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(54) WEFT-INSERTED WARP KNIT FABRIC

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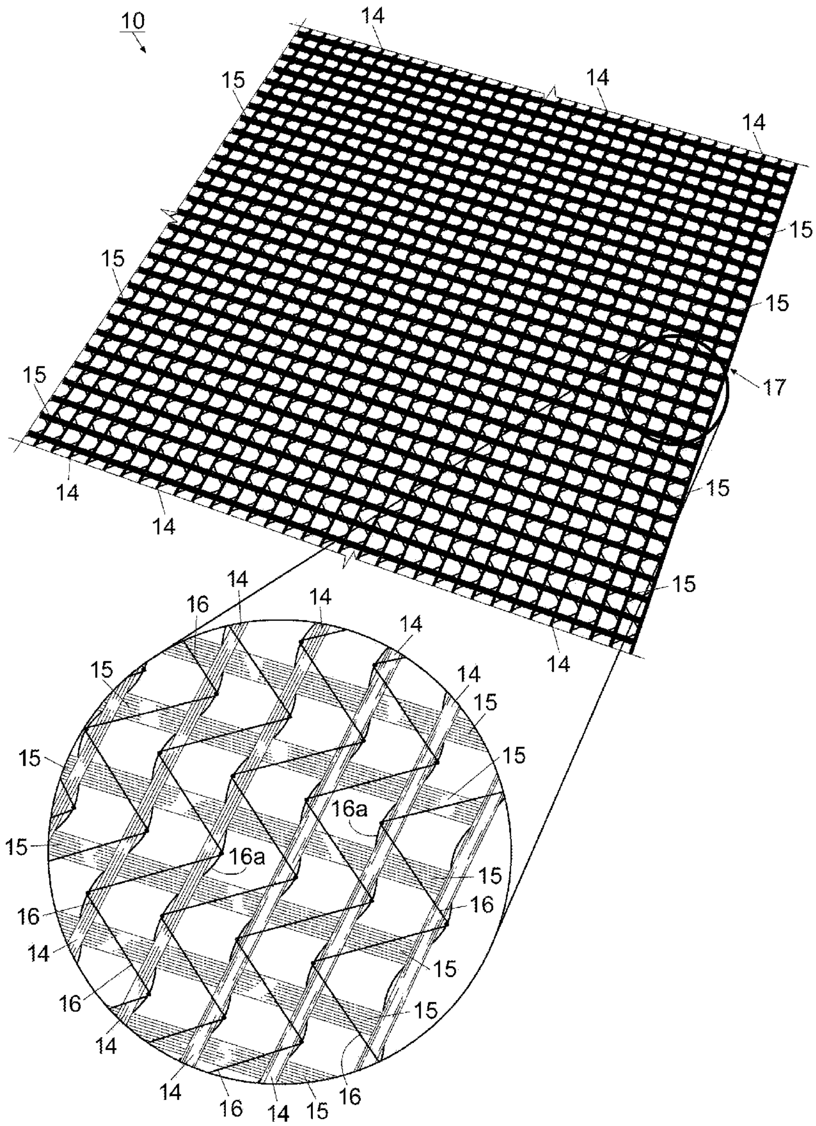
(57) **ABSTRACT**

A single-ply warp knitted fabric webbing with at least one sealed selvage edge is provided. The fabric is knit with a sheathed, bi-component warp (longitudinally extending) yarn positioned at an edge of the fabric and includes a sheath formed from a low melting point polyester and a core formed of a higher melting point polyester. A fabric is formed that has superior edge stabilization at lower amperage and air pressure manufacturing values than those exhibited by yarns coated with EVA, PVC, and TPO while simultaneously possessing abrasion and cut resistance which meet or exceed current regulatory requirements.



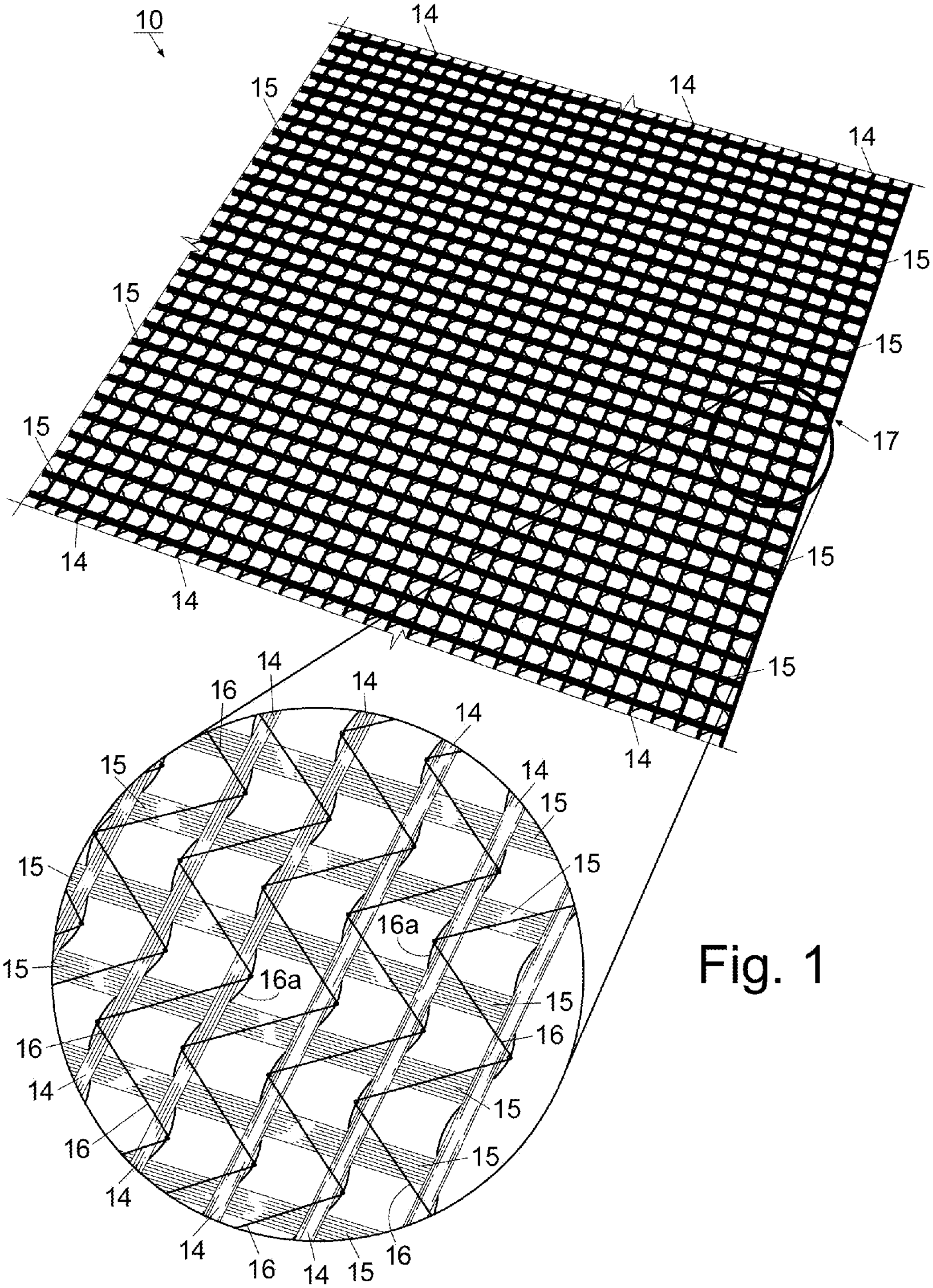

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Fig. 1

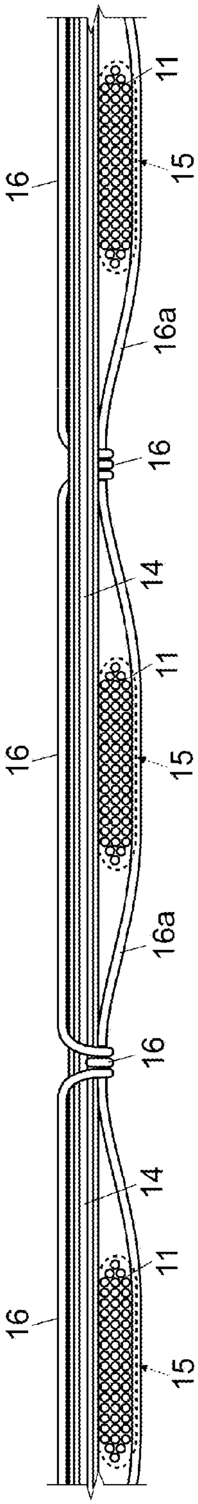

Fig. 2

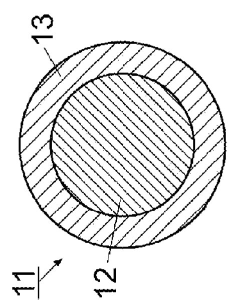

Fig. 3

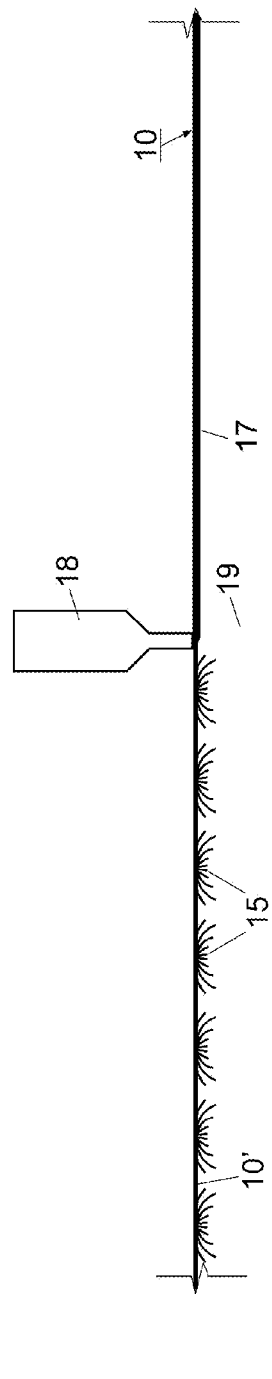

Fig. 4

WEFT-INSERTED WARP KNIT FABRIC

FIELD OF THE INVENTION

[0001] The invention herein pertains to sheaths of a first material wrapped around a core of a second material, and more particularly pertains to a fabric formed from edge warp yarns of low melt polyester wrapped around a core comprised of higher melt polyester yarn, resulting in a fabric with superior edge stabilization compared to fabrics formed from other unsheathed yarns.

DESCRIPTION OF THE PRIOR ART AND OBJECTIVES OF THE INVENTION

[0002] Fabric webbing in the form of belts and slings are conventionally used to bind, carry, and otherwise transport other members, for example conveyor belts or tie-down straps. In certain operating conditions, these webbings bear heavy articles that subject the webbing to repetitive, abrasive impact. This impact is most prevalent at the edges of the webbing, where increased cutting and abrasion may result in expedited fabric degradation. Various methods for increasing the structural stability of these webbings have been developed (see U.S. Pat. No. 5,419,951 to Golz, U.S. Pat. No. 4,856,837 to Hammersla, and U.S. Pat. No. 4,501,782 to Weatherly) but a continued need exists for a fabric webbing with a resistance to abrasion and degradation, particularly at the edges where the fabric may be the most susceptible to damage. This situation is exacerbated when the fabric webbing is exposed to the elements for extended periods of time, for example when the webbing serves as a roofing yarn in connection with residential or commercial siding. Further, with new regulations constantly being promulgated, a need also exists for a reinforced fabric that can meet and exceed current fabric regulations, for example ASTM D6878-11a *Standard Specification for Thermoplastic Polyolefin-based Sheet Roofing*, the contents of which are hereby incorporated in its respective entirety.

[0003] Thus, in view of the problems and disadvantages associated with prior art fabrics and webbings, the present invention was conceived and one of its objectives is to provide a fabric webbing edge formed from a sheathed, bi-component yarn.

[0004] It is another objective of the present invention to provide a weft-inserted warp knit fabric with at least one edge formed from a sheathed yarn with a sheath formed from a first material and a core formed from a second material.

[0005] It is still another objective of the present invention to provide a bi-component yarn with a sheath formed from a material defining a "low" melting point and a core formed from a material defining a "high" melting point.

[0006] It is yet another objective of the present invention to provide a sheathed yarn with a sheath formed from a polyester defining a "low" melting point and a core formed from a polyester defining a "high" melting point.

[0007] It is a further objective of the present invention to provide a fabric webbing formed from a bi-component warp yarn defining a stabilized selvage edge.

[0008] It is another objective of the present invention to provide a fabric webbing formed from a sheathed yarn with an ultrasonically sealed and stabilized edge.

[0009] It is still another objective of the present invention to provide a knit fabric formed from a sheathed yarn at the edge that does not experience surface softening at less than three hundred degrees Fahrenheit (300° F.) and more preferably at three hundred forty degrees Fahrenheit (340° F.).

[0010] It is yet another objective of the present invention to provide a sheathed yarn with a stabilized edge that meets or exceeds current regulations such as ASTM D6878-11a.

[0011] It is a further objective of the present invention to provide a fabric webbing that is efficient to manufacture and simple to use.

[0012] It is another objective of the present invention to provide a method of forming a fabric webbing with a stabilized edge from a sheathed yarn that is structurally superior to fabrics formed from EVA, PVA, PVC, and TPO coated yarns, in addition to fabrics formed by uncoated yarns.

[0013] Various other objectives and advantages of the present invention will become apparent to those skilled in the art as a more detailed description is set forth below.

SUMMARY OF THE INVENTION

[0014] The aforesaid and other objectives are realized by providing a single-ply, warp-knit fabric webbing with at least one ultrasonically-sealed longitudinally extending lateral edge. The fabric is knit with one or more sheathed warp (longitudinally extending) yarns including a sheath formed from low melting point polyester and a core with higher melting point polyester. A fabric is formed that demonstrates superior edge stabilization at equal to or lower amperage and air pressure manufacturing values than those exhibited by yarns coated with EVA, PVC, and TPO while simultaneously possessing abrasion and cut resistance and meeting or exceeding current regulatory requirements.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] FIG. **1** shows an elevated side perspective view of a fabric webbing formed from a bi-component yarn with a stabilized longitudinal edge;

[0016] FIG. **2** pictures an enlarged longitudinal end view of the fabric of FIG. **1**;

[0017] FIG. **3** depicts an enlarged end schematic view of one of the bi-component yarns which make up the fabric edge of FIG. **1**; and

[0018] FIG. **4** demonstrates a schematic representation of an edge stabilization process to form the fabric of FIG. **1**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS AND OPERATION OF THE INVENTION

[0019] For a better understanding of the invention and its operation, turning now to the drawings, FIGS. **1-3** display the preferred embodiment of fabric webbing **10** formed from a plurality of longitudinally oriented (warp) strands **14** knitted with generally perpendicular, laterally oriented (weft) strands **15** and a plurality of ground yarns **16** interacting therebetween. In the preferred embodiment of fabric webbing **10**, ground yarns **16** are between twenty and five hundred (20-500) denier weight, and preferably about seventy (70) denier strands "warp knitted" between warp strands **14** and weft strands **15** (meaning ground yarns **16** zigzag along the longitudinal length of the fabric). As would be understood each ground yarn **16** may laterally zigzag the span of two (2) side by side warp strands **14**, periodically forming loops about the span of a single warp strand **14**, and whereby ground yarns **16** each interact with one or more looping portions as explained in more detail below. The warp knitting pattern means that each ground yarn **16** passes over a first warp strand **14**, under and around a neighboring ground yarn **16** before pulling through and passing above the same warp strand **14** and traveling diagonally overtop one weft strand **15** and the second warp strand **14** and then under and around an opposing neighboring ground yarn **16** whereby ground yarn **16** zigzags back and forth between the first and second warp strands **14** interacting with respective neighboring ground yarns **16** as the knitting pattern repeats as seen in the enlarged portion in FIG. **1**. The second ground yarn **16** zigzags in parallel to the first such that the first ground yarn **16** interacts with the looping portion of the neighboring ground yarn **16** proximate one side of warp strand **14** and the second ground yarn **16** interacts with the first ground yarn **16** but on the opposite side of warp strand **14** and above a weft strand **15** positioned between the looping points. The terms "first" and "second" are used as an example to assist in describing the knitting pattern and should not be construed as a limitation. In this context, they are intended to indicate a yarn and the yarn longitudinally or laterally adjacent thereto but could equally apply to any of the yarns. Further, the preferred zigzag pattern described above should not be limiting as any number of configurations could be applied such as extending the diagonal path of travel of ground yarn **16** across two weft strands **15** rather than one or further passing to the second warp strand **14** rather than the adjacent warp strand **14**.

[0020] Each section of fabric webbing **10** is formed by knitting a plurality of warp strands **14** with weft strand **15**, whereby strands **14** and **15** are formed from conventional materials such as coated or uncoated polymeric yarns, polyester yarns such as PET, nylon yarns, or other such materials as are known in the art, ranging in size from a monofilament to two hundred filaments (1-200 filaments) or denier weights from seventy to three thousand (70-3000). In preferred fabric webbing **10**, a small number, preferably three to four (3-4), of edge warp strands **14'** positioned proximal at least one lateral edge of webbing **10** are comprised of one or more sheathed, bi-component yarns **11** comprised of a fiber defined by core **12** formed from a first material and sheath **13** formed from a second material (illustrated schematically in FIG. **3**). FIG. **1** shows an elevated perspective view of a section of single-ply fabric webbing **10** with a smaller section enlarged to illustrate greater detail. As would be understood by one of ordinary skill in the art, fabric webbing **10** preferably includes a selvage which may be formed into numerous structures for reinforcing the fabric edge, transferring tension and load onto the body of the fabric while preventing the fabric from experience a curling effect as well as providing a "clean" edge (i.e. no loose strands) for total encapsulation in a membrane formed from TPO, PVC, EPDM and other roofing materials. These structures may be formed by weaving, braiding, knitting, or other textile formations known in the art, but the preferred fabric webbing is formed by knitting. It is within the scope of the instant invention to construe one or more ply of fabric webbing **10** to produce a more robust fabric, but for the purpose of this disclosure a single-ply fabric will be described. FIG. **1** demonstrates fabric webbing **10** in a generally rectangular shape but the borders have been abbreviated to represent indeterminate length, with the exception of sealed selvage edge **17** (FIG. **4**), which will be described in further detail below.

[0021] FIGS. **2** and **3** demonstrate elevated longitudinal end views of fabric webbing **10** taken at a cross-section looking down edge warp strands **14'** which are heat treated, ultrasonically enhanced, or otherwise treated to form sealed selvage edge **17**. These figures show an end of fabric webbing **10** and a cross-sectioned edge warp strands **14'**, exposing sheathed yarns **11** and illustrating sheath **13** encircling core **12**, respectively. Each warp strand **14'** is defined by one or more bi-component yarns **11** defining a denier weight of at least two hundred (200) and more preferably includes between one hundred and one hundred fifty (100-150) bi-component filaments in yarn **11** defining a total denier weight between one thousand (1000) and thirteen hundred (1300). Sheath **13** may be formed from or coated with ethylene vinyl chloride (EVA), polyvinyl alcohol (PVA), polyvinyl chloride (PVC), thermoplastic polyolefin (TPO) and the like, but such is not preferred. Specifically, EVA softens at a temperature of approximately one hundred seventy degrees Fahrenheit (170°) which is far too low to satisfy current safety standards, for example ASTM D6878-11a. PVC and similar sheaths and coatings may initially satisfy the higher temperature requirements, but yarns with these types of sheaths and coatings are known to develop fissured membranes over prolonged exposure to high temperatures, resulting in degradation and structural failure. For example, this was observed in a PVC-treated roofing yarn that was exposed to a heat aging test which subjected the yarn to two hundred seventy-five degree Fahrenheit (275° F.) temperature for twenty-eight (28) consecutive days. Therefore, preferably sheath **13** is formed from a polymer such as a "low melt" polyester, and wrapped around core **12** that is formed from a polymer such as a "high melt" polyester. The most preferred embodiment of sheathed yarn **11** is formed from core **12** which is formed from polyester that defines a significantly greater melting point than the polyester that forms sheath **13**. For example, in the most preferred embodiment of sheathed yarn **11**, core **12** is formed from a polyester defining a melting point in excess of four hundred degrees Fahrenheit (400° F.) and more preferably defines a melting point between four hundred and fifty degrees Fahrenheit and four hundred and sixty degrees Fahrenheit (450°–460° F.), and is surrounded by sheath **13** formed from a polyester defining a melting point in excess of three hundred degrees Fahrenheit (300° F.) and more preferably defines a melting point of about three hundred and forty degrees Fahrenheit (340° F.). Thus, it would be understood that sheath **13** could be subjected to sufficient heat to melt and bond with proximal sheath **13** structures, forming a more structurally robust yarn. Bi-component yarn **11** formed from these components and defining these characteristics is capable of meeting and exceeding the present regulatory guidelines. Another unexpected benefit of bi-component yarn **11** is the ability to maintain the round shape of the high melt core **12**, even after the edge treatment described below. By maintaining its shape, sealed selvage edge **17** remains flexible with a textile-like modulus of flexion, as well as shear and tear properties similar to that of the textile body. Conventional sheathed yarns are totally sealed, resulting in deformation of the core **12**, producing a selvage that becomes stiff and paper-like in consistency which defines poor tear properties, as well as reduced strength and a reduction in the ability to transfer load without curling or shearing.

[0022] It is known in the art that webbing and selvage formed from untreated, non-coated, or otherwise "plain" polymer yarns requires edge treatment in the nature of stabilization, usually with heat or an adhesive, to prevent degradation and destruction of the webbing, curling prevention, and to ensure total encapsulation both in the sealed edge and within the roofing material (not shown). Polymer yarns are preferred for this treatment, as the treatment results in a uniform fabric edge for encapsulation. However, non-coated polymer yarns are disadvantageous in the formation of fabric webbing **10** as they require significantly more manufacturing resources during production to produce a sealed edge, such as energy in the form of amperage and pressure as required by the ultrasonic edge sealing system, resulting in less efficient production and higher cost. Failure to provide these increased resources during production results in a webbing that contains structural abnormalities as has been experimentally proven (not shown).

[0023] By way of example, but not intended to limit the scope of the instant invention, FIG. **4** illustrates a schematic representation of the ultrasonic edge sealing process preferred in the production of fabric webbing **10** that encapsulates and seals at least one longitudinally extending lateral edge **17** of fabric webbing **10**. Untreated fabric webbing **10'** is moved between a mechanical system including a hammer member **18** or horn and an anvil member **19** or drum. In the preferred ultrasonic edge sealing method, hammer member **18** is an ultrasonic sonotrode in communication with a generator and anvil member **19** is referred to as a counter tool (for example, see Duo 300 W fabric sealing machine, commercially available from Decoup+ of Roche la Molière, France). A terminal portion of the sonotrode oscillates approximately thirty thousand (30,000) times per second approximately one millimeter (1.0 mm) above the surface of fabric **10**, causing displacement on the order of a micrometer (μm), producing localized temperature increase on the surface of fabric **10**, more specifically proximate edge warp yarns **14'**. This oscillation and resulting heat reach temperatures sufficient to melt the polyester making up sheath **13**, but not so great as to melt the polyester of core **12**. The melting may occur in a pattern referred to as a sealing track, and the sealing track may vary depending on the structural characteristics of the counter tool. For example, a counter tool with thin, deep teeth may be used to penetrate thick substrates, while a counter tool with a knurled knob is better suited for lighter, thinner materials (not shown). This process leads to fabric edges with no fraying or unraveling and a webbing sealed edge **17** that is structurally reinforced but that exhibits the characteristics of the "unsealed" (i.e. open) fabric, such as suppleness, lack of tough points, and avoidance of fabric over-thickness. It would be understood that the edge warp yarns **14'** may be positioned along one or more edges of fabric webbing **10**, such that one or more edges could be treated in the above described manner.

[0024] The illustrations and examples provided herein are for explanatory purposes and are not intended to limit the scope of the appended claims.

We claim:

1. A fabric webbing comprising a plurality of warp strands oriented generally perpendicular to a plurality of weft strands, at least one warp strand formed from at least one yarn including a core of polyester defining a first melting point and a sheath surrounding the core formed from polyester defining a second melting point, whereby the first melting point is greater than the second melting point, and whereby the at least one warp strand is positioned in a sealed selvage edge of the fabric webbing.

2. The fabric webbing of claim **1** whereby the at least one warp yarn is a bi-component warp yarn.

3. The fabric webbing of claim **1** further comprising at least one ground yarn disposed between the plurality of warp strands and the plurality of weft strands.

4. The fabric webbing of claim **3** whereby the at least one ground yarn is warp knit between the plurality of warp strands and the plurality of weft strands.

5. The fabric webbing of claim **1** whereby the core defines a melting point of at least four hundred degrees Fahrenheit (400° F.).

6. The fabric webbing of claim **1** whereby the sheath defines a melting point of at least three hundred degrees Fahrenheit (300° F.).

7. The fabric webbing of claim **1** whereby the at least one warp strand is formed by at least one hundred (100) filaments.

8. The fabric webbing of claim **7** whereby each of the at least one hundred (100) filaments define a denier weight in excess of eight hundred (800).

9. A fabric webbing comprising a plurality of longitudinally oriented warp strands knitted generally perpendicular to a plurality of laterally oriented weft strands, at least one of the warp strands formed from at least one hundred (100) bi-component filaments, each filament including a core of polyester defining a first melting point and a sheath surrounding the core formed from polyester defining a second melting point, whereby the first melting point is greater than the second melting point, and whereby the at least one warp strand is positioned at a selvage edge of the fabric webbing which is ultrasonically sealed.

10. The fabric webbing of claim **9** further comprising a plurality of ground yarns, one of the plurality of ground yarns disposed between the plurality of warp strands and the plurality of weft strands.

11. The fabric webbing of claim **10** whereby the plurality of ground yarns are each warp knit between the plurality of warp strands and the plurality of weft strands.

12. The fabric webbing of claim **9** whereby the at least one warp strand is formed from one hundred and fifty (150) bi-component filaments.

13. The fabric webbing of claim **12** whereby the bi-component filaments each define a denier weight between one thousand (1000) and thirteen hundred (1300).

14. The fabric webbing of claim **9** whereby each core defines a melting point of between four hundred fifty degrees Fahrenheit and four hundred sixty degrees Fahrenheit (450° F.-460° F.).

15. The fabric webbing of claim **9** whereby each sheath defines a melting point of about three hundred forty degrees Fahrenheit (340° F.).

16. A method of supplementing siding with a fabric webbing comprising the steps of

providing the fabric webbing of claim **1**,

passing at least one edge of the fabric webbing between a hammer member and an anvil member to seal the edge, and

positioning the fabric webbing within the siding substrate.

17. The method of claim **16** whereby the step of providing a fabric webbing includes providing a plurality of ground yarns, the plurality of ground yarns disposed between the plurality of warp strands and the plurality of weft strands.

18. The method of claim **17** further comprising the step of warp knitting the plurality of ground yarns among the plurality of warp strands and the plurality of weft strands.

19. The method of claim **18** whereby the step of passing at least one edge of the fabric webbing between a hammer member and an anvil member further includes passing the fabric between an ultrasonic sonotrode and a drum.

20. The method of claim **19** further comprising the step of oscillating the sonotrode thirty thousand times (30,000) per second approximately one millimeter (1.0 mm) from the fabric webbing.

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