrylate, methyl acrylate, and a photo-initiator such as Irgacure 651 available from Ciba-Geigy Corp. Hawthorne, NY. Optional additives such as isooctyl thioglycolate, hexanediol diacrylate, alphanaphthoquinone, and Irganox 1076 antioxidant available from Ciba Specialty Chemicals Corporation, Tarrytown, NY, may also be included in the polymerizable liquid monomer mixture.

10 In some embodiments, the non-slip coating layer 14 can be applied as a liquid suspension, such as an aqueous dispersion, an aqueous emulsion such as a latex, or as a hot melt adhesive.

Liquids may be applied using a variety of known printing and/or coating techniques including, for example, roll coating (*e.g.*, rotogravure coating), transfer roll coating, solvent coating, hot melt coating, spray coating, Meyer rod coating, and drop die coating. Particularly desirable techniques for applying aqueous emulsions and dispersions include Meyer rod coating, rotogravure and transfer roll coating techniques. Such aqueous emulsions and dispersions are then allowed to dry to produce the non-slip coating layer 14. A particularly desirable technique for applying a hot melt adhesive, such as an acrylate hot melt adhesive, is drop die coating. Such a hot melt coated adhesive is then further polymerized to produce a non-slip coating layer 14 having the desired characteristics.

20 In one embodiment, the non-slip coating layer 14 is provided with a surface texture. Such a textured surface may be provided by applying the liquid emulsion or liquid dispersion to the backing layer 12 using, for example, a microcell foam roller or through spray coating. In a particular embodiment, a liquid emulsion or liquid dispersion is applied using a microcell foam roller to a coating weight of about 3 grains/24 square inch. The liquid coating may then be dried, for example, in a forced air oven at a temperature of 225 degrees Fahrenheit for 5 minutes to produce the non-slip coating layer.

25 In the embodiment illustrated in FIG. 1, the non-slip coating 14 defines a generally planer outer surface 14a of the sandpaper 10 opposite the make coat 16 and abrasive particles 18. That is, the non-slip coating layer 14 defines a smooth outer surface that does not include a textured surface or a macroscopic three dimensional surface topography. The coating layer 14 may be continuous, discontinuous, and/or applied in random or repeating patterns, such as dots and stripes.

30 In some embodiments, the non-slip coating layer 14 may be clear. In this manner, any information or indicia printed on the backing 12 will remain visible through the non-slip coating layer 14. In addition, the appearance of the sandpaper remains similar to the appearance of conventional sandpaper, to which users have become accustomed.

35 As illustrated in FIG. 2, the outer surface 14a of the non-slip coating layer 14 may include a regular patterned surface texture or geometry. In the specific embodiment illustrated, the patterned surface texture of the non-slip coating layer 14 outer surface 14a may be such that the pattern inter-

engages with itself when the sandpaper 10 of folded over onto itself. That is, the outer surface 14a includes raised 14a' and recessed 14a'' regions that mate with each other when the outer surface 14a is folded over onto itself.

In either of the embodiments shown in FIGS. 1 or 2, the non-slip coating layer 14 may further
5 comprise filler material or particles to provide the non-slip coating layer 14 outer surface 14a with a rough or randomly textured surface. Such a rough or textured surface serves to enhance the traction properties of the non-slip coating layer 14.

Make Coat 16

10 In general, any adhesive make coat 16 may be used to adhere the abrasive particles 18 to the backing layer 12. "Make coat" refers to the layer of hardened resin over the backing layer 12 of the sandpaper 10. Suitable materials for the adhesive make coat 16 include, for example, phenolic resins, aminoplast resins having pendant α,β -unsaturated carbonyl groups, urethane resins, epoxy resins,
15 ethylenically unsaturated resins, acrylated isocyanurate resins, urea-formaldehyde resins, isocyanurate resins, acrylated urethane resins, acrylated epoxy resins, bismaleimide resins, fluorene-modified epoxy resins, and combinations thereof.

The make coat 16 may be coated onto the backing layer 12 by any conventional technique, such as knife coating, spray coating, roll coating, rotogravure coating, curtain coating, and the like. The sandpaper 10 may also include an optional size coat (not shown).

Abrasive Particles 18

20 In general, any abrasive particles 18 may be used with this disclosure. Suitable abrasive particles include, for example, fused aluminum oxide, heat treated aluminum oxide, alumina-based ceramics, silicon carbide, zirconia, alumina-zirconia, garnet, emery, diamond, ceria, cubic boron nitride, ground
25 glass, quartz, titanium diboride, sol gel abrasives and combinations thereof. The abrasive particles 18 can be either shaped (*e.g.*, rod, triangle, or pyramid) or unshaped (*i.e.*, irregular). The term "abrasive particle" encompasses abrasive grains, agglomerates, or multi-grain abrasive granules. The abrasive particles can be deposited onto the make coat 16 by any conventional technique such as electrostatic coating or drop coating.

Additives

30 The make coat 16 and/or the optional size coat may contain optional additives, such as fillers, fibers, lubricants, grinding aids, wetting agents, thickening agents, anti-loading agents, surfactants, pigments, dyes, coupling agents, photo-initiators, plasticizers, suspending agents, antistatic agents, and
35 the like. Possible fillers include calcium carbonate, calcium oxide, calcium metasilicate, alumina trihydrate, cryolite, magnesia, kaolin, quartz, and glass. Fillers that can function as grinding aids include

cryolite, potassium fluoroborate, feldspar, and sulfur. The amounts of these materials are selected to provide the properties desired, as is known to those skilled in the art.

In a specific embodiment, the sandpaper 10 is a standard 9 x 11 inch sheet of sandpaper. In other embodiments, the sandpaper 10 may have a width of about 3 to about 4 inches, or of about 5 to about 6 inches, and a length of about 8 to about 10 inches, or about 10 to about 12 inches.

In another aspect, the present disclosure provides a package of sandpaper including a stack of sheets of sandpaper. The stack may include at least 2 sheets, at least about 6 sheets, or at least about 10 sheets.

Methods of Making

The various embodiments described above may be made using a variety of techniques, and will vary depending on the particular material used to produce the non-slip coating layer 14. For example, the abrasive article 10 may be made by providing a paper backing layer, coating an adhesive make coat on one major surface of the backing layer, at least partially embedding abrasive particles in the make coat, thereby forming an abrasive surface, dissolving a non-slip coating material, such as a mixture of rubber and tackifier, in a hydrocarbon solvent, such as toluene, thereby to form a coatable non-slip material, coating the non-slip material and solvent onto the surface of the backing layer opposite the make coat, and allowing the solvent to evaporate from the non-slip material, thereby forming a non-slip coating layer 14 on the backing layer 12. Using this technique, the non-slip coating layer 14 is said to be “solvent coated” onto the backing.

In another method of making the abrasive article 10, an aqueous emulsion or aqueous dispersion is coated onto the backing layer 12 opposite the make coat 16, and is dried, thereby forming the non-slip coating layer 14.

Alternatively, the abrasive article 10 may be made by providing a paper backing layer 12, coating an adhesive make coat 16 on one major surface of the backing layer 12, at least partially embedding abrasive particles 18 in the adhesive make coat 16, thereby forming an abrasive surface, providing a non-slip material such as a mixture of rubber and tackifier, heating the non-slip material, thereby forming a coatable non-slip material, and coating the non-slip material onto the surface of the backing layer 12 opposite the make coat 16, thereby forming a non-slip coating layer 14. With this technique, the non-slip coating layer 14 may be coated onto the backing layer 12 using, for example, roll coating, hot melt coating, or drop die coating techniques.

In one embodiment, the roller used to apply the coatable non-slip material is a foam roller, which imparts a surface texture to the non-slip coating layer. Alternatively, a foam roller may be used to post treat the non-slip coating layer 14 after it has been coated onto the backing layer 12, thereby imparting the non-slip coating layer with a surface texture.

In another method of making the abrasive article 10, an adhesive, such as an acrylic hot melt adhesive, is coated onto the backing layer 12 opposite the make coat 16, and is cured by, for example, polymerization or drying, thereby forming the non-slip coating layer 14.

5 In any of the above techniques, it will be recognized that the order in which the non-slip coating layer 14 and make coat layer 16 are applied to the backing layer 12 may be varied. That is, the non-slip coating layer 14 may be applied to the backing layer 12 either before or after the make coat 16 is applied to the backing layer 12.

10 In addition, it will be recognized that the backing layer 12, make coat 16, and abrasive particles 18 may be provided in the form of a pre-formed (*i.e.*, otherwise complete) abrasive sheet. That is, rather than providing a backing layer 12, which is then coated with make coat 16 and provided with abrasive particles 18 to form an abrasive sheet, a pre-formed abrasive sheet including a backing, make coat and abrasive particles may be provided. The non-slip coating layer 14 can then be applied directly to the pre-formed abrasive sheet.

15 Representative examples of suitable pre-formed abrasive sheets are available under the product designation 216U, from 3M Company, St. Paul, MN. 216U is sandpaper having an A weight backing, a phenolic make coat, aluminum oxide abrasive particles, and a stearic acid supersize coating, which is provided to minimize loading. If a pre-formed abrasive sheet is used, the non-slip coating layer 14 may be applied to the backing layer 12 using, for example, solvent coating, roll coating, hot melt coating, drop die, or powder coating techniques. For ease of manufacturing, it is desirable to provide the finished sandpaper in bulk form, and then coat the bulk sandpaper with the non-slip coating material prior to producing the individual sheets of sandpaper that are ultimately used by the end user.

A wide variety of commercially available conventional sandpaper constructions having a wide variety of backing materials (*e.g.*, papers, films, cloths), weights (*e.g.*, A, B, or C weight paper), and abrasive particles may be coated with a non-slip coating according to the present disclosure.

25 Surprising, the abrasive articles including the non-slip coating layer of the present disclosure display superior resistance to curling when immersed in water or subjected to humid environments. When tested in accordance with the Wet Curl test (described in the Examples section below), the abrasive articles preferably do not substantially curl.

30 In order that the disclosure described herein can be more fully understood, the following examples are set forth. It should be understood that these examples are for illustrative purposes only, and are not to be construed as limiting this disclosure in any manner.

Examples

Materials

35 PRODAS 2075, a poly alpha olefin based hot melt adhesive resin, available from Beardow Adams, Bradville, Milton Keynes, England.

3M SCOTCHWELD 3789, a polyamide hot-melt adhesive, is available from 3M Company, St. Paul MN. HJ-H2060 polyamide is available from Shandong Huijin Chemical Co., Ltd. (Daozhuang, Guangrao, Dongying City, Shandong Province, China)

UNIREZ 2626, a hot-melt polyamide, is available from Kraton Corporation, Houston, TX.

5 UNIREZ 2720, a hot-melt polyamide, is available from Kraton Corporation, Houston, TX.

KRATON D1161, a styrene-isoprene-styrene block copolymer, is available from Kraton Corporation, Houston, TX.

WINGTACK PLUS, a C-5 tackifier resin, is available from TOTAL Cray Valley, Exton.

10 Relative Hot Melt Adhesion Test (Axial Force)

Samples for this test method were prepared using a Type Six melt mixer with CAM blades from Brabender Instruments, Inc., South Hackensack, NJ. The melt mixer was heated to 180 °C and the CAM blades were set to mix at a rate of 65 rpm. Ingredients were added in the relative amounts described for the non-slip coating formulations in Table 1 to provide sample sizes of approximately 60 grams.

15 After the contents were visually well mixed, usually lasting a period from 2-3 minutes, the mixture was then drained from the mixing bowl into an aluminum tray for analysis.

Analysis was performed using a Discovery Hybrid Rheometer HR-2 from TA Instruments, New Castle, DE. About 3 grams of test material (non-slip formulation) was melted and set between two circular parallel steel plates of the rheometer at a gap of 0.8 mm. The top plate measured 20 mm in diameter while the bottom plate measured 100 mm in diameter. The bottom plate was a Peltier temperature controlled plate that performed a temperature sweep from 190°C to 80°C in steps of 10°C with an equilibrium of 60 seconds at each temperature step. The top plate subjected each sample to a fixed 1.25% small amplitude oscillatory strain at a constant frequency of 10 Hz. As each sample cools while traveling through the temperature regime, it contracts and exerts an axial force that pulls on the top plate of the rheometer. The magnitude of the axial force is proportional to the relative adhesion of the non-slip coating material to the top plate and is measured by a force transducer attached to the top plate of the rheometer and recorded.

Dry Coefficient of Friction Test

Coefficient of Friction is measured according to ASTM D 1894-08.

30

Wet Coefficient of Friction Test

Samples for this test method are placed in water under ambient conditions in a tin pan (approx. 1 inch of water) and soaked for approximately 5 minutes. Samples are promptly removed and the Coefficient of Friction is measured according to ASTM D 1894-08.

35

Tack Test

Tack is measured according to Probe Tack Test ASTM 2979-01.

Wet Curl Test

Samples for this test method are provided or cut into 3 inch by 6 inch strips. Samples are placed in water under ambient conditions in a tin pan (approx. 1 inch of water) and soaked for approximately 5 minutes. Samples are visually inspected for curling while still in water. As used in reference to this test method, a sample does not substantially curl if the opposing ends are not drawn towards one another such that; a) neither of the opposing end edges reaches a location adjacent the center of the strip; and/or b) the opposing ends of the strip are generally coplanar.

Examples E1-E8 and Comparative Examples CE1-CE4

The non-slip formulations in Table 1 were all prepared by a melt mixing process, conducted on an 18mm Berstoff Twin screw extruder (KraussMaffei Technologies GmbH, Munich, Germany). The extrudate from the extruder was then coated on to 216U P150 sandpaper, available from by 3M Company, St. Paul, MN. 216U P150 sandpaper is a general purpose sandpaper having an A-weight paper backing, a phenolic resin coated on one side, and aluminum oxide abrasive particles at least partially embedded on the phenolic resin. The second side (*i.e.*, the non-abrasive side opposite the abrasive surface) of the sandpaper was then coated with one of the non-slip coating formulations to a thickness of about 4-5 mils. The Dry Coefficient of Friction and Tack for the non-slip coatings of Examples E1-E8 were measured. As a control, the Dry Coefficient of Friction and Tack was also measured for 3M 216U P150 sandpaper. Dry Coefficient of Friction was also measured for Comparative Examples CE1-CE4. The results are summarized in Table 2.

Table 1

Example	KRATON 1161D SIS block copolymer (wt%)	HJ-H2060 polyamide (wt%)	WINGTACK PLUS tackifier resin (wt%)
E1	16	59	25
E2	35	45	20
E3	25	52	23
E4	26	57	17
E5	45	33	22
E6	35	51	14
E7	55	31	14
E8	16	70	14

Table 2

Example	Static Coefficient of Friction	Kinetic Coefficient of Friction	Probe Tack (grams)
E1	1.238	1.234	0
E2	3.384	2.187	27
E3	5.692	1.674	0
E4	3.660	1.884	0
E5	5.943	3.157	0

Example	Static Coefficient of Friction	Kinetic Coefficient of Friction	Probe Tack (grams)
E6	2.962	2.587	0
E7	5.471	2.898	0
E8	3.331	3.124	0
CE1 (UNIREZ 2720)	0.584	1.100	Not measured
CE2 (UNIREZ 2626)	0.252	0.777	Not measured
CE3 (SCOTCHWELD 3789)	2.938	2.790	Not measured
CE4 (PRODAS 2075)	1.731	2.605	Not measured
Control (3M 216U P150 sandpaper)	0.268	0.189	0

The Relative Hot Melt Adhesion was measured for the non-slip formulations of Examples E6, E7, E9 and the Comparative Examples CE1-CE4 using the Relative Hot Melt Adhesion test method described above. The evolution of this axial force for the samples tested is summarized in Table 3. The negative sign of the force is in reference to its direction as a compressive force, *i.e.*, meaning exerting a pull on the top plate. The 80°C is a relevant temperature because the non-slip coatings on the sandpaper typically will soften or melt and stick to power tools around that that temperature. The less pull exerted (lower negative number) is an indication that there would be relatively low or no adhesion to a power tool surface.

Table 3

Temperature (°C)	Axial Force (Newtons)						
	E6	E7	E8	CE1 (UNIREZ 2720)	CE2 (UNIREZ 2626)	CE3 (SCOTCHWELD 3789)	CE4 (PRODAS 2075)
190	0.01	0.20	0.02	0.01	0.09	0.03	0.02
180	0.00	0.13	0.00	0.01	0.28	0.03	0.01
170	0.00	0.06	0.00	0.01	1.15	0.03	0.02
160	-0.01	-0.07	-0.01	0.01	0.51	0.03	0.01
150	-0.01	-0.22	-0.01	0.01	-5.16	0.03	-0.01
140	0.00	-0.45	-0.01	0.01	-14.14	0.02	0.00
130	-0.03	-0.76	-0.03	0.01	-25.83	0.02	0.00
120	-0.03	-1.21	-0.02	0.01		0.01	-1.50
110	-0.06	-2.13	-0.07	0.01		-0.06	-10.66
100	-0.14	-3.65	-0.13	0.01		-0.56	-20.68
90	-1.01	-6.05	-0.51	-3.35		-6.21	-27.04
80	-12.48	-10.88	-5.49	-21.24		-18.24	-32.45

Examples E9-E12

To construct Examples E9-E12, the second, non-abrasive side of 431Q sandpaper, available from by 3M Company, St. Paul, MN, was coated with the non-slip coating formulation of Example E6 (prepared as above) to a thickness of about 4-5 mils. 431Q sandpaper is a general-purpose sandpaper having a C-weight paper backing, a phenolic resin coated on one side, and silicon carbide abrasive particles at least

partially embedded in the phenolic resin. Examples E9-E10 feature 431Q, P240 sandpaper, while Examples E11-E12 feature 431Q, P600 sandpaper. The Dry Coefficient of Friction for the non-slip coatings of Examples E9 and E11 were measured. The Wet Coefficient of Friction for the non-slip coatings of Examples E10 and E12 were measured. The Dry and Wet Coefficient of Friction was also measured for Comparative Example CE5 and CE6, respectively. The results are summarized in Table 4.

Table 4

Example	Static Coefficient of Friction	Kinetic Coefficient of Friction
E9	2.211	2.292
E10	1.793	1.883
E11	2.243	2.498
E12	2.176	2.360
CE5 (SANDWET, P400)	0.241	0.112
CE6 (SANDWET, P400)	0.856	0.812

10 Example 13

To construct example E13, the second, non-abrasive side of 413Q, P400 sandpaper, available from by 3M Company, St. Paul, MN, was coated with the non-slip coating formulation of Example E6 to a thickness of about 4-5 mils. 413Q sandpaper is a general-purpose sandpaper having an A-weight paper backing, a phenolic resin coated on one side, and silicon carbide abrasive particles at least partially embedded in the phenolic resin. A GATOR brand P320 waterproof sanding sheet and 413Q, P400 sandpaper served as Comparative Examples CE7 and CE8, respectively.

The Wet Curl was evaluated for E13, CE7, and CE8 using the Wet Curl test method described above. The results for the tested samples are depicted in Fig. 3.

20 The patents, patent documents, and patent applications cited herein are incorporated by reference in their entirety as if each were individually incorporated by reference. It will be apparent to those of ordinary skill in the art that various changes and modifications may be made without deviating from the inventing concepts set from above. Thus, the scope of the present disclosure should not be limited to the structures described herein. Those having skill in the art will appreciate that many changes may be made to the details of the above-described embodiments and implementations without departing from the underlying principles thereof. Further, various modifications and alterations of the present disclosure will become apparent to those skilled in the art without departing from the spirit and scope of the invention. The scope of the present application should, therefore, be determined only by the following claims and equivalents thereof.

30

What is claimed is:

1. Sandpaper, comprising:
a backing layer having opposed first and second major surfaces;
5 an adhesive make coat directly on the first major surface;
abrasive particles at least partially embedded in the make coat, thereby defining an
abrasive surface; and
a non-slip layer on the second major surface, the non-slip layer comprising:
a dimer acid polyamide;
10 an elastomer; and
a tackifying agent.
2. The sandpaper of claim 1, wherein the elastomer is selected from the group consisting of natural
rubber, synthetic rubber, ethylene-vinyl acetate (EVA), polyvinyl acetate (PVA), thermoplastic
15 vulcanizates, acrylates, acrylic polymers, thermoplastic olefins and combinations thereof.
3. The sandpaper of claim 2, wherein the synthetic rubber is selected from the group consisting of
styrene-butadiene rubber (SBR), polystyrene-polyisoprene-polystyrene (SIS) rubber, polyisoprene,
ethylene-propylene terpolymers (EPDM rubber), silicone rubber, and polyurethane rubber.
20
4. The sandpaper of any of the preceding claims, wherein the non-slip layer includes between about
10% and about 60% by weight of a styrene-isoprene-styrene block copolymer.
5. The sandpaper of any of the preceding claims, wherein the non-slip layer includes between about
25 15% and about 75% by weight of a dimer acid polyamide.
6. The sandpaper of any of the preceding claims, wherein the ratio of dimer acid polyamide to
styrene-isoprene-styrene block copolymer is between about 70:16 to about 31:55.
- 30 7. The sandpaper of any of the preceding claims, wherein the non-slip layer includes between about
10% and about 25% by weight of tackifying agent.
8. The sandpaper of any of the preceding claims, wherein the tackifying agent is a C5 or C9 tackifier
resin.
35
9. The sandpaper of any of the preceding claims, wherein the non-slip coating layer is non-tacky.

10. The sandpaper of any of the preceding claims, wherein the non-slip coating layer has an average tack level, as measured by ASTM D2979-01 using a 10 second dwell time, and a probe removal speed of 1 cm/s of no greater than about 300 grams.

5 11. The sandpaper of any of the preceding claims, wherein the non-slip coating layer is configured to selectively fold over onto itself, bond to itself, and release from itself such that, when bonded to itself, the non-slip coating layer has an adhesion that is less than a two-bond adhesion of the non-slip coating layer to the backing layer, whereby the non-slip coating layer does not separate from the backing layer when the non-slip coating layer is separated from itself.

10

12. The sandpaper of any of the preceding claims, wherein the non-slip coating layer has a thickness of between at least about 0.2 mils and no greater than about 50 mils.

15

13. The sandpaper of any of the preceding claims, wherein the non-slip coating layer has a coating weight of at least about 4 g/m² and no greater than about 20 g/m².

14. The sandpaper of any of the preceding claims, wherein the non-slip coating layer comprises a continuous uniform outer surface opposite the abrasive particles.

20

15. The sandpaper of any of the preceding claims, wherein the non-slip coating layer has an average peak static coefficient of friction of at least about 1 gram when measured according to ASTM D 1894-08.

16. The sandpaper of any of the preceding claims, wherein the non-slip coating layer has an average kinetic coefficient of friction of at least about 0.75 grams when measured according to ASTM D 1894-08.

25

17. The sandpaper of any of the preceding claims, wherein the relative hot-melt adhesion of the non-slip coating layer generates an axial force of -18 Newtons, preferably in the range -15 Newtons to -5 Newtons, at 80°C.

30

18. The sandpaper of any of the preceding claims, wherein the non-slip layer having a rough or randomly textured surface and configured to selectively fold over onto itself, bond to itself, and release from itself such that, when bonded to itself, the non-slip coating layer has an adhesion level that is less than a cohesive strength of the non-slip coating layer, whereby the non-slip coating layer is not damaged when the non-slip coating layer is separated from itself.

35

1/2

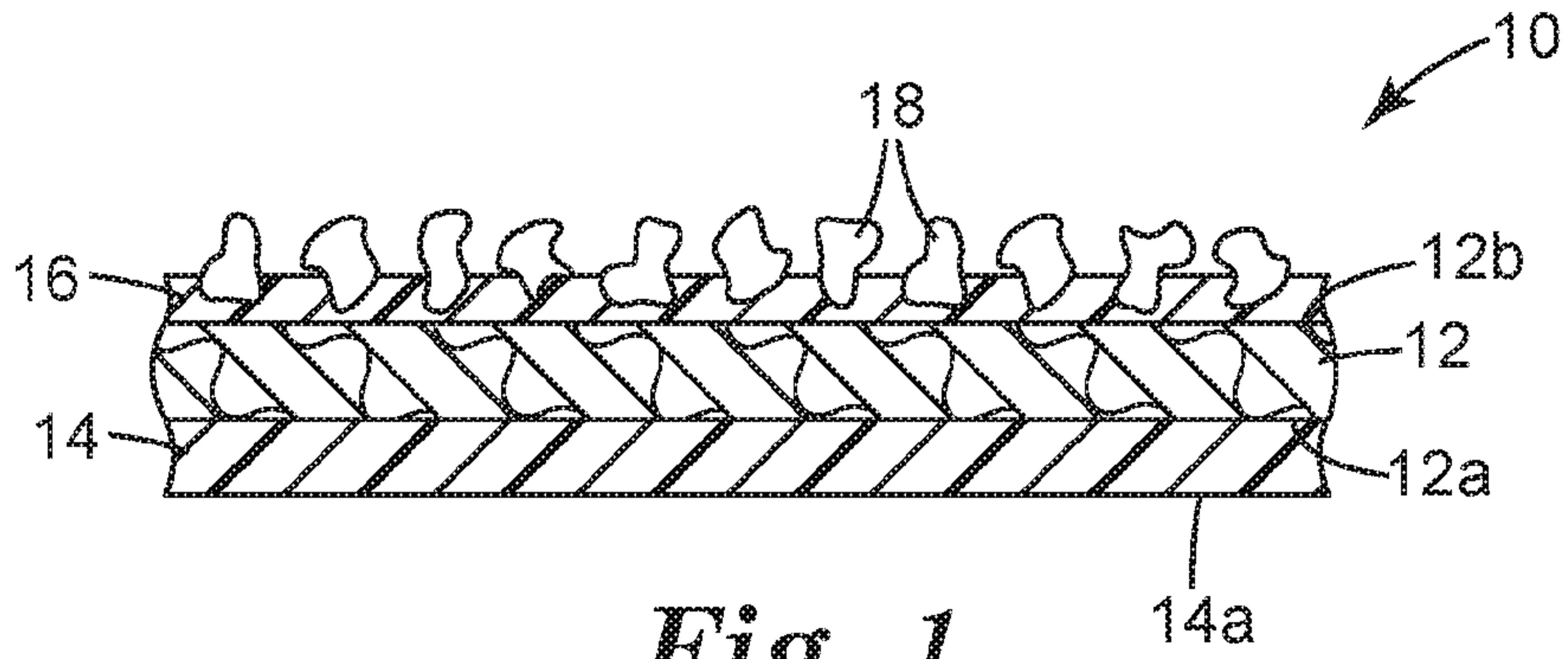


Fig. 1

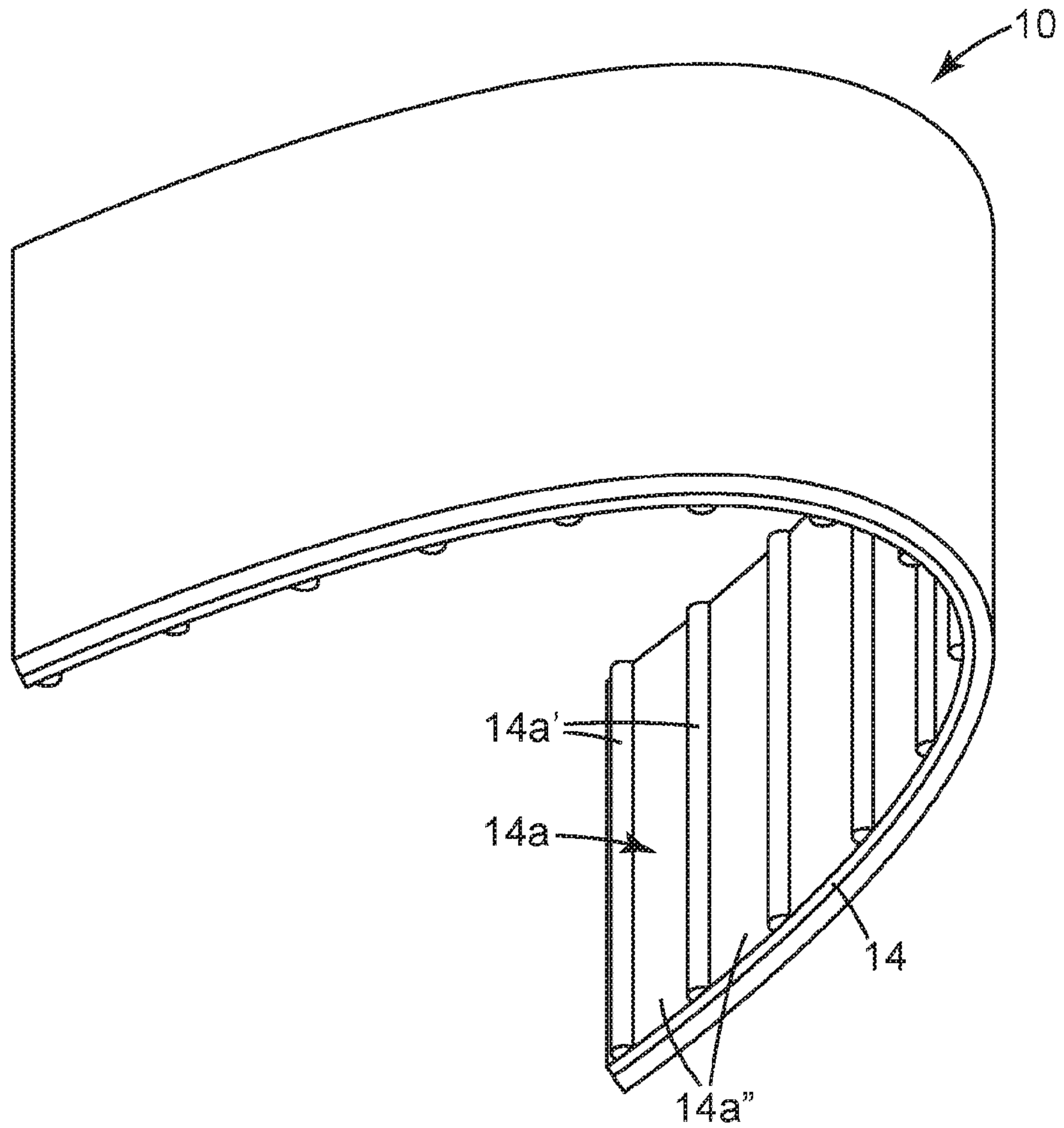


Fig. 2

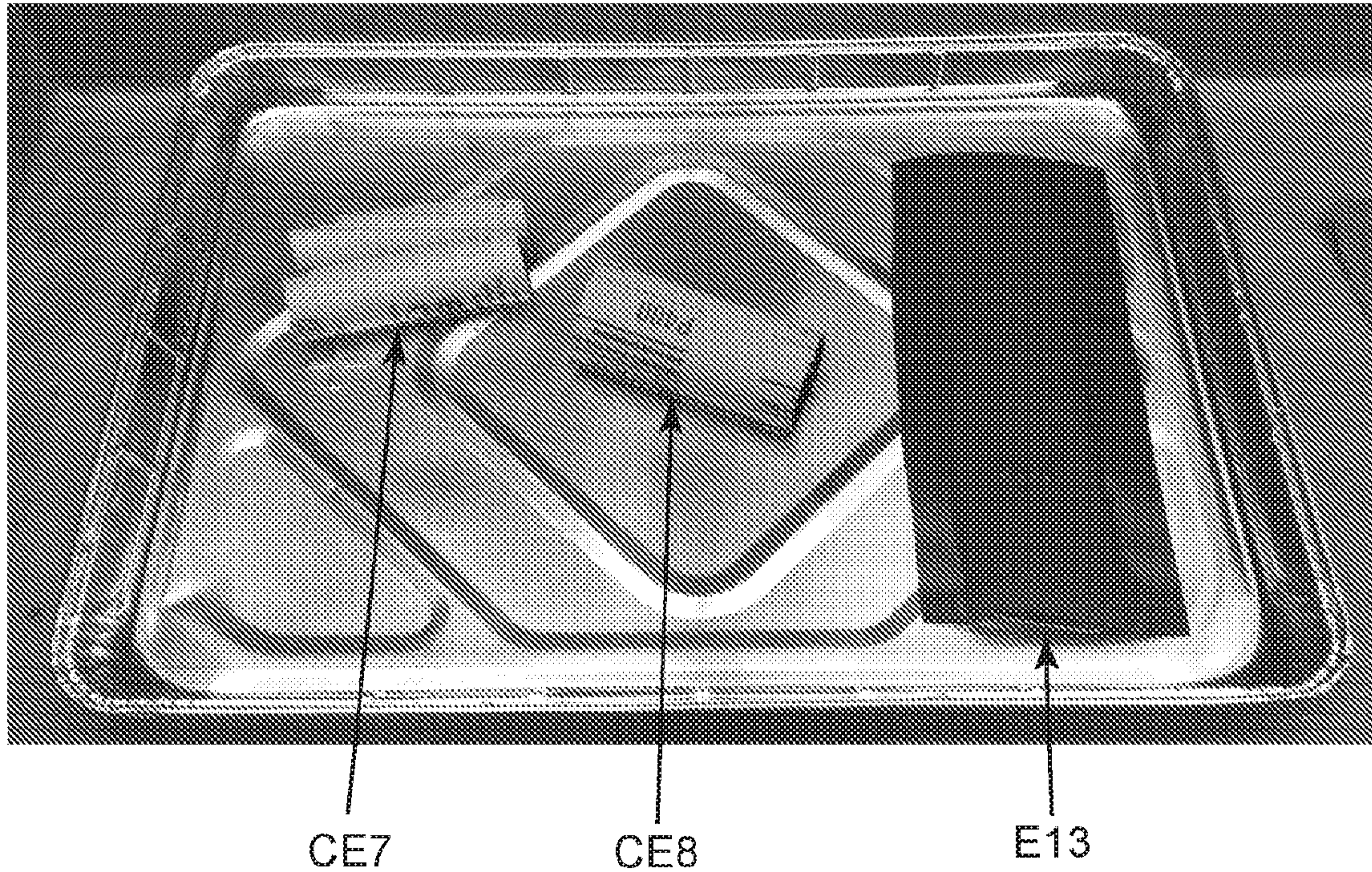


Fig. 3

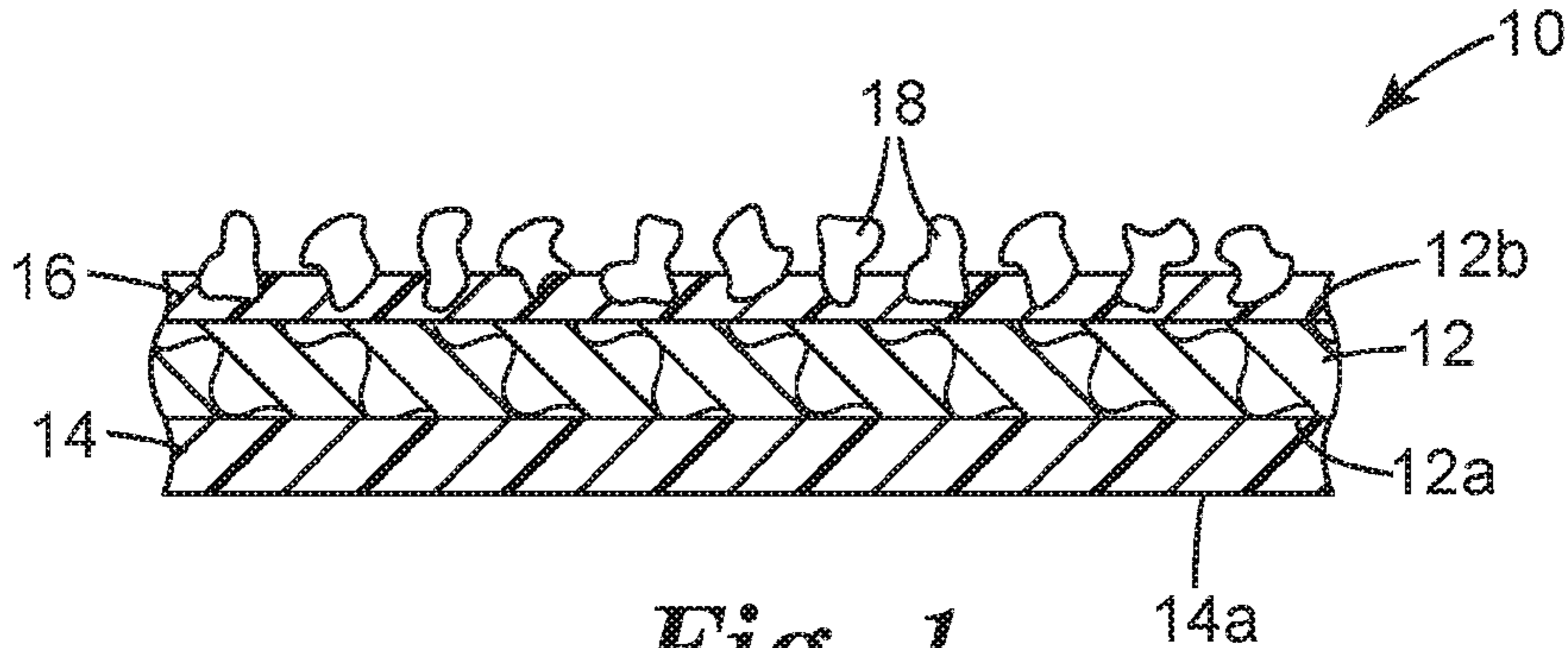


Fig. 1