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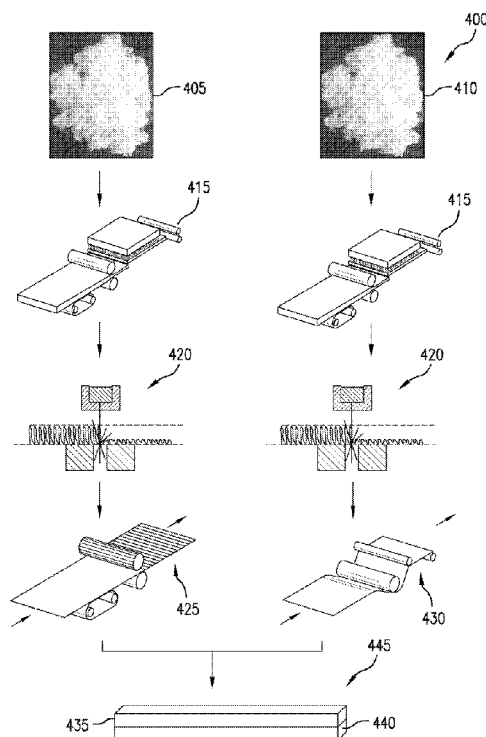


FIG. 4

(57) Abstract: A flexible protective insert for a garment, such as a Perforation-Resistant Flexible Footwear Insert (PRFFI) manufactured using randomly oriented fibers which may be processed by needle-punching, hydro-entanglement, thermal bonding, and chemical bonding. In an illustrative example, the protective insert may include two layers, a comfort layer and a protective layer. Both layers may be formed from a needle-punching process and a hydro-entanglement process of randomly arranged fibers. The random arrangement of fibers may substantially reduce or prevent puncture therethrough yet permit flexibility. The comfort layer may then be subjected to a thermal bonding process while the protective layer may be subjected to a chemical bonding process. In some embodiments, the protective layer may be formed from non-woven fabric which may include a random arrangement of high-tenacity fibers. These entangled high-tenacity fibers may then be chemically bonded which may further increase cohesion and resistance to perforation.

PERFORATION-RESISTANT FLEXIBLE INSERT FOR GARMENT OR FOOTWEAR

TECHNICAL FIELD

Various embodiments relate generally to footwear safety and more specifically to a perforation-resistant protective insert for use with footwear.

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BACKGROUND

Safety products for protecting a foot within an article footwear are widely used. The use of safety products with footwear may assist in preventing injuries to the foot of the user, such as for example due to puncture from sharp objects or compression from heavy objects falling onto the footwear. In some applications, a protective device may be integrated into an article of footwear to prevent sharp or pointed objects from protruding within the interior of the footwear. To minimize the likelihood of puncture or compression of the foot, the protective device may include a rigid and/or hardened structure, such as for example a metal insert. However, by increasing the rigidity and stiffness of the protective device, comfort of the foot of the user and flexibility of the footwear are often sacrificed.

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SUMMARY

Apparatus and associated methods may relate to a Perforation-Resistant Flexible Footwear Insert (PRFFI) manufactured using randomly oriented fibers which may be processed by needle-punching, hydro-entanglement, thermal bonding, and chemical bonding. In an illustrative example, the protective insert may include two layers, a comfort layer and a protective layer. Both layers may be formed from a needle-punching process and a hydro-entanglement process of randomly arranged fibers. The random arrangement of fibers may substantially reduce or prevent puncture therethrough yet permit flexibility. The comfort layer may then be subjected to a thermal bonding process while the protective layer may be subjected to a chemical bonding process. In some embodiments, the protective layer may be formed from non-woven fabric which may include a random arrangement of high-tenacity fibers. These entangled high-tenacity fibers may then be chemically bonded which may further increase cohesion and resistance to perforation.

In an illustrative embodiment, the protective insert may be formed from non-woven fabric including a random arrangement of polymer-type fibers, such as high-tenacity Poly-

Ethylene Terephthalate (PET), high tenacity Poly-Ethylene (PE), Aramid fibers, and/or Ultra-High-Molecular-Weight Poly-Ethylene (UHMWPE). In an exemplary embodiment, the protective insert may be formed from multiple thin, flexible layers of the non-woven fabric bonded together. For example, the protective insert may include a comfort layer
5 located adjacent a user foot and a protective layer attached to the comfort layer and located adjacent an exterior layer of the footwear.

In accordance with an exemplary embodiment, the non-woven fabrics may include aramid or par-aramid fibers mixed with polyamide or polyester fibers. For example, the different types of fibers may be mixed together and bonded through an adhesive process. In
10 an exemplary embodiment, all of the layers of the protective insert may include similar type fibers. In other exemplary embodiments, certain layers may include one or more different types of fibers. In some embodiments, some layers may be impregnated with a polymer, such as, for example, rubber latex, polyurethane, or acrylic. Impregnation of the layer(s) may increase cohesion and resistance to perforation. In an exemplary embodiment, the
15 protective layer may be impregnated with the polymer. In other exemplary embodiments, conductive fibers may be added to one or more layers to provide antistatic properties to the protective insert.

Various embodiments may achieve one or more advantages. For example, some embodiments may provide increased flexibility of the protective insert by forming the insert
20 from multiple thin layers of non-woven fabrics. For example, a combined thickness of the layers of the protective insert may be less than 3.8 millimeters. In other exemplary embodiments, the protective insert may be formed from a single, thicker layer. In an exemplary embodiment, the use of a combination of aramid type fibers and polymer type fibers may result in a protective insert having high tenacity and high cohesion between
25 fibers.

The details of various embodiments are set forth in the accompanying drawings and the description below. Other features and advantages will be apparent from the description and drawings, and from the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

30 FIG. 1 depicts an exemplary field application of Perforation-Resistant Flexible Footwear Insert (PRFFI).

FIG. 2A depicts a view of the toe portion of a shoe with an exemplary PRFFI.

FIG. 2B depicts a magnified cross-sectional view of the circled portion of FIG. 2A shoe with an exemplary PRFFI.

FIG. 3 depicts a perspective view of an exemplary PRFFI.

FIG. 4 depicts a flow diagram of an exemplary manufacturing process of exemplary
5 PRFFIs.

FIG. 5 depicts a cross-section of an exemplary article of footwear incorporating an exemplary PRFFI.

FIG. 6 depicts a cross-section of an exemplary article of footwear incorporating an
10 exemplary PRFFI.

FIG. 7A depicts a view of an exemplary article of footwear incorporating another
embodiment of a PRFFI.

FIG. 7B depicts a magnified cross-sectional view of the circled portion of FIG. 7A shoe with an exemplary PRFFI.

Like reference symbols in the various drawings indicate like elements.

15 DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

To aid understanding, this document is organized as follows. First, exemplary articles of footwear each incorporating a protective insert are briefly introduced with reference to FIGs. 1A-2B. Second, with reference to FIG. 3, the discussion turns to an exemplary embodiment that illustrates a multi-layered protective insert. Specifically, the
20 protective insert includes a comfort layer and a protective layer each formed from in a substantial part from non-woven fabrics. Then, with reference to FIG. 4, further explanatory discussion and experimental data is presented to explain improvements in a process of manufacturing the protective insert. Finally, with reference to FIGs. 5-7, cross-sectional diagrams will assist in the discussion regarding various embodiments.

FIG. 1 depicts an exemplary field application of Perforation-Resistant Flexible Footwear Insert (PRFFI). In FIG. 1, a construction site 100 for a new home is depicted. At the construction site 100, a carpenter 105 is navigating the site 100. The carpenter is about to step on a nail 110 projecting out of a board 115. The carpenter 105 is wearing a work boot 120 that has a Perforation-Resistant Protective Footwear Insert (PRFFI) 125. The nail
30 110 has penetrated an outsole 130 of the work boot 120, but has been stopped by the PRFFI 125. The PRFFI 125 has thus saved the carpenter 105 from a dangerous situation.

FIG. 2A depicts a view of the toe portion of a shoe with an exemplary PRFFI. In the depicted example, a PRFFI 225 forms the insole of the article of footwear 200. For example, the PRFFI 225 is attached to an upper surface of an outsole 220 of the article of footwear 200. In another exemplary embodiment, the PRFFI 225 may be attached to an already
5 existing insole of the article of footwear 200, such as for example by being positioned on an upper surface of the existing insole. By positioning the PRFFI 225 at an insole-located position of the article of footwear 200, the PRFFI 225 may prevent sharp objects from extending into an interior of the article of footwear 205 from below.

FIG. 2B depicts a magnified cross-sectional view of the circled portion of FIG. 2A
10 shoe with an exemplary PRFFI. The PRFFI 225 is shown having a comfort layer 235 and the protective layer 240. The protective layer 240 forms the lower part of the PRFFI 225 to prohibit intrusion of incoming objects. The comfort layer 235 forms the upper part of the protective insert 225 to provide a comfortable surface for a user to stand upon. In an exemplary embodiment, the comfort layer 235 may include additional padding, such as for
15 example by adding thickness via additional fabric to the comfort layer 235. In another exemplary embodiment, an additional padded insole may be positioned upon an upper surface of the comfort layer 235 of the protective insert 225. In the depicted example, the protective insert 225 may be adhesively attached to the outsole 220.

FIG. 3 depicts a perspective view of an exemplary PRFFI. The protective insert 225
20 includes the comfort layer 235 and the protective layer 240. In the depicted example, the comfort layer 235 and the protective layer 240 are shown as having similar dimensions. However, in other exemplary embodiments, the comfort layer 235 and the protective layer 240 may have different dimensions. For example, the comfort layer 235 may be thicker or thinner than the protective layer 240. In other exemplary embodiments, the comfort layer
25 235 may have a larger or smaller surface area than the protective layer 240. For example, the protective layer 240 may extend along a greater portion of the article of footwear 200 than the comfort layer 235.

In the depicted example, both the comfort layer 235 and the protective layer 240 include a mixture of non-woven fibers, such as for example high-tenacity type fibers 250 and
30 low tenacity type fibers 255. In some exemplary embodiments, one or more of the layers 235, 240 may include only a singular type of fiber. For example, the comfort layer 235 may only include a Polyester or Polyamide type of fiber 250 to increase a degree of comfort and the protective layer 240 may include only an aramid or an Ultra-High Molecular Weight

Polyethylene (UHMWPE) type of fiber 255 to increase a resistance to perforation. In other exemplary embodiments, the comfort layer 235 and/or the protective layer 240 may include additional fibers other than aramid type fibers 250 and/or polymer type fibers 255. For example, glass types of fibers and steel fibers both exhibit very high measures of tenacity
5 and may be used in an exemplary PRFFI embodiment. In some embodiments a mix of a high-tenacity fibers and low-tenacity fibers may be used on one or more layers.

In an exemplary embodiment, the layers 235, 240 may include a random arrangement of the non-woven fabric. The random arrangement of the non-woven fabric may increase cohesion between the fibers 250 and/or 255, thus reducing perforation or the likelihood of
10 puncture through the layers 235, 240. The manufacture of the layers 235, 240 using a random arrangement of fibers 250, 255 may also increase flexibility of the layers 235, 240 leading to a greater degree of comfort for the user while wearing the footwear incorporating the protective insert 225. In an exemplary embodiment, the fibers 250, 255 may be small in size to increase a compaction of the fibers 250, 255 within the layers 235, 240. In an
15 exemplary embodiment, conductive fibers may be added to one or more of the layers 235, 240 to provide antistatic properties.

FIG. 4 depicts a flow diagram of an exemplary manufacturing process of the protective insert. A manufacturing process 400 is used to build a multi-layered protective insert for reinforcing garments against penetration yet permitting flexibility and comfort. In
20 an exemplary embodiment, a garment type to receive the protective insert is an article of footwear.

The manufacturing process includes a first fabric mass 405 of non-woven fabric and a second fabric mass 410 of non-woven fabric. The first fabric mass 405 and the second fabric mass 410 both undergo a needle punching process 415 and a hydro-entanglement
25 process 4420. In the depicted example, the first fabric mass 405 and the second fabric mass 410 each separately undergo the needle punching process 415 and then the hydro-entanglement process 420. In an exemplary embodiment, a singular fabric mass may undergo the needle punching process 415 and the hydro-entanglement process 420 and afterwards be separated into the first fabric mass 405 and the second fabric mass 410.

30 In the needle punching process 415, the fabric masses 405, 410 may be subjected to puncture via needles to create nodes between the fibers and increase cohesion. In an exemplary embodiment, a starting fabric mass 405, 410 having a thick or large mass with a high percentage of air may be subjected to the needle punching process 415. The needle

punching process 415 may compact the large masses 405, 410 into a thin layer and cause the fibers of the masses 405, 410 to be linked together via the creation of nodes between the fibers. In an exemplary embodiment, smooth or barbed needles may be pushed through the fabric masses 405, 410 in a rapid manner from one or multiple directions. The speed and
5 protrusion of the needles and spacing between protrusions may differ for different types of materials used in the fabric masses 405, 410, as well as different pre-determined degrees of flexibility and/or strength of the protective insert.

The hydro-entanglement process 420 may be used to increase cohesion of the fibers forming fabric masses 405, 410. In an exemplary embodiment, the hydro-entanglement
10 processes 420 may include a spray of water on the fabric masses 405, 410, where the water may be caused to pass-through the fabric masses 405, 410, and bounce back through the fabric masses 405, 410 in an opposite direction due to contact with a surface behind the fabric masses 405, 410. The hydro-entanglement process may create additional nodes between fibers and make the fabric masses 405, 410 more compact.

Both the needle-punching process 415 and hydro-entanglement process 420 may
15 increase the strength of the fabric masses 405, 410, thus providing difficult-to-cut-through and/or difficult-to-penetrate fabric masses 405, 410. The processes may also cause compression upon the fabric masses 405, 410, thus increasing a number of snarls or direction changes of the fibers to further inhibit cutting, tearing, or puncture through the fabric masses
20 405, 410.

After the needle punching process the 415 and hydro-entanglement process 420, the first fabric mass 405 is subjected to a thermal bonding process 425 and the second fabric mass 410 is subjected to a chemical bonding process 430, in the depicted embodiment. In the depicted embodiment, the thermal bonding process 425 is performed by rolling the fabric
25 mass 405 between two heated rollers. The heated rollers cause any protruding fibers to flatten thus creating the smooth, soft surface. The thermal bonding process 425 may thin the fabric mass 405 and/or may create a smooth upper and lower surface on the first fabric mass 405 to form the comfort layer 435. In an exemplary embodiment, the thermal bonding process 425 may be a surface-treatment process, such as not changing an internal structural
30 integrity of the comfort layer 435, wherein only a surface of the comfort layer 435 may be altered. For example, the surface of the comfort layer 435 may be formed to smooth shape.

After the needle punching process 415 and hydro-entanglement process 420, the second fabric mass 410 is subjected to the chemical bonding process 430. In an exemplary

embodiment of the chemical bonding process 430, the second fabric mass 410 may be impregnated with a polymer, such as for example a rubber latex, polyurethane, or acrylic to increase a strength and increase a resistance to perforation through the second fabric mass 410, and thus form the protective layer 440. This chemical bonding process 430 may
5 increase the resistance to perforation of the second fabric mass 410. But the chemical bonding process 430 may also reduce the flexibility of the second fabric mass 410. The flexibility of the second fabric mass 410 may be maximized by making the protective layer 440 thin, because thicker layers may be generally less flexible.

After the comfort layer 435 is formed from the thermal bonding process 425 and the
10 protective layer 440 is formed from the chemical bonding process 430, the comfort layer 435 and the protective layer 440 are connected together to form the protective insert 445. As previously described, the protective insert 445 may be attached to or within a garment, such as for example an article of footwear to provide puncture resistant properties to the garment, without sacrificing comfort. In some embodiments, more than two layers will be used to
15 create a PRFFI. For example, thin comfort layers may be interposed between each of two or more thin protective layers having high flexibility. An interposed comfort layer may permit the two adjacent thin flexible protective layers to flex independently, which may permit the sandwich structure to have more flexibility than an equally protective but thicker single protective layer.

20 Means for forming a flexible protective insert having puncture-resistant properties may be realized by gluing the protective layer 440 to the comfort layer 435, for example. In some embodiments, means forming a flexible protective insert having puncture-resistant properties may be realized by gluing multiple thin protective layers together with flexible inter-protective layers and a comfort layer, for example.

25 FIG. 5 depicts a cross-section of an article of footwear incorporating a PRFFI. In the FIG. 5 embodiment, a cross-section of a shoe 500 is depicted with an exemplary PRFFI 505. The PRFFI 505 is affixed in an insole-position of the shoe immediately upon the outsole 510. The sidewalls 515 of the shoe's upper, which may be made of leather, for example. The outsole 510 may be made of rubber, Polyurethane, or EVA, for example. In some
30 embodiments, the PRFFI 505 may be flat. In other embodiments, the PRFFI 510 may be formed to shape the topography of the insole. In various embodiments, the PRFFI 505 may be glued to an upper portion of an article of footwear. In some exemplary embodiments the

upper, including the PRFFI 505, may then be later glued to an outsole. In some embodiments, the PRFFI 505 may be sewn to the upper. In some exemplary embodiments the outsole may be injected onto the upper, after the upper has been manufactured to some state of finish. In some embodiments the upper may be stitched to the outsole.

5 FIG. 6 depicts a cross-section of an article of footwear incorporating an exemplary PRFFI. In the FIG. 6 embodiment, an exemplary PRFFI 600 is affixed to an outsole 605. The PRFFI 600 may have been thermoformed to the interior shape of the outsole 605. The PRFFI 600 has a sidewall portion 610 on each lateral side of the outsole 605. The sidewall portions 610 may help permit the perforation of a nail or other sharp object that may be
10 directed at these sidewall portions 610 of the outsole 605. In this example, the sidewall height 615 is shown as 1.5 cm. Thus, more protection from punctures of stepped-upon objects may be permitted by such sidewall portions 610.

 FIG. 7A depicts a view of an article of footwear incorporating another embodiment of a PRFFI. A reinforced footwear system 700 includes an article of footwear 705 including
15 an upper part 710 having a toe portion 715, and attached to the lower side of the upper part 710 is an outsole 720. In an exemplary embodiment, the article of footwear 705 may be a work boot. In other exemplary embodiments, the article of footwear 705 may be a safety shoe, a hiking shoe, a construction boot, or a military boot. The upper part 710 of the article of footwear 705 may be formed from a variety of materials, such as for example leather,
20 suede, or cloth. The outsole 720 of the article of footwear 705 may include a variety of formed patterns along the bottom surface to enable traction. In an exemplary embodiment, the outsole 720 may be formed from a resilient material, such as for example rubber. The reinforced footwear system 705 may include a protective toe-cap 725 attached to the toe portion 715 of the article of footwear 105. In an exemplary embodiment, the protective toe-
25 cap 725 may be formed from a rigid or semi-rigid material. For example, the top-cap 725 could be made of steel.

 FIG. 7B depicts a magnified cross-sectional view of the circled portion of FIG. 7A shoe with an exemplary PRFFI. As shown, the article of footwear 705 includes an exemplary PPRFI 730 positioned over an upper surface of the outsole 720. In an exemplary
30 embodiment, the PPRFI 730 provides a soft layer on which to stand and a protective layer underneath. In the depicted figure, the toe-cap 725 may have a comfort layer 735 and a protective layer 740 in an analogous fashion to the PPRFI 730.

In some exemplary embodiments, a PRFFI may be resistant to penetration of a nail. There exist standard tests for determining the penetration resistance of an article of footwear's sole. An example of such a standard is the EN ISO 20344:2004 standard, the entire disclosure of which is herein incorporated by reference. An exemplary test of penetration resistance of a sole is described, for example, at least with reference to section 5.8.2, pages 23-24, and figures 15-16 of that standard. In this exemplary test, a sole is supported on a base plate with a 25 mm aperture. A nail is pressed through the sole immediately above the aperture at a constant rate of 10 millimeters per minute, while recording the applied force. After the nail has completely penetrated the sole, the maximum force that was applied during the test is recorded as the test result. The nail has a flat circular point of 1.0 millimeter dimension. The nail then broadens from this point at an angle of 30 degrees until the nail reaches a diameter of 4.5 millimeters. A sole may be considered to have successfully passed this test if the maximum recorded force is greater than 1100 Newtons.

An exemplary PRFFI having a protective layer which may include, for example, PET HT non-woven fabric and injected with, for example, Polyurethane. The resulting PRFFI may pass the above described standard penetration test. This test may be modified by using different diameter nails, like, for example, a nail with a maximum diameter of 3.0 millimeters. Smaller diameter nails may penetrate a sole more readily than larger diameter nails under the same applied force conditions. Thus a protective layer that achieves up to at least 1100 Newton test result using a smaller diameter nail may be deemed to have better penetration resistance than a protective layer that realizes the same test result for a larger diameter nail.

In an exemplary embodiment, the protective layer of a PRFFI may be configured to substantially prohibit puncture therethrough. An article of footwear may substantially prevent perforation of its exemplary PRFFI when exposed to a 4.5 millimeter diameter probe under a load of up to 1100 Newtons. For example, the protective layer may include aramid type fibers mixed with polymer type fibers to enable increased strength. In an exemplary embodiment, the relative mixture of the fibers may permit one to increase or decrease the layer's resistance to penetration. In various embodiments, the comfort layer and the protective layer are attached together to form a one-piece protective insert. In an exemplary embodiment, the comfort layer and the protective layer may be bonded together via an

adhesive substance. In another exemplary embodiment, the comfort layer and the protective layer may be attached together via a mechanical structure, such as for example a sewing thread.

Means for forming a flexible protective insert having puncture-resistant properties
5 may be , wherein said flexible protective insert (125) comprises a flexible comfort layer (235) and a flexible protective layer (240);

Although various embodiments have been described with reference to the figures, other embodiments are possible. For example, the protective insert may be formed from non-metallic and non-woven fabric including a random arrangement of aramid-type fibers
10 and polymer-type fibers. The random arrangement of fibers may prevent puncture therethrough yet permit flexibility. In an exemplary embodiment, the protective insert may be formed from multiple thin, flexible layers of the non-woven fabric bonded together. For example, the protective insert may include a comfort layer located adjacent a user foot and a protective layer attached to the comfort layer and located adjacent an exterior layer of the
15 footwear. Both the comfort layer and the protective layer may be formed from a needle-punching process and a hydro-entanglement process; however, the comfort layer may then be subjected to a thermal bonding process while the protective layer may be subjected to a chemical bonding process.

In accordance with an exemplary embodiment, the non-woven fabrics may include
20 aramid or par-aramid fibers mixed with polyamide or polyester fibers. In another exemplary embodiment, the non-woven fabric may include Ultra-High-Molecular-Weight-Polyethylene (UHMWPE) fibers. For example, the different types of fibers may be mixed together and bonded through an adhesive process. In an exemplary embodiment, all of the layers of the protective insert may include similar type fibers. In other exemplary embodiments, certain
25 layers may include one or more different types of fibers. For example, some layers may be impregnated with a polymer, such as for example rubber latex, polyurethane, or acrylic. Impregnation of the layer(s) may increase cohesion and resistance to perforation. In an exemplary embodiment, the protective layer may be impregnated with the polymer. In other exemplary embodiments, conductive fibers may be added to one or more layers to provide
30 antistatic properties to the protective insert.

Various embodiments may achieve one or more advantages. For example, some embodiments may provide increased flexibility of the protective insert by being formed from

multiple thin layers of non-woven fabric. For example, a combined thickness of the layers of the protective insert may be less than 3.8 millimeters. In other exemplary embodiments, the protective insert may be formed from a single, thicker layer. In an exemplary embodiment, a surface mass of the non-woven fabric may be between 250 grams/meter² and 500 grams/meter². In an exemplary embodiment, using a combination of aramid type fibers and polymer type fibers may result in a protective insert having high tenacity and high cohesion between fibers.

In an exemplary embodiment, various types of binding agents may be used to bond the layers of the protective insert. For example, an adhesive substance may be used to bind the comfort layer and the protective layer. In other exemplary embodiments, a thermal or chemical process may be used to bind the multiple layers. In another exemplary embodiment, a mechanical locking structure may be used to connect the comfort layer to the protective layer.

In an exemplary embodiment, a specific mixture of fibers may be used to form the non-woven fabric and thus protective insert. For example, a mixture of about 70% high-tenacity polyethylene terephthalate (PET HT) and about 30% UHMWPE may be beneficial in some applications. In other exemplary embodiments, a mixture of about 50% PET HT and about 50% UHMWPE may prove more beneficial. For example, if a higher degree of strength and a less degree of flexibility and comfort is desired, a higher percentage of polymer type fibers may be used. In other exemplary embodiments, a higher degree of comfort may be preferred, thus incorporating a higher percentage of aramid type fibers. In an exemplary embodiment, non-woven fabrics may be flat, porous sheets made directly from separate fibers or from molten plastic or plastic film, for example, contrary to weaving or knitting, such as required when converting fibers to yarn.

In an exemplary embodiment, one or more of the layers of the protective insert may include water-absorption properties. In another exemplary embodiment, one or more of the layers may be tear-resistant due to the high number of non-woven fibers forming the layers. Other exemplary embodiments may include aramid type fibers which are new or recycled from other products.

In accordance with some embodiments, more than one comfort layer and one protective layer may be used to form the protective insert. For example, multiple comfort layers and/or multiple protective layers may be used depending upon the particular application or environment that the garment will be worn. In an exemplary embodiment,

each comfort layer and/or protective layer may be increased in number, but decreased in thickness, such that an overall width of the protective insert remains unchanged. In an exemplary embodiment, by increasing a number of layers while decreasing layer thickness, a protective insert may be formed having increased puncture resistant properties without
5 sacrificing flexibility. In some exemplary embodiments, the comfort layer may be thicker or thinner than the protective layer. In some exemplary embodiments, multiple comfort layers and/or protective layers of different thicknesses may be used in a single protective insert.

In accordance with various embodiments, the protective insert may be attached to or embedded within other garments rather than footwear. For example, the protective insert
10 may be incorporated within a glove for providing hand protection. In another exemplary embodiment, the protective insert may be incorporated within headgear, such as for example a helmet for providing head protection. In some exemplary embodiments, the protective insert could be incorporated in a coat, such as may be worn by lumber jacks or emergency personnel.

Apparatus and associated methods may relate to a reinforced footwear system having a non-metallic protective insert. In an illustrative embodiment, the protective insert may be formed from non-woven fabric including a random arrangement of aramid-type fibers and polymer-type fibers. The random arrangement of fibers may prevent puncture therethrough yet permit flexibility. In an exemplary embodiment, the protective insert may be formed
20 from multiple thin, flexible layers of the non-woven fabric bonded together. For example, the protective insert may include a comfort layer located adjacent a user foot and a protective layer attached to the comfort layer and located adjacent an exterior layer of the footwear. Both the comfort layer and the protective layer may be formed from a needle-punching process and a hydro-entanglement process; however, the comfort layer may then be
25 subjected to a thermal bonding process while the protective layer may be subjected to a chemical bonding process.

A number of implementations have been described. Nevertheless, it will be understood that various modification may be made. For example, advantageous results may be achieved if the steps of the disclosed techniques were performed in a different sequence,
30 or if components of the disclosed systems were combined in a different manner, or if the components were supplemented with other components. Accordingly, other implementations are within the scope of the following claims.

CLAIMS

What is claimed is:

1. A system for providing a flexible protective insert for an article of footwear, the system
5 comprising:
 a flexible comfort layer formed substantially from a first non-woven fabric
 comprising randomly-oriented fibers, said flexible comfort layer being formed from a
 combination of a needle-punching process, a hydro-entanglement process, and a thermal
 bonding process; and
10 a flexible protective layer formed from a second non-woven fabric comprising
 randomly-oriented high-tenacity fibers, said flexible protective layer being formed from a
 combination of said needle-punching process, said hydro-entanglement process, and a
 chemical bonding process;
 wherein said flexible comfort layer and said flexible protective layer are connected to
15 form a flexible protective insert, wherein said flexible protective insert is adapted for
 attachment to a article of footwear to substantially prevent perforation of the flexible
 protective insert when exposed to a 4.5 millimeter diameter probe under a load of up to 1100
 Newtons.
2. The system of Claim 1, wherein said first non-woven fabric comprises polymer type
20 fibers.
3. The system of Claim 1, wherein said first non-woven fabric comprises two or more types
of fibers.
4. The system of Claim 1, wherein said first non-woven fabric comprises electrically
conductive fibers.
- 25 5. The system of Claim 1, wherein said second non-woven fabric comprises two or more
types of fibers.
6. The system of Claim 1, wherein said chemical bonding process renders said flexible
protective layer electrically conductive.
7. The system of Claim 1, wherein said article of footwear further comprises a rigid or
30 semi-rigid toe-shield.

8. The system of Claim 1, wherein said flexible protective insert is formed in the shape of an insole of said article of footwear.
9. The system of Claim 1, wherein said chemical bonding process comprises impregnating said second non-woven fabric with polyurethane.
- 5 10. The system of Claim 1, wherein said chemical bonding process comprises impregnating said second non-woven fabric with a polymer resin.
11. The system of Claim 1, wherein said chemical bonding process comprises impregnating said second non-woven fabric with a natural rubber.

12. A flexible protective insert for a garment, the flexible protective insert comprising:
a flexible comfort layer formed substantially from a first non-woven fabric comprising randomly oriented fibers, said flexible comfort layer being formed from a combination of a needle-punching process, a hydro-entanglement process, and a thermal bonding process; and
a flexible protective layer formed from a second non-woven fabric comprising randomly oriented high-tenacity fibers, said flexible protective layer being formed from a combination of said needle-punching process, said hydro-entanglement process, and a chemical bonding process;
wherein said flexible comfort layer and said flexible protective layer are connected to form a flexible protective insert, wherein said flexible protective insert is adapted for attachment to said to substantially prevent perforation of said garment.
13. The flexible protective insert of Claim 12, wherein said garment comprises an article of footwear.
14. The flexible protective insert of Claim 12, wherein the said flexible protective insert substantially prevents perforation when exposed to a 4.5 millimeter diameter probe under a load of up to 1100 Newtons.
15. The flexible protective insert of Claim 12, wherein said first mixture of non-woven fibers comprises conductive fibers.

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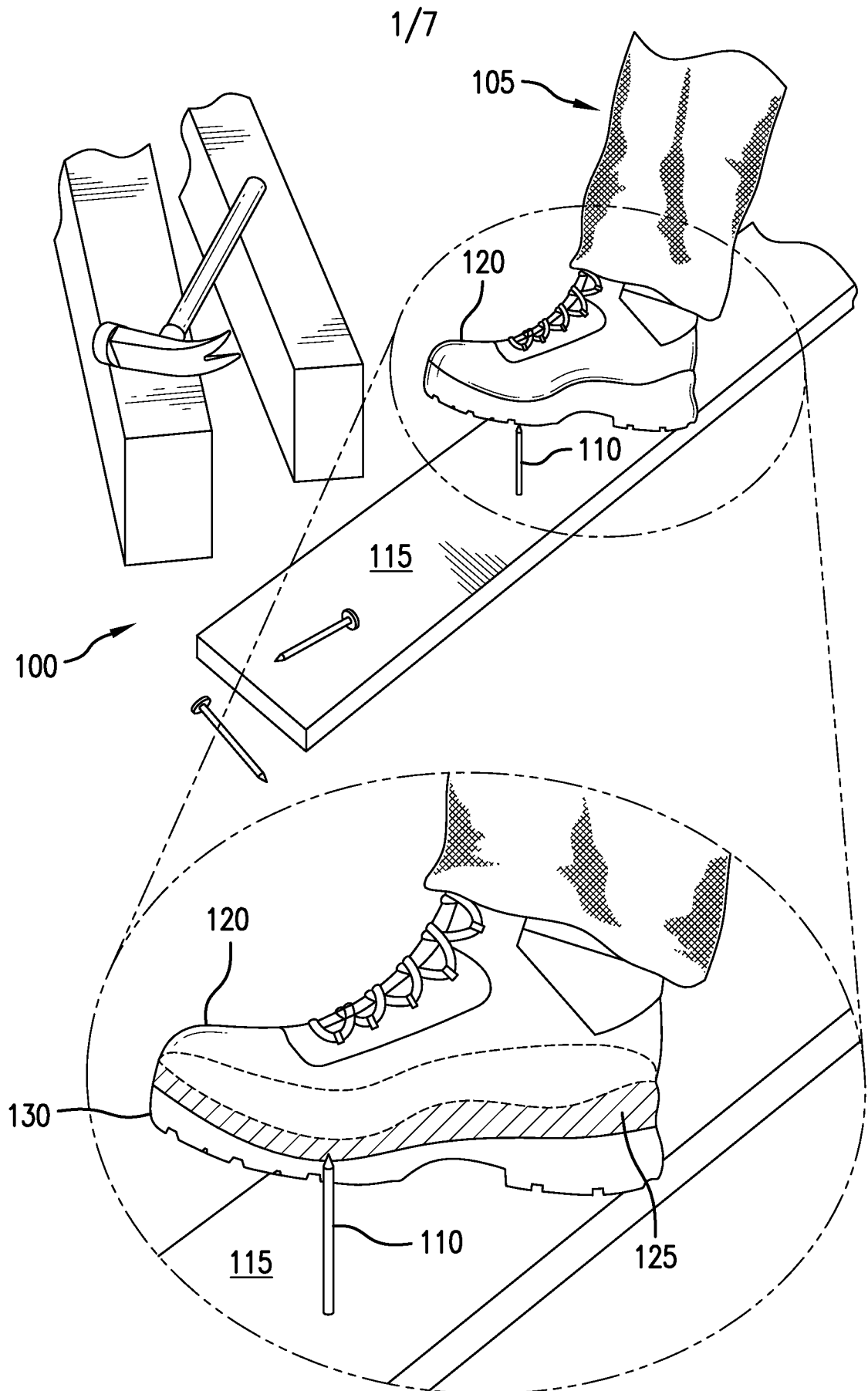


FIG. 1

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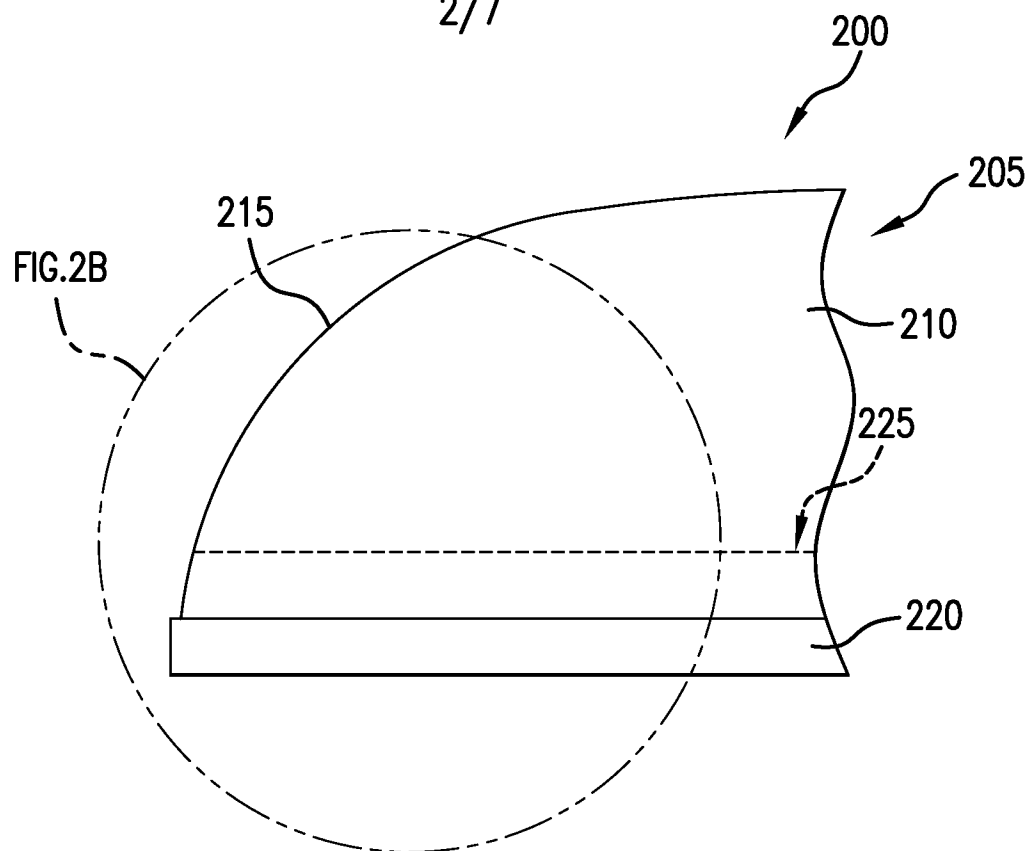


FIG. 2A

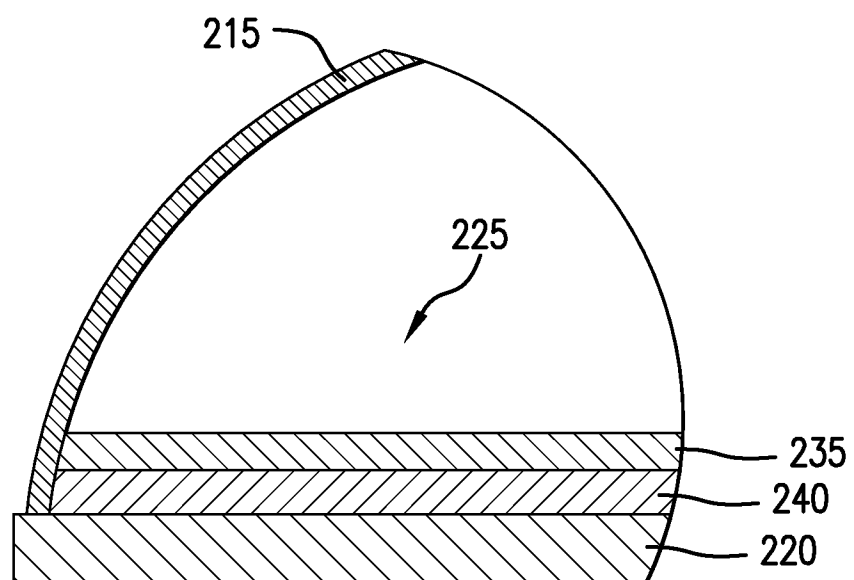


FIG. 2B

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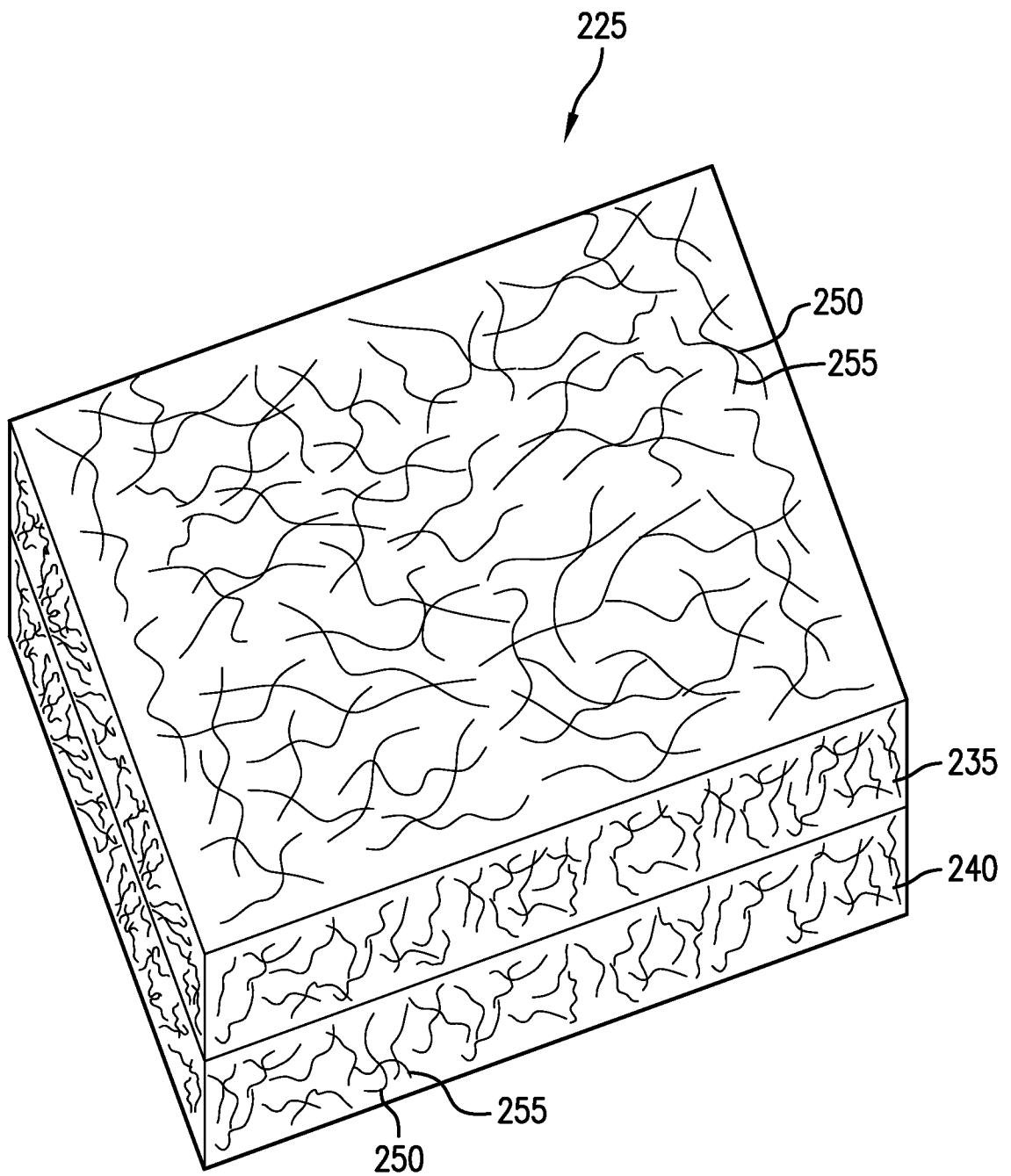


FIG. 3

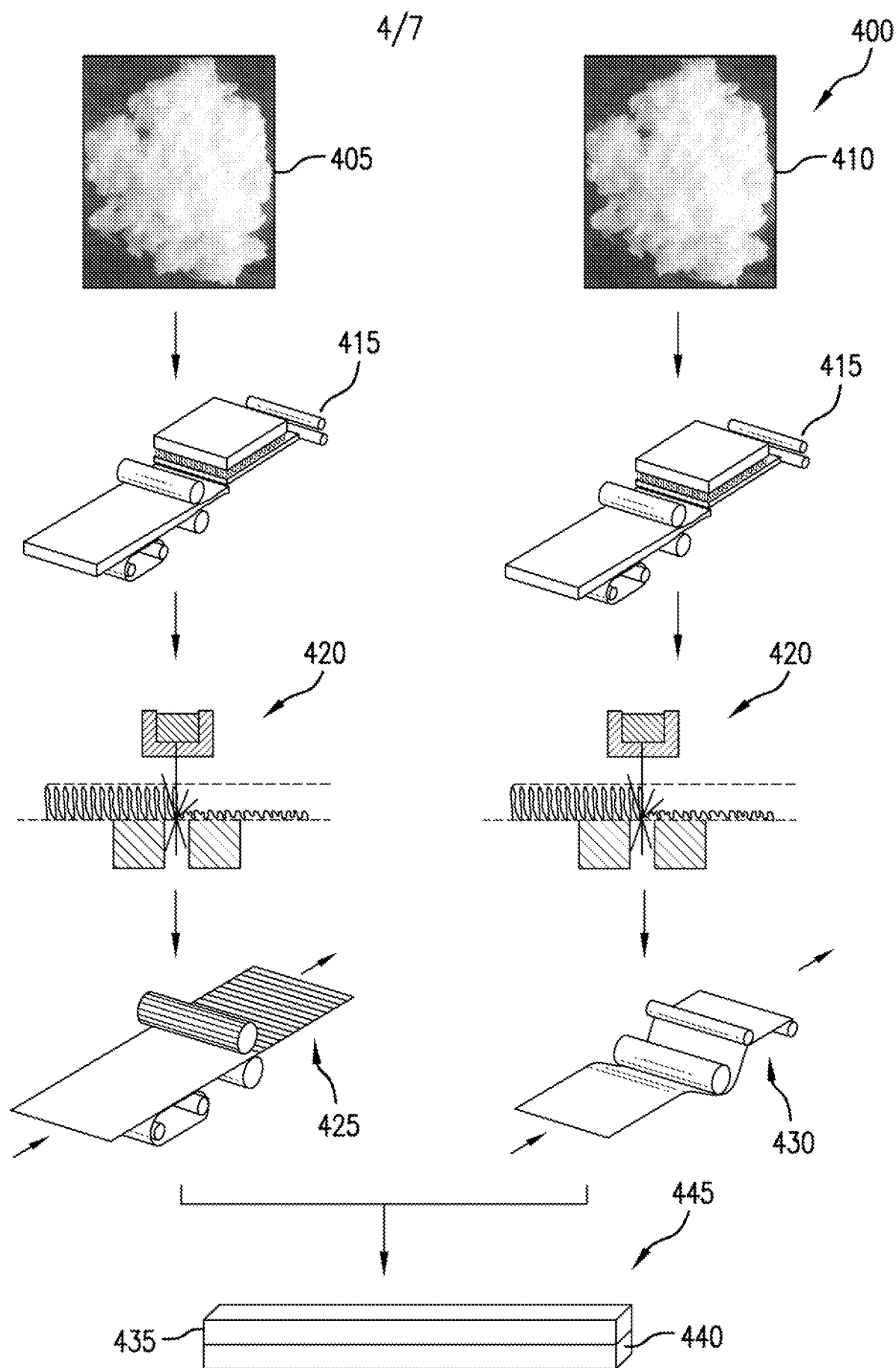


FIG.4

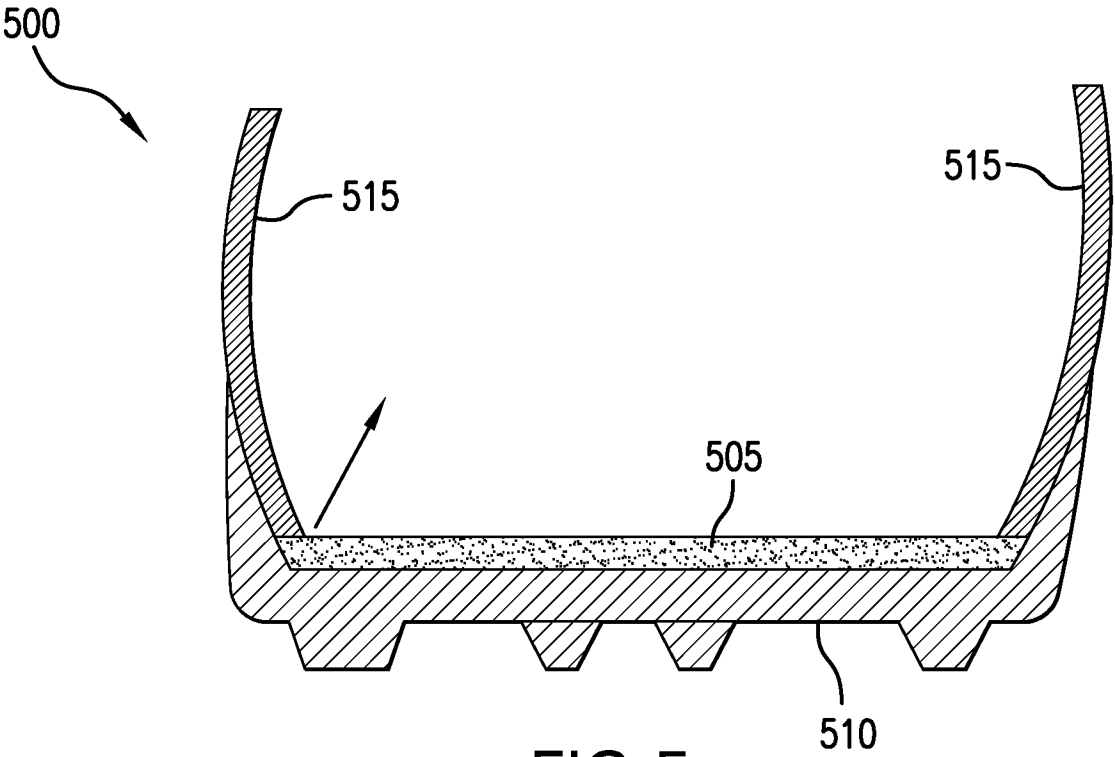


FIG.5

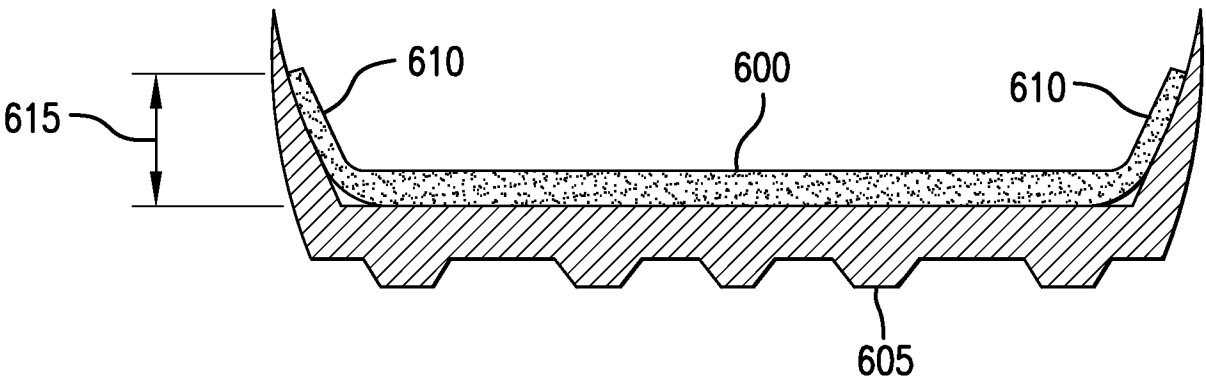


FIG.6

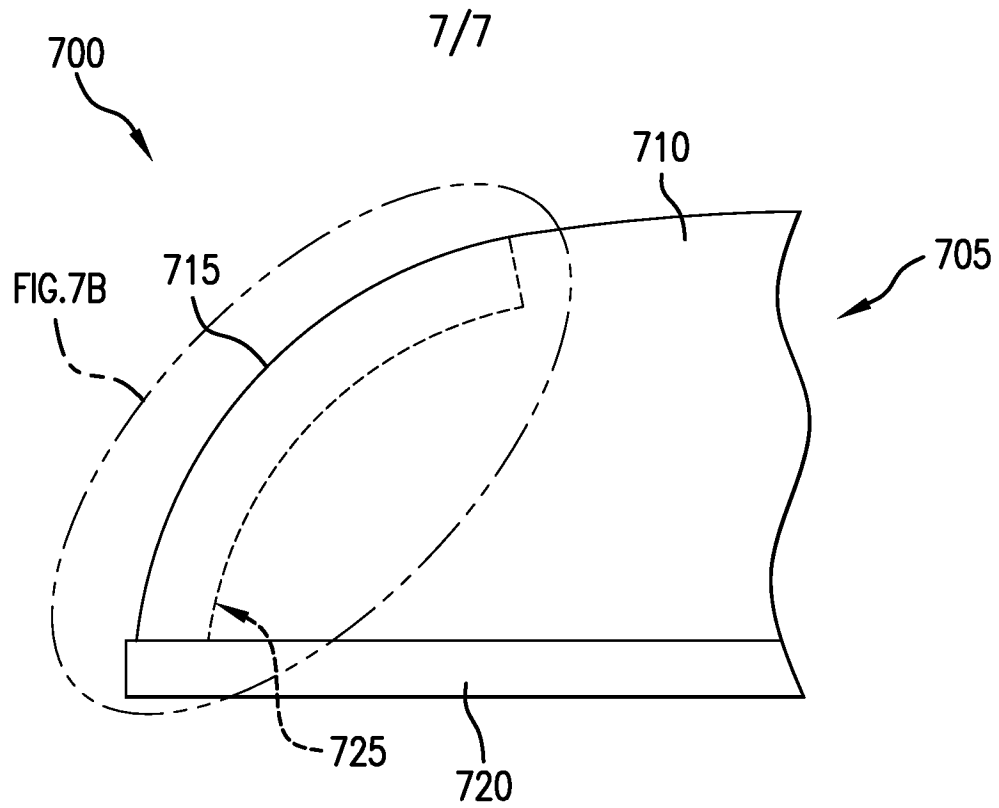


FIG. 7A

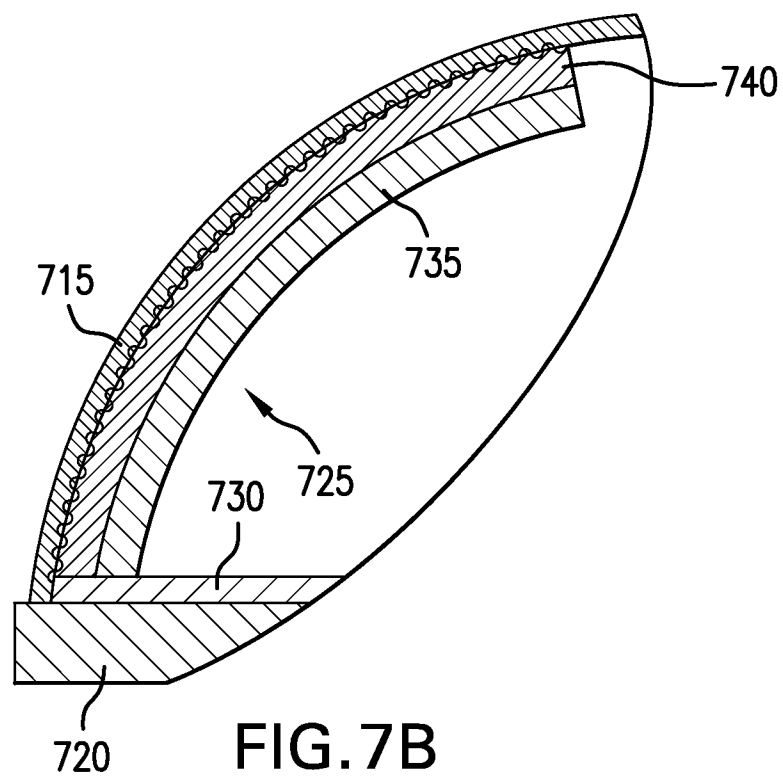


FIG. 7B

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2013/045089

A. CLASSIFICATION OF SUBJECT MATTER INV. A41D31/00 A43B7/32 A43B13/38 A43B17/00 ADD.		
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) A41D A43B		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2010/083594 A1 (TEXEL UNE DIVISION DE ADS INC [AD]; SCHEUBEL GERARD [CA]; LAPLANTE DEN) 29 July 2010 (2010-07-29) page 1, lines 6-11 page 8, lines 1-5 page 8, line 24 - page 9, line 6; figures; example 3 -----	1-4, 8-10, 12-15
A	US 6 668 868 B2 (HOWLAND CHARLES A [US] ET AL) 30 December 2003 (2003-12-30) column 24, line 54 - column 25, line 62; claim 28; figures 6a-7b -----	1,2,12, 13
A	WO 2004/089143 A2 (LENZI EGISTO SPA [IT]; FENZI ROBERTO [IT]) 21 October 2004 (2004-10-21) page 2, lines 11-19; figures 1,5 page 5, lines 1-3 -----	1,2,4,9, 10,12, 13,15
-/-		
☒ 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 another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 24 March 2014		Date of mailing of the international search report 11/04/2014
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Jones, Mark

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2013/045089

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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