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[Continued on next page]

(54) Title: MULTI-LAYER CHEMICAL AND BIOLOGICAL PROTECTION FABRIC FOR MOBILE SHELTERS

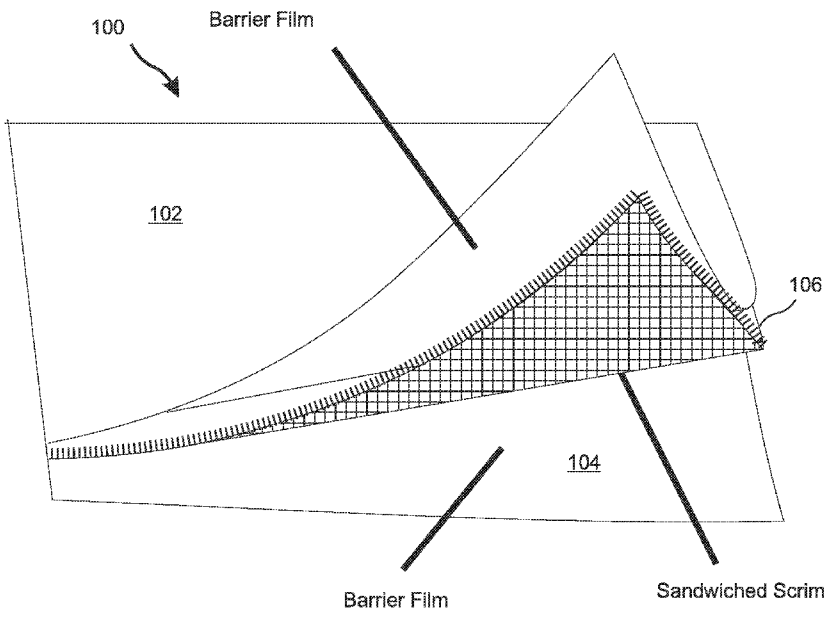


Figure 1A

(57) Abstract: A lightweight, low bulk, mobile CB shelter fabric includes a high tensile strength woven scrim laminated between two thin CB-impenetrable polymer films. Laminate adhesives can include isocyanate adhesion promotors. Coatings can be applied to the films for camouflage, increased light opacity, increased CB protection, sun, fire, and weather resistance. Lamination heat and pressure can cause the films to conform and bond through the scrim, while a pre- applied coating does not flow and remains uniform in thickness. The resulting fabric weight can be approximately 50% of conventional CB fabrics. The films can be hard-drawn polymers. A coating of hammer milled kaolin clay can provide increased light opacity. The films can be 1 micron thick, and can be nylon, aliphatic nylon, urethane, or poly-ether. The scrim can be a 1500 denier vectran with a 4.5 ends-per-inch warp and a 3.5 ends-per-inch fill. The scrim yarns can be flattened bundles of untwisted fiber.

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MULTI-LAYER CHEMICAL AND BIOLOGICAL PROTECTION FABRIC FOR MOBILE SHELTERS

STATEMENT OF GOVERNMENT INTEREST

[0001] Portions of the present invention may have been made in conjunction with Government funding under contract number W911QY-11-C-0078, and there may be certain rights to the Government.

RELATED APPLICATIONS

[0002] This application claims the benefit of U.S. Provisional Application No. 61/674,896, filed July 24, 2012, which is herein incorporated by reference in its entirety for all purposes.

FIELD OF THE INVENTION

[0003] The invention relates to fabrics used in the manufacture of mobile shelters, and more particularly, to fabrics used in the manufacture of mobile shelters that provide protection against chemical and biological agents.

BACKGROUND OF THE INVENTION

[0004] A continuing need exists for mobile shelters or shelter liners that can protect soldiers and emergency workers from chemical and biological ("CB") agents. Of course, these mobile shelters must also protect occupants from environmental conditions such as rain and wind, and they must be resistant to fire as well as the long term effects of direct sun exposure. Often, such shelters must also have a camouflaged exterior, and they must be opaque to visible and infrared light, so as to reduce detectability when sources of heat and light are present within the shelter at night.

[0005] The mobility of a mobile shelter is directly dependent on the weight and packed volume of the fabric used in its manufacture. Current chemical and biological barrier fabrics are typically manufactured by selecting a woven fabric having a desired tensile strength and applying one or more coatings to the fabric that will provide the required protection.

[0006] The use of a woven fabric as the basic material from which to fabricate a mobile shelter is dictated by the need for high flexibility combined with high tensile strength. However, woven fabrics by their nature have an uneven surface, whereby as much as 50% or more of the surface consists of pockets or gaps that lie between the interwoven yarns. When applying CB protective coatings, these gaps must be filled by the applied coating material before the coating material can form a protective surface layer over the entire fabric. The excess coating material that fills these gaps can significantly increase the bulk and mass of the coated protective fabric, while contributing little if anything to the protective qualities of the fabric.

[0007] CB barrier materials typically have a mass of approximately 25 oz/yd^2, and are often provided as liners for standard mobile shelters. These heavy and bulky materials can create a high logistical burden and setup time to warfighters. The burden is so great that often the liners are not supplied or are rarely installed, resulting in fielded shelters that are often not ready to provide CB protection. For example, a typical fabric shelter with a bed capacity of 44 requires an additional CBRN liner with a mass 5,570lbs, and with a packed volume of approximately 808 ft^3.

[0008] What is needed, therefore, is a barrier fabric for a mobile shelter that can provide chemical and biological protection equivalent to or better than fabrics currently in use, but with a significantly lower weight and bulk.

SUMMARY OF THE INVENTION

[0009] A lightweight, low bulk, mobile shelter fabric that provides chemical and biological protection equivalent to or better than current designs is formed by sandwiching and laminating a high tensile strength woven scrim between two thin, CB impenetrable films. The woven scrim provides the required tensile strength, while the outer and inner films provide the necessary barrier to chemical and biological agents.

[0010] In embodiments, the inner and outer films also provide smooth surfaces to which coatings can be applied for camouflage, increased light opacity, increased CB protection, sun and weather resistance, flame resistance, adhesion, and other requirements as needed. Due to the smooth, impenetrable nature of the films, any such applied coatings remain entirely on the surface, thereby minimizing the bulk and weight added by the coatings. In some of these embodiments, the coatings are made with reduced viscosity in solvent formulations, while in other embodiments they are made as reactive formulations.

[0011] In various embodiments, the films are applied to the scrim with sufficient heat and pressure to create a conformal laminate in which the films penetrate into the "window" regions in the weave of the scrim, causing the thermoplastic urethane on the inside faces of the films to flow together to form one adhesive layer encapsulating a scrim between them, thereby strengthening the attachment of the films to the laminate. As a result, the films in these embodiments are no longer strictly flat.

[0012] In some of these embodiments at least one coating is applied to a film before lamination of the films onto the scrim. The applied heating and pressure are controlled so that the bonding of the inside faces of the films through the scrim weave is maximized without causing the coating to flow. As a result, the thickness of the coating on the film remains uniform, even though the underlying film is no longer completely flat. Substantially complete coverage of the laminate by the coating is thereby maintained without requiring additional coating material

to fill the "windows" in the scrim weave. If the face coating were allowed to flow during lamination, then excess coating material would tend to flow into the depressions where the films penetrated into the scrim "windows," and expose yarns creating pinholes disrupting opacity. Additional coating mass would be required to fill any holes created, thereby increasing the overall system mass.

[0013] In some embodiments, the films are hard-drawn polymer films, whereby the hard-drawn feature increases the crystallinity of the polymer, and thereby increases the polymer density and reduces its permeability to CB agents.

[0014] In various embodiments, the films have a roughness of less than 10 microns. In some embodiments, hammer milled kaolin clay is applied to at least one of the films, either as a separate coating or as a disbursed additive in an elastomeric coating, so as to increase light opacity.

[0015] In some embodiments, at least one of the films is a 1 mil nylon film. In other embodiments, at least one of the films is a 1 mil polyimide films or a 1 mil polyester film.

[0016] In embodiments, the outer film is coated with an aliphatic urethane for superior weathering and color stability. This urethane can be pigmented to provide camouflage or other required cosmetic appearance. In some embodiments, urethane resin is mixed into a solvent in which it is soluble, to create a urethane coating that can be applied to the film. The percentage of solids in the mixture affects the coating's viscosity, which impacts the final coating deposited. Heating the coating to an elevated temperature of at least 180 F after application to a substrate causes the solvent to rapidly evaporate, depositing the urethane onto the film and forming a solid coating.

[0017] In various embodiments, a two-part urethane (herein referred to as "2K urethane") is applied as a coating to one of the film surfaces. 2K urethane coatings are created by reacting the two components used to form urethanes, polyols and isocyanates, directly on the film. Controlling temperature of the two

components during mixing allows for the coating viscosity to be maintained for consistent pickup. Forming the urethane directly on the film enhances adhesion of the coating to the film. Adjustments to the 2K urethane recipes can be made to control the amount of crosslinking in the polymer, which can alter the film's hardness, and can adjust its thermo-plasticity. Controlling the thermo-plasticity of the film coatings allows for the thermal lamination of the material without causing the coating to flow.

[0018] The inner surface can be coated with a poly-ether urethane for improved strength and reduced cost, since the inner surface is shielded from weathering and UV light. These coatings are typically applied in a solvent based process described supra.

[0019] In various embodiments, the use of high bulk strength adhesives overcomes the shear failure often seen in laminated systems between a hard fabric and film. In some embodiments, the use of isocynate adhesion promoters in combination with the crosslinking of the adhesives reduces adhesive failure.

[0020] In embodiments, the scrim is a 1500 denier vectran scrim having 4.5 and 3.5 ends per inch in the warp and fill directions respectively.

[0021] In various embodiments, the yarn bundles of the scrim are spread into flattened shapes so as to reduce the thickness of the scrim and increase its surface area or "cover factor," thereby providing more surface area for adhesion between the scrim and the film. Increased bonding surface area helps to overcome the delamination often seen in laminated systems. Flat yarns help to create an overall flatter laminate, and reduce the stress put onto the film at the knuckles (where the yarns cross) during lamination. This stress can lead to pinholes in coatings and sometimes in films.

[0022] In embodiments, the films are laminated to the scrim one at a time.

[0023] In some embodiments, the weight of the assembled layers is less than 12 oz/yd^2.

[0024] One general aspect of the present invention is a multi-layer fabric suitable for constructing mobile shelters that provide protection against chemical and biological agents. The fabric includes a woven scrim, an outer polymer film layer attached by a first adhesive to an outer surface of the woven scrim, and an inner polymer film layer attached by a second adhesive to an inner surface of the woven scrim, at least one of the outer polymer film layer and the inner polymer film layer being resistant to penetration by chemical and biological ("CB") agents.

[0025] In embodiments, at least one of the films is made from a hard drawn polymer. In some embodiments, at least one of the films has a roughness of less than 10 microns.

[0026] In various embodiments, at least one coating is applied to at least one surface of one of the films. In some of these embodiments, the coating includes a hammer milled kaolin clay. In other of these embodiments the coating provides a camouflaged exterior appearance to the fabric. In still other of these embodiments, the coating provides at least one of increased light opacity, increased infra-red opacity, increased CB penetration protection, flame retardance, and increased resistance to damage from sunlight. In yet other of these embodiments the coating includes an aliphatic urethane. In still other of these embodiments the coating is formed by reacting two components directly on the film. And in yet other of these embodiments the coating is uniform in thickness.

[0027] In certain embodiments, the outer and inner polymer films conform to the weave of the scrim, and the outer and inner film layers are bonded to each other through openings in the scrim weave.

[0028] In embodiments, at least one of the first adhesive and the second adhesive includes an isocyanate adhesion promoter. In some embodiments at least one of the films is a 1 mil film made from at least one of nylon, polyimide, and polyester. In other embodiments at least one of the films is flame retardant. various embodiments the outer film is an aliphatic nylon. In certain embodiments

the inner film is coated with a poly-ether urethane. And in some embodiments the scrim is a vectran scrim.

[0029] In various embodiments the scrim is a 1500 denier vectran scrim. In some of these embodiments, the scrim has 4.5 and 3.5 ends per inch in the warp and fill directions respectively.

[0030] And in certain embodiments, the scrim includes flattened, non-twisted yarns.

[0031] Another general aspect of the present invention is a method for fabricating a multi-layer fabric suitable for constructing mobile shelters that provide protection against chemical and biological agents. The method includes applying a first adhesive to an outer surface of a woven scrim, applying an outer polymer film to the outer surface of the woven scrim, applying a second adhesive to an inner surface of the woven scrim, applying an inner polymer film to the inner surface of the woven scrim, and applying at least one of pressure and heat to the assembled scrim and films so as to cure and set the adhesives.

[0032] Embodiments further include applying a coating to at least one surface of at least one of the films. In some of these embodiments the coating includes a hammer milled kaolin clay. In other of these embodiments the coating is applied with a uniform thickness to the film before the film is laminated onto the scrim, sufficient heat and pressure are applied during the lamination to cause the films to conform to the weave of the scrim and to bond to each other through openings in the scrim weave. and the applied heat and pressure are insufficient to cause the coating to flow, so that the coating remains uniform in thickness after the lamination.

[0033] In still other of these embodiments the coating is formed by reacting two components on the surface of the film. And in yet other of these embodiments, at least one of the adhesives is applied using an isocyanate adhesion promoter.

[0034] And in various embodiments further include preparing yarns made of untwisted bundles of fiber, spreading the untwisted bundles into flattened shapes, and weaving the flattened yarns to form the woven scrim.

[0035] The features and advantages described herein are not all-inclusive and, in particular, many additional features and advantages will be apparent to one of ordinary skill in the art in view of the drawings, specification, and claims. Moreover, it should be noted that the language used in the specification has been principally selected for readability and instructional purposes, and not to limit the scope of the inventive subject matter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0036] Figure 1A is a perspective view of a partially disassembled multi-layer fabric in an embodiment of the present invention;

[0037] Figure 1B is a close-up exploded perspective view of a conformal laminate embodiment of the present invention;

[0038] Figure 2A is a block diagram that illustrates the layer structure of an embodiment of the present invention;

[0039] Figure 2B is a block diagram similar to Figure 2A, except that an opacity additive has been disbursed in the adhesive layers; and

[0040] Figure 3 is a perspective view that compares a scrim yarn formed from a rounded bundle of non-twisted fibers with a scrim yarn formed from a flattened bundle of non-twisted fibers.

DETAILED DESCRIPTION

[0041] The present invention is a lightweight, low bulk, multi-layer fabric that can be used to construct mobile shelters for protecting occupants against chemical and biological ("CB") agents as well as environmental factors such as rain, wind, and sun exposure. The fabric of the present invention provides chemical and

biological protection that is equivalent to or better than current designs, while the bulk and weight of the present invention are typically about half of the bulk and weight of the currently used materials. For example, typical CB protection materials currently weigh about 20 oz/yd^2, while embodiments of the present invention weigh only about 12 oz/yd^2 or less.

[0042] The excess weight and bulk of the currently used fabrics arises mainly from excess coating material that must fill in the gaps between yarns in the woven fabric before a protective coating can be formed over the entire surface. Of course, this problem could be avoided by using a non-woven fabric such as a polymer sheet. However, a polymer sheet cannot provide the required tensile strength, unless it is made so thick that it is no longer sufficiently flexible.

[0043] With reference to Figure 1A, the present invention resolves this dilemma by providing a multi-layer solution 100. The outer 102 and inner 104 layers are thin polymer films that have a high resistance to CB agents and provide smooth surfaces for the application of coatings as required. A woven scrim 106 is sandwiched between the two film layers 102, 104 so as to provide the required tensile strength. Accordingly, this multi-layer approach combines the CB barrier and smooth surface advantages of a polymer film with the tensile strength advantage of a woven fabric.

[0044] In certain embodiments, either or both of the film layers 102, 104 is a hard drawn polymer film, whereby the hard-drawn feature increases the crystallinity of the polymer, and thereby increases the polymer density and reduces its permeability to CB agents.

[0045] In embodiments, the use of high bulk strength adhesives overcomes the shear failure often seen in laminated systems between a hard fabric and film. In some embodiments, the use of Isocynate adhesion promoters in combination with the crosslinking of the adhesives reduces adhesive failure.

[0046] With reference to Figure 1B, in various embodiments the films 102, 104 are applied to the scrim 106 with sufficient heat and pressure to create a conformal laminate in which the films102, 104 penetrate into the "window" regions 108 in the weave of the scrim 106, causing the thermoplastic urethane on the inside faces of the films 102, 104 to flow together to form one adhesive layer encapsulating the scrim 106 between them, thereby strengthening the attachment of the films 102, 104 to the laminate 100. As a result, the films 102, 104 in these embodiments are no longer strictly flat. Note that Figure 1B is a close-up exploded view of the laminate 100 of Figure 1A.

[0047] While the polymer film layers themselves provide significant protection against CB agents, it can be desirable to apply coatings to the outer and/or to the inner surfaces of the multilayer fabric assembly 100 for camouflage, increased light opacity, increased CB protection, sun and weather resistance, flame resistance, and other requirements as needed. Due to the smooth, impenetrable nature of the films, any such applied coatings remain entirely on the surfaces, thereby minimizing their added bulk and weight. In various embodiments, the films have a roughness of less than 10 microns.

[0048] In some embodiments at least one coating is applied to a film before lamination of the films onto the scrim. In embodiments such as Figure 1B, the applied heating and pressure are controlled so that the bonding of the inside faces of the films102, 104 through the scrim weave 106 is maximized without causing the coating to flow. As a result, the thickness of the coating on the film remains uniform even though the underlying film102, 104 is no longer completely flat. Substantially complete coverage of the laminate 100 by the coating is thereby maintained without requiring additional coating material to fill the "windows" 108 in the scrim weave 106. If the face coating were allowed to flow during lamination, then excess coating material would tend to flow into the depressions 108 where the films 102, 104 penetrate into the scrim "windows " 108, and additional coating mass would be required to fill any holes created, thereby increasing the overall system mass.

[0049] In some of these embodiments, the coatings are made with reduced viscosity in solvent formulations, while in other embodiments they are made as reactive formulations.

[0050] In various embodiments, a two-part urethane (herein referred to as "2K urethane") is applied as a coating to one of the film surfaces. 2K urethane coatings are created by reacting the two components used to form urethanes, polyols and isocyanates, directly on the film. Forming the urethane directly on the film enhances adhesion of the coating to the film. Adjustments to the 2K urethane recipes can be made to control the amount of crosslinking in the polymer, which can alter the film's hardness, and can adjust its thermo-plasticity. Controlling the thermo-plasticity of the film coatings allows for the thermal lamination of the material without causing the coating to flow.

[0051] Figure 2A is a block diagram that illustrates an assembly of layers and coatings in an embodiment of the invention. The embodiment includes an outer "weathering film" section 200 in which a barrier film 202 includes an outer camouflage coating 204 and an inner opacity layer 206. In embodiments, the opacity layer 206 is a coating that contains hammer-milled kaolin clay to further reduce permeation by CB agents while increasing the light opacity of the assembled material.

[0052] The weathering film section 200 is joined by an adhesive layer 208 to a central thin ply scrim 210, which in this embodiment is a 1500 denier vectran scrim having 4.5 and 3.5 ends per inch in the warp and fill directions respectively.

[0053] A back-coated film section 212 includes a second barrier film 214 with a white back-coating 216 on its exterior surface for cosmetic purposes, and a second opacity layer 218 on its other surface. The back-coated film section 212 is joined by the adhesive layer 220 to the inner side of the scrim 210. The weight of each layer is indicated in the figure, providing a total weight of 11.2 oz/yd^2.

[0054] Figure 2B is a block diagram of an embodiment that is similar to Figure 2A, except that the separate opacity layers 206, 218 have been omitted, and instead an opacity-enhancing additive such as hammer milled kaolin clay has been disbursed into the adhesive layers 222, 224.

[0055] In some embodiments, at least one of the films 202, 214 is a 1 mil nylon film. In other embodiments, at least one of the films 202, 214 is coated with a urethane, which provides good flame retardance and color. In the embodiments of Figures 2A and 2B, the outer film 202 is an aliphatic nylon for superior weathering, while the inner film 214 is a poly-ether for improved strength and reduced cost.

[0056] With reference to Figure 3, in various embodiments the yarn bundles of the scrim are untwisted bundles of fibers 300 that are initially round, but are spread into flattened shapes 302 so as to reduce the thickness of the scrim and increase its surface area or "cover factor," thereby providing more surface area for adhesion of the film layers and reducing any tendency of the films to be depressed into gaps between the scrim yarns. Figure 3 shows a first bundle of fibers 300 as it appears before spreading, and a second bundle of fibers 302 as it appears after spreading.

[0057] The foregoing description of the embodiments of the invention has been presented for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed. Many modifications and variations are possible in light of this disclosure. It is intended that the scope of the invention be limited not by this detailed description, but rather by the claims appended hereto.

CLAIMS

What is claimed is:

1. A multi-layer fabric suitable for constructing mobile shelters that provide protection against chemical and biological agents, the fabric comprising:

a woven scrim;

an outer polymer film layer attached by a first adhesive to an outer surface of the woven scrim; and

an inner polymer film layer attached by a second adhesive to an inner surface of the woven scrim;

at least one of the outer polymer film layer and the inner polymer film layer being resistant to penetration by chemical and biological ("CB") agents.

2. The fabric of claim 1, wherein at least one of the films is made from a hard drawn polymer.

3. The fabric of claim 1, wherein at least one of the films has a roughness of less than 10 microns.

4. The fabric of claim 1, wherein at least one coating is applied to at least one surface of one of the films.

5. The fabric of claim 4, wherein the coating includes a hammer milled kaolin clay.

6. The fabric of claim 4, wherein the coating provides a camouflaged exterior appearance to the fabric.

7. The fabric of claim 4, wherein the coating provides at least one of increased light opacity, increased infra-red opacity, increased CB penetration protection, flame retardance, and increased resistance to damage from sunlight.

8. The fabric of claim 4, wherein the coating includes an aliphatic urethane.

9. The fabric of claim 4, wherein the coating is formed by reacting two components directly on the film.

10. The fabric of claim 4, wherein the coating is uniform in thickness.

11. The fabric of claim 1, wherein the outer and inner polymer films conform to the weave of the scrim, and the outer and inner film layers are bonded to each other through openings in the scrim weave.

12. The fabric of claim 1, wherein at least one of the first adhesive and the second adhesive includes an isocyanate adhesion promoter.

13. The fabric of claim 1, wherein at least one of the films is a 1 mil film made from at least one of nylon, polyimide, and polyester.

14. The fabric of claim 1, wherein at least one of the films is flame retardant.

15. The fabric of claim 1, wherein the outer film is an aliphatic nylon.

16. The fabric of claim 1, wherein the inner film is coated with a poly-ether urethane.

17. The fabric of claim 1, wherein the scrim is a vectran scrim.

18. The fabric of claim 1, wherein the scrim is a 1500 denier vectran scrim.

19. The fabric of claim 14, wherein the scrim has 4.5 and 3.5 ends per inch in the warp and fill directions respectively.

20. The fabric of claim 1, wherein the scrim includes flattened, non-twisted yarns.

21. A method for fabricating a multi-layer fabric suitable for constructing mobile shelters that provide protection against chemical and biological agents, the method comprising:

applying a first adhesive to an outer surface of a woven scrim;

applying an outer polymer film to the outer surface of the woven scrim;

applying a second adhesive to an inner surface of the woven scrim;

applying an inner polymer film to the inner surface of the woven scrim; and

applying at least one of pressure and heat to the assembled scrim and films so as to cure and set the adhesives.

22. The method of claim 21, further comprising applying a coating to at least one surface of at least one of the films.

23. The method of claim 22, wherein the coating includes a hammer milled kaolin clay.

24. The method of claim 22, wherein:

the coating is applied with a uniform thickness to the film before the film is laminated onto the scrim;

sufficient heat and pressure are applied during the lamination to cause the films to conform to the weave of the scrim and to bond to each other through openings in the scrim weave; and

the applied heat and pressure are insufficient to cause the coating to flow, so that the coating remains uniform in thickness after the lamination.

25. The method of claim 22, wherein the coating is formed by reacting two components on the surface of the film.

26. The method of claim 22, wherein at least one of the adhesives is applied using an isocyanate adhesion promoter.

27. The method of claim 21, further comprising:

preparing yarns made of untwisted bundles of fiber;

spreading the untwisted bundles into flattened shapes; and

weaving the flattened yarns to form the woven scrim.

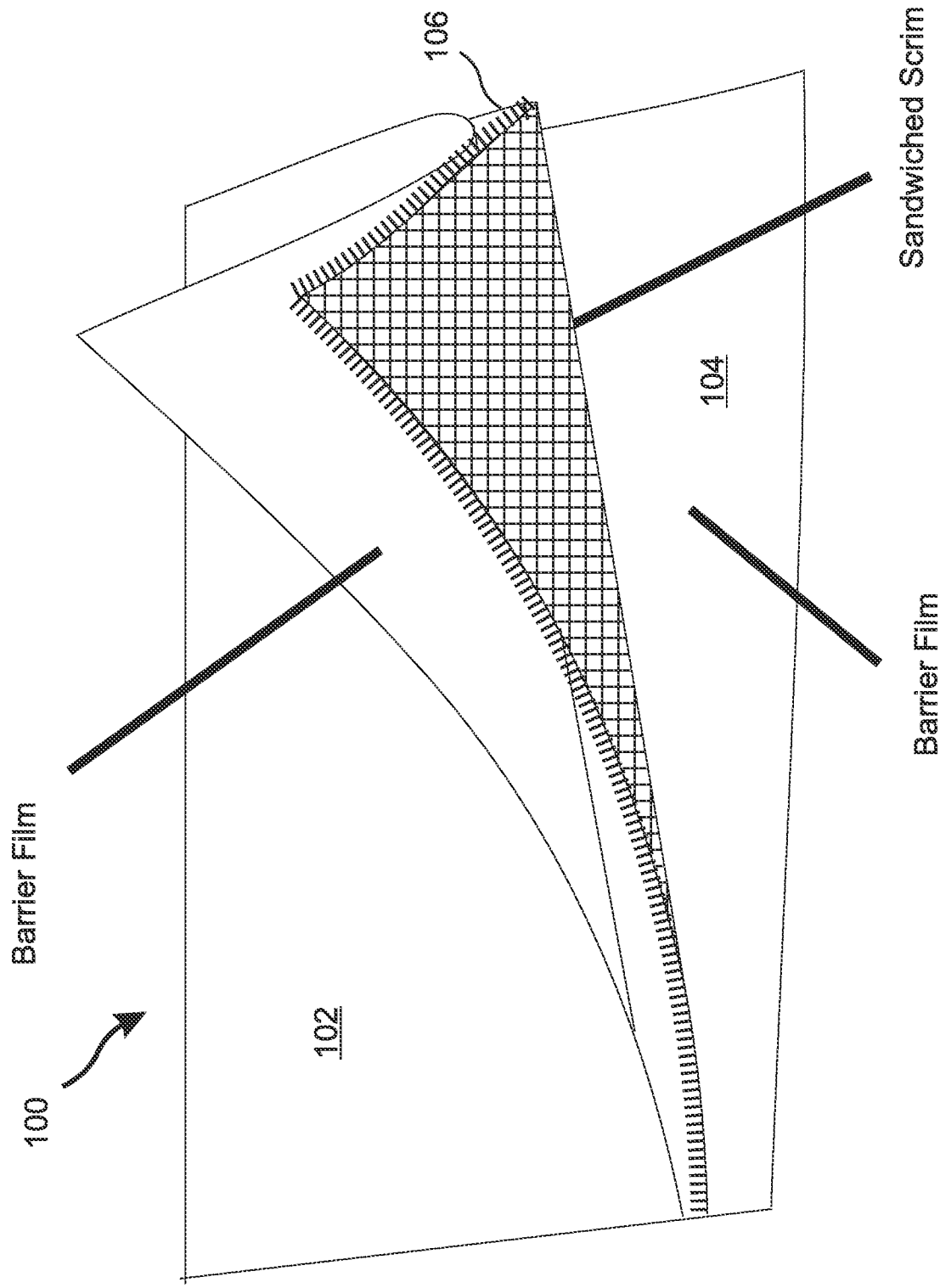


Figure 1A

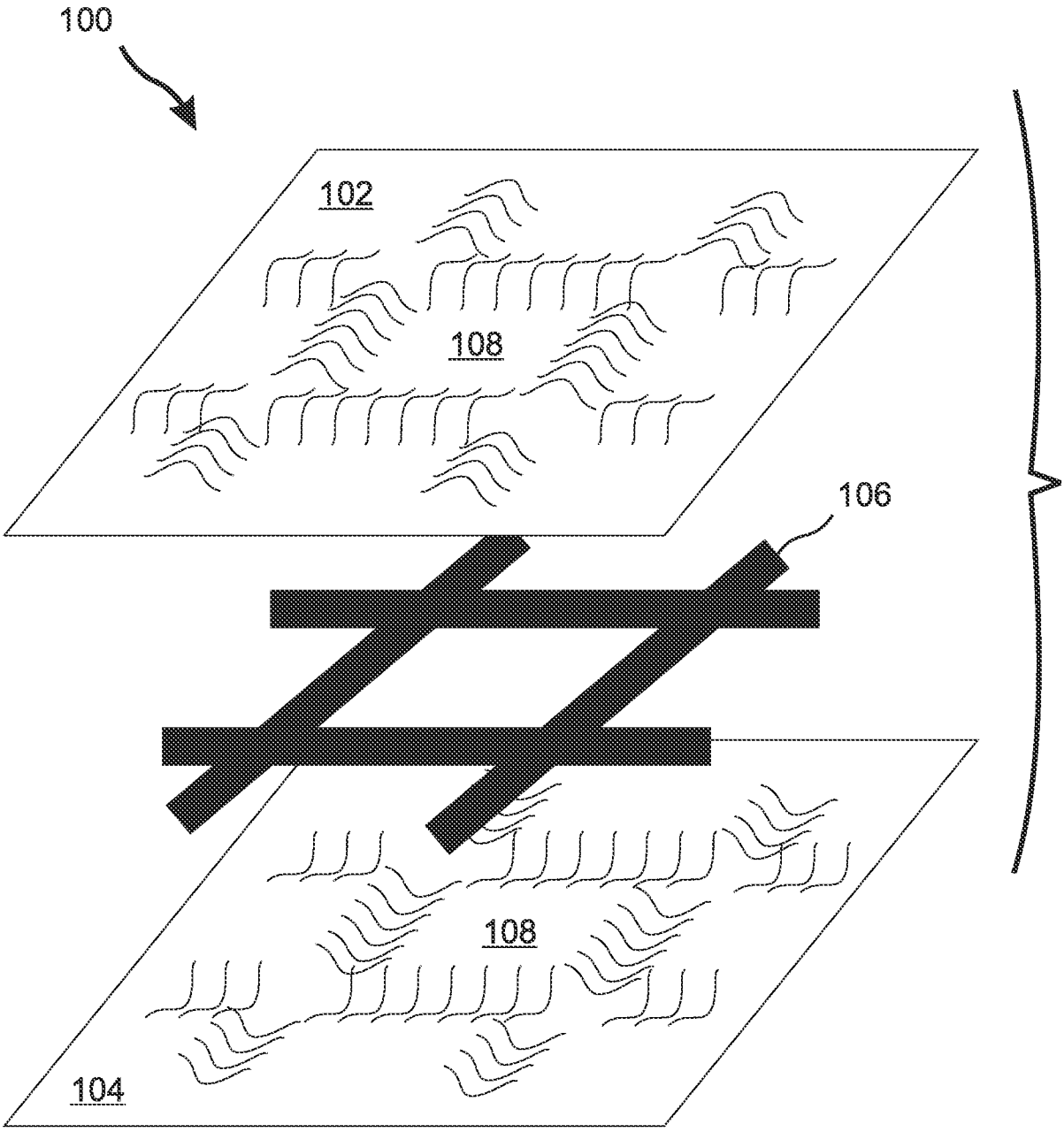


Figure 1B

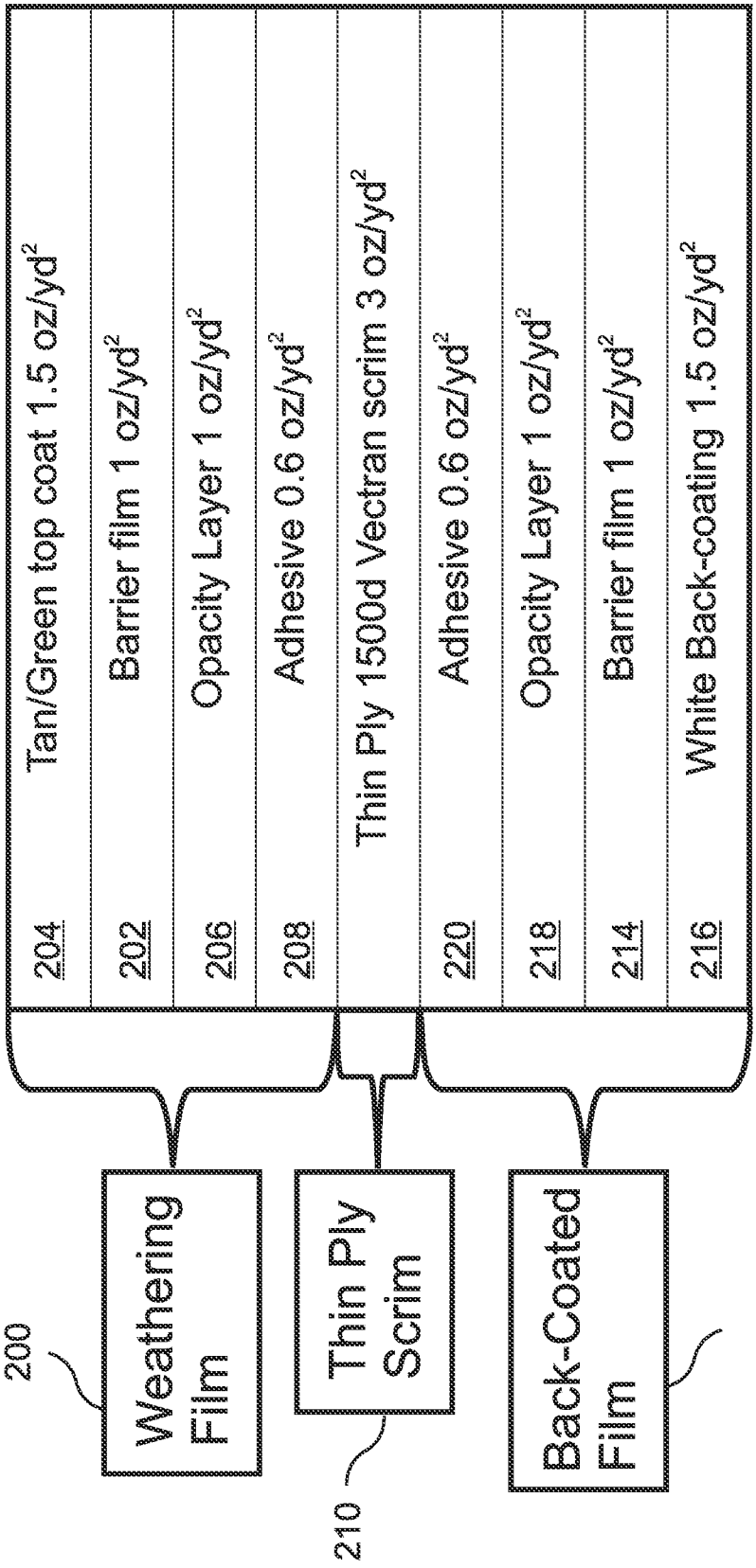

204
Tan/Green top coat 1.5 oz/yd²
202
Barrier film 1 oz/yd²
206
Opacity Layer 1 oz/yd²
208
Adhesive 0.6 oz/yd²
Thin Ply 1500d Vectran scrim 3 oz/yd²
220
Adhesive 0.6 oz/yd²
218
Opacity Layer 1 oz/yd²
214
Barrier film 1 oz/yd²
216
White Back-coating 1.5 oz/yd²
200
Weathering Film
210
Thin Ply Scrim
Back-Coated Film
212

Figure 2A

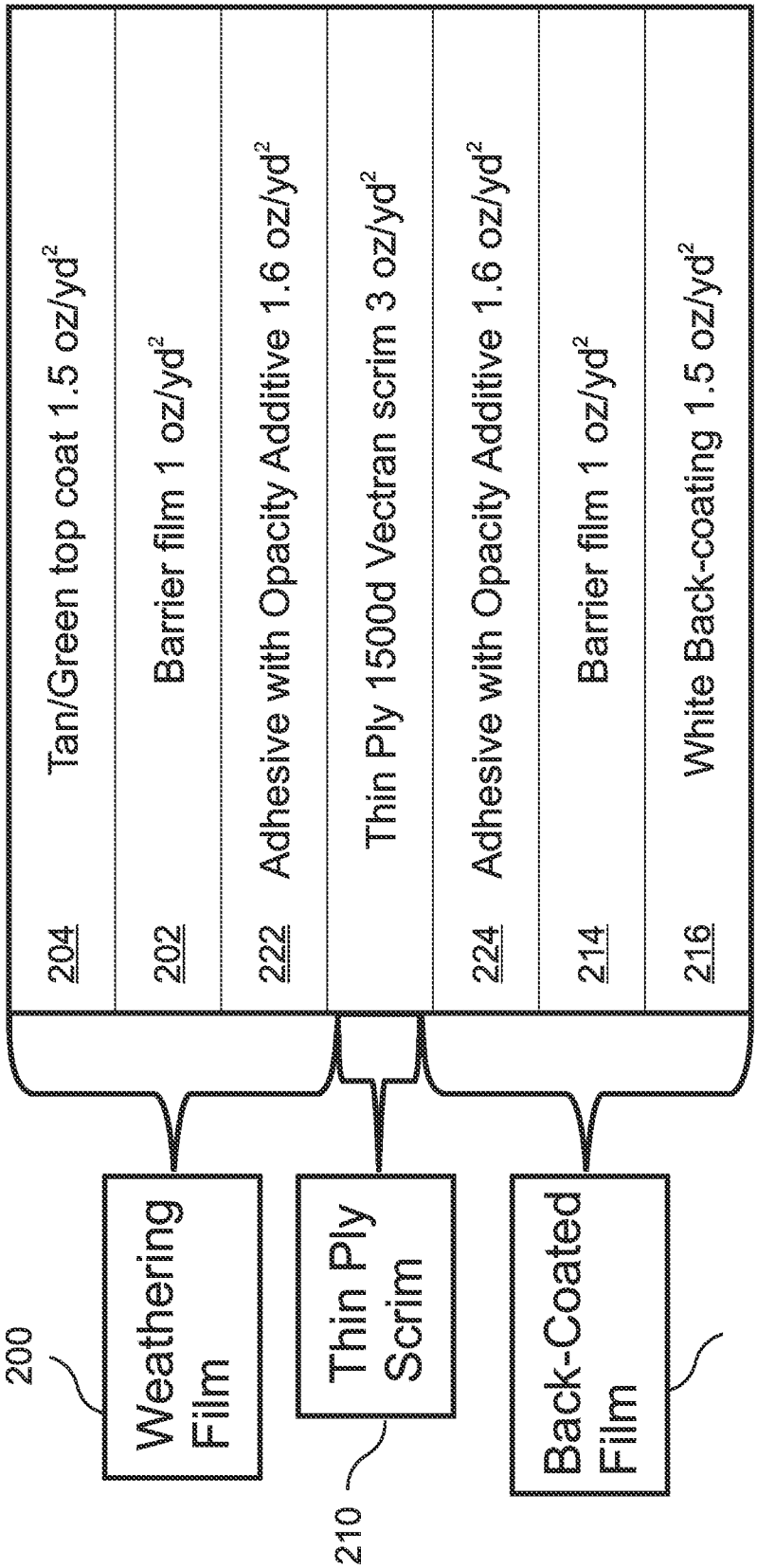

204 Tan/Green top coat 1.5 oz/yd²
202 Barrier film 1 oz/yd²
222 Adhesive with Opacity Additive 1.6 oz/yd²
Thin Ply 1500d Vectran scrim 3 oz/yd²
224 Adhesive with Opacity Additive 1.6 oz/yd²
214 Barrier film 1 oz/yd²
216 White Back-coating 1.5 oz/yd²
200
Weathering Film
Thin Ply Scrim
Back-Coated Film
210
212

Figure 2B

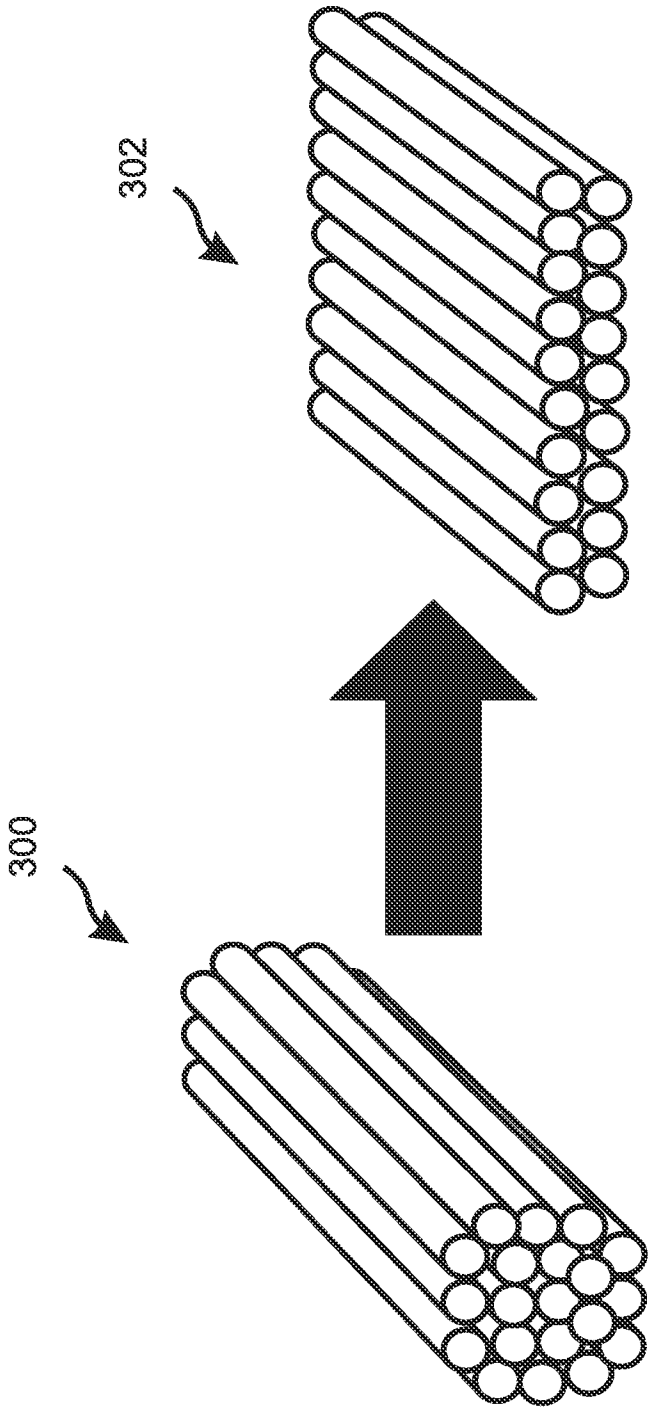


Figure 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/051758

A. CLASSIFICATION OF SUBJECT MATTER

B32B 27/12(2006.01)i, B32B 3/24(2006.01)i, B32B 5/02(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)
B32B 27/12; D04H 11/00; B32B 9/00; B32B 37/00; D03D 15/00; B32B 3/00; B32B 5/12; B32B 33/00; B29C 65/00; B32B 3/24; B32B 5/02

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
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & keywords: multi-layer fabric, CB agents, woven scrim, polymer film, adhesive, alipatic urethane, isocyanate adhesion promoter, vectran scrim

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2011-0123757 A1 (HOWLAND. C. A.) 26 May 2011 See figure 3; paragraphs [0014]-[0021], [0028]-[0035], [0068]-[0070]; claims 1, 10, 12, 24.	1,2,13-16,20,21,27
A		3-12,17-19,22-26
Y	US 2005-0191918 A1 (LANGLEY, J. D. et al.) 1 September 2005 See figures 1-3; paragraphs [0048]-[0050], [0056]-[0062]; claims 1, 4, 11-16, 18.	1,2,13-16,20,21,27
A	US 7595104 B2 (ROMANOWSKI, J. R.) 29 September 2009 See figure 1; column 8, lines 15-44; column 10, lines 36-column 11, lines 9; claims 1-5, 8, 9, 11, 12, 16, 17.	1-27
A	US 5773373 A (WYNNE, L. K. et al.) 30 June 1998 See figure 1; column 2, lines 34-50; column 4, lines 1-10; claims 1-11.	1-27
A	US 6322657 B1 (PONTUTI, J. A. et al.) 27 November 2001 See abstract; column 2, lines 9-52; claims 1-3, 5-7.	1-27

☐ 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	Date of mailing of the international search report
30 October 2013 (30.10.2013)	**01 November 2013 (01.11.2013)**

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2013/051758

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2011-0123757 A1	26/05/2011	EP 2501247 A2	26/09/2012
		WO 2011-063261 A2	26/05/2011
		WO 2011-063261 A3	20/10/2011
		WO 2011-063261 A4	26/05/2011
US 2005-0191918 A1	01/09/2005	US 7196023 B2	27/03/2007
US 7595104 B2	29/09/2009	US 2004-0071916 A1	15/04/2004
US 05773373 A	30/06/1998	US 05985071 A	16/11/1999
US 6322657 B1	27/11/2001	CA 2062839 A1	20/10/1992
		CA 2062839 C	03/09/2002
		DE 69208500 D1	04/04/1996
		DE 69208500 T2	10/10/1996
		EP 0509678 A1	21/10/1992
		EP 0509678 B1	28/02/1996
		JP 03090287 B2	18/09/2000
		JP 05-116256 A	14/05/1993
		KR 10-0202325 B1	15/06/1999
		US 05260113 A	09/11/1993
		US 05906696 A	25/05/1999