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(54) Title: MAGNETIC FABRIC FOR MOLDING APPLICATIONS

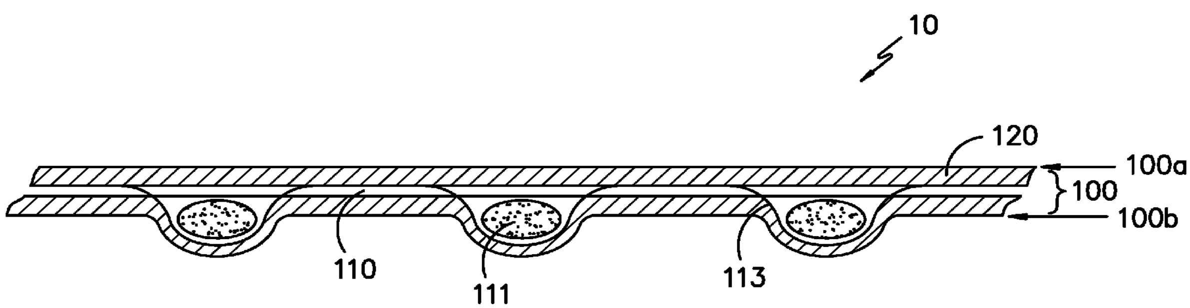


FIG. -1-

(57) **Abstract:** The invention relates to a magnetically responsive scrim containing a scrim which contains a plurality of yarns and a magnetically responsive coating covering at least a portion of the yarns of the scrim. The magnetically responsive coating contains magnetically responsive particulate material and a binder, where the magnetically responsive coating is at least about 40% by weight magnetically responsive particulate material, and where the magnetically responsive coating has an areal density of at least twice the areal density of the scrim.

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# MAGNETIC FABRIC FOR MOLDING APPLICATIONS

## FIELD OF THE INVENTION

[0001] The present invention generally relates to creating magnetic scrims for easier processing for molding applications.

## BACKGROUND

[0002] In some molding applications, foams such as polyurethanes are combined with other textile layers such as scrims during the molding process. The scrims can give the polyurethane additional strength and other characteristics such as fire resistance. There is a need for a scrim that is more easily inserted and positioned within the mold to reduce incorrect molding location and operator time to position the scrim.

## BRIEF SUMMARY

The invention relates to a magnetically responsive scrim containing a scrim which contains a plurality of yarns and a magnetically responsive coating covering at least a portion of the yarns of the scrim. The magnetically responsive coating, which contains magnetically responsive particulate material dispersed in a binder, where the magnetically responsive coating is at least about 40% by weight magnetically responsive particulate material, and where the magnetically responsive coating has an areal density of at least twice the areal density of the scrim.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0003] Figure 1 illustrates one embodiment of a magnetic scrim.

[0004] Figure 2 is a photograph of one embodiment of the scrim (before being coated with the magnetic coating).

*DETAILED DESCRIPTION*

[0005] Referring now to Figure 1, there is shown one embodiment of the magnetically responsive scrim 10. The magnetically responsive scrim 10 contains a scrim 100 having a first side 100a and a second side 100b. The scrim 100 contains a plurality of yarns. The magnetically responsive scrim 10 also contains a magnetically responsive coating 120 that covers at least a portion of the yarns of the scrim 100.

[0006] This magnetically responsive scrim 10 would preferably be placed in a mold with at least one magnet to hold the scrim in place while the mold is prepared and polyurethane (or other moldable material) is introduced and then cured in the mold.

[0007] As used herein, the term "scrim" shall mean any fabric having an open construction used as a base fabric or a reinforcing fabric. This may include a laid scrim, a woven scrim, a knit scrim, a weft-inserted warp knit scrim, a multi-axial warp knit scrim, a stitch-bonded scrim, or a cross-plied scrim. The scrim contains a plurality of yarns and the yarns may be adhesively or thermally bonded to each other at cross-over points (where one yarn or fiber crosses over another yarn or fiber) or may be unbonded from each other.

[0008] The scrim 100 may be any suitable scrim including any suitable light-weight woven, knit, or nonwoven fabric. Preferably, the scrim layer is a weft inserted warp knit scrim. A weft inserted warp knit scrim 100 contains a plurality of warp yarns 110, weft yarns 111, and stitching yarns 113. The stitching yarns 113 may have any suitable stitching pattern, including tricot stitches or pillar stitches, or other stitches. The weft yarns 111 can be laid in every course (every row of stitches from the stitching yarn), every second course (every second row of stitches from the stitching yarn), every third course (every third row of stitches from the stitching yarn) or more. How open or closed (how close together the yarns are within the scrim 100, is determined by the types and sizes of the yarns and the desired properties of the scrim 100 and magnetically response scrim 10. A photograph of one example of the scrim 100 being a weft inserted warp knit scrim is shown in Figure 2.

[0009] In one embodiment the scrim 100 comprises a plurality of yarns in a warp direction and a plurality of yarns in a weft direction defined to be approximately perpendicular to the warp direction. In another embodiment, at least a portion of the plurality of yarns in a weft direction are polyester texturized polyester yarns.

[0010] The yarns of the scrim can be any suitable yarns, include any suitable materials, structure, and thickness. The yarns making up the strip-shaped textile forming the strip-shaped substrate 200 may be any suitable yarn. "Yarn", in this application, as used herein includes a monofilament elongated body, a multifilament elongated body, ribbon, strip, fiber, tape, and the like. The term yarn includes a plurality of any one or combination of the above. The yarns may be of any suitable form such as spun staple yarn, monofilament, or multifilament, single component, bi-component, or multi-component, and have any suitable cross-section shape such as circular, multi-lobal, square or rectangular (tape), and oval. In one embodiment, the yarns are monofilament. In another embodiment, the yarns are multifilament. In another embodiment, the yarns contain mono and multifilaments. In one preferred embodiment, at least a portion of the yarns are texturized as this has been found to be beneficial in the coating process. In one embodiment, the weft yarns of the weft inserted warp yarn knit scrim are texturized (and in one embodiment, the warp yarns are not texturized). The textured weft yarns 111 are shown in Figure 1.

[0011] Some suitable materials for the yarns include polyamide, aramid (including meta and para forms), rayon, PVA (polyvinyl alcohol), polyester, polyolefin, polyvinyl, nylon (including nylon 6, nylon 6,6, and nylon 4,6), polyethylene naphthalate (PEN), cotton, steel, carbon, fiberglass, steel, polyacrylic, polytrimethylene terephthalate (PTT), polycyclohexane dimethylene terephthalate (PCT), polybutylene terephthalate (PBT), PET modified with polyethylene glycol (PEG), polylactic acid (PLA), polytrimethylene terephthalate, nylons (including nylon 6 and nylon 6,6); regenerated cellulosics (such as rayon or Tencel); elastomeric materials such as spandex; high-performance fibers such as the polyaramids, and polyimides natural fibers such as cotton, linen, ramie, and hemp, proteinaceous materials such as silk, wool, and other animal hairs such as angora, alpaca, and vicuna, fiber reinforced polymers, thermosetting polymers, blends thereof, and mixtures thereof. In a preferred embodiment, the yarns comprise polyester yarns. In another embodiment, the yarns of the magnetically response scrim 10 consist essentially of polyester yarns (defined to be mean at least 98% of the yarns are polyester yarns).

[0012] Referring back to Figure 1, the magnetically responsive scrim 10 contains a magnetically responsive coating 120. The magnetically responsive coating 120 preferably covers at least a portion of yarns of the scrim 100. More preferably, the magnetically responsive coating 120 covers essentially all of the surface area of the yarns in the scrim (defined as covering at least 95% of the surface area of the yarns). The magnetically responsive coating 120 contains magnetically responsive particulate material and a binder.
In this application “magnetically responsive” is defined to mean the particles present in the coating are only magnetically responsive in the presence of external magnets. Once the magnetic field is removed from the vicinity, the particles will become non-magnetic. The magnetically responsive behavior or responsive magnetic behavior falls broadly under paramagnets or superparamagnets (particle size less than 50 nm), or weak ferromagnets. Iron oxide, steel, iron, nickel, aluminum or their alloys that are not included in ferromagnets are some of the examples that can be applied in the coatings.

[0013] The magnetic responsive components can also be doped with rare earth materials to increase the magnetic response and the ferromagnetic behavior. In some cases, the magnetically responsive particles can be converted to permanent magnetic coatings. These flexible permanently magnetic scrims may then be directly applied to any magnetically receptive surface such as certain metallic, iron, or steel surfaces.

[0014] The surface of the components may be magnetically responsive or magnetizable in any suitable manner. In one embodiment, surface is made to be magnetically responsive or magnetizable by applying a magnetically responsive or magnetizable coating on the surface. In another embodiment, surface is made to be magnetically responsive or magnetizable by materials within the component (preferably located near or close to the surface of the component).

[0015] In a preferred embodiment, the magnetically responsive coating preferably comprises a binder and a magnetically responsive particulate material. The binder can be any suitable binder that will adhere to the scrim and bind together the magnetically responsive particulate material. Suitable binders include, but are not limited to, urethane binders, acrylic binders, silicone binders, thermoplastic binders, thermoset binders, cements, rubber, and geopolymers. The binder preferably remains flexible after curing. Thus, in a preferred embodiment, the binder preferably is selected from the group consisting of urethane binders, acrylic binders, silicone binders, and mixtures thereof.

[0016] Preferably, the magnetically responsive particulate material is selected from the group consisting of paramagnetic particles, superparamagnetic particles, ferromagnetic particles, ferrimagnetic particles, and mixtures thereof. More preferably, the magnetically responsive particulate material is selected from the group consisting of paramagnetic particles, superparamagnetic particles, and mixtures thereof. Preferably, the magnetically responsive particulate material is selected from the group consisting of iron particles, iron oxide particles, and mixtures thereof. In a preferred embodiment, the magnetically responsive particulate material comprises iron oxide particles, such as $Fe_2O_3$ particles and $Fe_3O_4$ particles. Iron oxide particles are generally preferred over iron particles because iron particles may rust in high humidity environments, and such rusting can discolor one or more components of the system.

[0017] The magnetically responsive particulate material can have any suitable particle size. Preferably, the magnetically responsive particulate material has a particle size of about 100 microns or less. More preferably, the magnetically responsive particulate material has a particle size of about 50 microns or less. The particle size of the material can affect the magnetic response exhibited by the magnetically responsive particulate material. Generally, the magnetic susceptibility of the particles increases with decreasing particle size. Thus, iron oxide particles having a particle size of 50 nm or larger are generally paramagnetic, owing to the fact that individual particles are sufficiently large to possess two or more magnetic domains. In one embodiment, the magnetically responsive particulate material has an average particle size range of between about 50 nm to 50 microns. Iron oxide particles having a particle size less than 50 nm are generally superparamagnetic, owing to the fact that individual particles are sufficiently small that they possess only one magnetic domain.

[0018] The magnetically responsive particulate material can be present in the magnetically responsive coating in any suitable amount. The amount of magnetically responsive particulate material present in the magnetically responsive coating may depend upon several factors, such as the desired strength of the magnetic response and the type of magnetically responsive particulate material(s) used in the magnetically responsive coating. Generally, in order to achieve a sufficiently strong magnetic response, the magnetically responsive particulate material(s) generally account for an appreciable percentage of the overall magnetically responsive coating. Preferably, the magnetically responsive particulate material is present in the magnetically responsive coating in an amount of about 20 wt.% or more, about 30 wt.% or more, about 40 wt.% or more, about 50 wt.% or more, or about 60 wt.% or more of the coating. In another preferred embodiment, the magnetically responsive particulate material is present in the magnetically responsive coating in an amount of about 90 wt.% or less. In a more preferred embodiment, the magnetically responsive particulate material is present in the magnetically responsive coating in an amount of about 20 wt.% to about 90 wt.% (e.g., about 30 wt.% to about 90 wt.%, about 40 wt.% to about 90 wt.%, about 50 wt.% to about 90 wt.%, or about 60 wt.% to about 90 wt.%), about 30 wt.% to about 80 wt.%, about 30 wt.% to about 70 wt.%, or about 40 wt.% to about 60 wt.% of the coating. In another embodiment, the magnetically responsive particulate material is present in the magnetically responsive coating in an amount of at least about 40 wt. %, more preferably at least about 60 wt. %.

[0019] The magnetic coating can be applied to the scrim in any suitable amount. The amount of coating applied to the substrate will depend upon several factors, such as the magnetizability of the magnetically responsive particulate material, the amount of magnetically responsive particulate material in the coating, and the desired magnetic flux density to be exhibited by the coating 120. Due to the amount of coating 120 applied to the scrim 100 and the high content of magnetically responsive particulate matter in the coating, the coating has a high areal density (weight per area). In one embodiment, the magnetically responsive coating has an areal weight of at least about twice that of the areal density of the scrim. In another embodiment, the magnetically responsive coating has an areal weight of at least about 2.5 times that of the areal density of the untreated scrim. In one embodiment, the magnetically responsive coating has an areal weight of at least about 40 $g/m^2$. In another embodiment, the magnetically responsive coating has an areal weight of between about 40 and 110 $g/m^2$.

[0020] The magnetically responsive particulate material present in the coating 120 exhibits a positive magnetic susceptibility (X). Thus, an externally applied magnetic field will induce magnetic fields in the magnetically responsive particulate material, and these induced magnetic fields are in the same direction as the externally applied magnetic field. The externally applied magnetic field therefore attracts the magnetically responsive particulate material, this attraction produces a force drawing together the magnetically responsive particulate material and the source of the externally applied magnetic field. Here, the source of the externally applied magnetic field is the magnet(s) in the mold. Therefore, the mold magnet(s) and the magnetically responsive elements are attracted to and will engage with each other when brought into close proximity. The attractive force between these complementary elements does not just pull the scrim into contact with the mold, but when the magnetically responsive coating is patterned onto the scrim substrate, a precise and designed alignment within the mold is possible.

[0021] The magnetically responsive coating 120 is applied to the scrim 100 in any suitable manner. Preferably, the coating 120 is applied from an aqueous solution (or mixture or emulsion). An aqueous based system is preferred for environmental reasons. In other embodiments, the coating is solvent based. In one embodiment, the coating 120 is coated by gravure coating, knife coating, curtain coating, printing, and transfer coating.

[0022] Through deliberate design of the scrim construction, deliberate placement of the coating via a controlled coating process, or using both of these routes, a patterned deposition of the magnetically responsive coating is possible. This patterned specificity can give a reduced final weight of the coated scrim, reduced cost, and/or design motifs that lend greater functionality to the final article.

[0023] The pattern, if employed, could be in any suitable pattern. The pattern may be continuous or discontinuous, regular and repeating or random. "Continuous" in this application means that from one edge of the textile to the other edge there is a path that contains the pattern and that at least some of the pattern areas are connected. Examples of continuous patterns include straight lines and a grid. "Discontinuous" in this application means that the areas of the pattern are discontinuous and not touching one another. In a discontinuous pattern, there is no path from one edge of the fabric to the other that contains the pattern. Examples of discontinuous patterns include dots. Regular or repeating patterns mean that the pattern has a repeating structure to it. The pattern may also be a random pattern where there is no repeat to the pattern. In a random pattern, it is preferred that the random pattern is also discontinuous, not continuous. The pattern may take any patterned form including but not limited to indicia, geometric shapes or patterns, lines (straight and curved), grids, and text.

[0024] The scrim 100 may be coated with additional layers before or after the magnetically responsive coating 120 is applied. In one embodiment, the scrim 100 is coated with PVC (polyvinyl chloride) before being coated with the magnetically responsive coating 120. The PVC pre-coating step may provide stability to the loose knit, giving it a structure that may be easily handled without creating any distortion in the arrangement of the warp and weft yarns. The PVC coating may also keep the warp yarns tightly bundled and the textured weft yarns fixed in a bloomed, high surface-area form.

[0025] The tightness of the warp yarns compared to the open receptiveness of the weft yarns makes this scrim substrate highly biased towards the addition of any further chemical treatment being concentrated almost exclusively in and on the weft yarns. After the magnetically responsive coating is applied, this pronounced difference may be quantified by bisecting the fabric into separate warp and weft components. An elemental analysis of these separated yarns, detecting and quantifying the elemental signature of the magnetically responsive particulates, shows >95% by weight of the magnetically responsive particulates localized on the weft yarns.

[0026] The magnetic elements within the receiving mold have a persistent magnetic field. As utilized herein, the term “persistent magnetic field” refers to a magnetic field that persists for an extended period of time, such as the magnetic field of a traditional permanent magnet. As is explained in detail below, the magnetic elements in the mold and the magnetically responsive particulate material are magnetically attracted when in close proximity to each other. This magnetic attraction produces a force that draws and reversibly holds together the magnetically responsive scrim within the mold. The magnetic elements can be any suitable material that has a persistent magnetic field. For example, the magnetic elements can be permanent magnets made from materials such as iron, nickel, cobalt, alloys of such metals (e.g., $BaFe_3O_4$, $SrFe_3O_4$, AlNiCo) and alloys of rare earth metals, such as NdFeB and CoSm.

[0027] The magnetic elements within the mold can have any suitable magnetic flux density. The magnetic flux density of the magnetic elements is one factor that will determine the strength of the attraction between the magnetic elements and the magnetically responsive particulate material. Therefore, the desired magnetic flux density of the magnetic elements will depend, at least in part, on the desired attractive force between the elements (and substrates attached to those elements). Preferably, the magnetic elements exhibit a magnetic flux density of about 50 gauss (G) or more (about 5 millitesla (mT) or more), about 100 G or more (about 10 mT or more), about 150 G or more (about 15 mT or more), or about 200 G or more (about 20 mT or more).

Example 1

[0028] A weft inserted warp knit textile substrate was knitted using 250 denier filament polyester yarns in the warp direction with 6 warp ends per inch, 335 denier 2-ply textured filament polyester yarn in the weft direction with 12.7 wefts per inch, and 45 denier filament polyester yarns as the stitching yarns (in the warp direction).

[0029] In the griege state the areal density of this textile was approximately 31 g/m$^2$ (0.90 oz/yd$^2$). The textile substrate was then treated with a treatment composition comprising approximately 20 parts by weight of a polyvinyl copolymer dispersion and approximately 85 parts by weight water. The treatment composition was padded onto the textile substrate at a wet pickup of approximately 70% by weight. The treated textile substrate was then dried for approximately 3 minutes in a convection oven at a temperature of approximately 165°C. (330°F) to give an areal density of approximately 47 g/m$^2$ (1.4 oz/yd$^2$).

[0030] This intermediate textile substrate was then treated with a treatment composition comprising approximately 30 parts by weight of a magnetite ($Fe_3O_4$) powder finely suspended into an approximately 70 parts by weight of a diluted acrylic emulsion. This dilute acrylic emulsion had a composition of approximately 50 parts by weight of an acrylic emulsion and approximately 50 parts by weight water. The treatment composition was padded onto the textile substrate at a wet pickup of approximately 300% by weight. The treated textile substrate was then dried for approximately 3 minutes in a convection oven at a temperature of approximately 165°C. (330°F) to give an areal density of approximately 113 g/m$^2$ (3.3 oz/yd$^2$) and a magnetite mass-add-on of approximately 100% by weight.

[0031] Essentially all the magnetically responsive binder composition was deposited on the textured weft yarns. If any was picked up on the warp yarns, by design it was a negligibly insignificant amount. A sample of this textile, with a surface area of 1m$^2$, had a strong enough magnetic response to hold itself above the ground via attraction to a circular flat-faced magnet with a surface area of approximately 12.6 cm$^2$ (4 cm diameter).

[0032] All references, including publications, patent applications, and patents, cited herein are hereby incorporated by reference to the same extent as if each reference were individually and specifically indicated to be incorporated by reference and were set forth in its entirety herein.

[0033] The use of the terms “a” and “an” and “the” and similar referents in the context of describing the invention (especially in the context of the following claims) are to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context. The terms “comprising,” “having,” “including,” and “containing” are to be construed as open-ended terms (i.e., meaning “including, but not limited to,”) unless otherwise noted. Recitation of ranges of values herein are merely intended to serve as a shorthand method of referring individually to each separate value falling within the range, unless otherwise indicated herein, and each separate value is incorporated into the specification as if it were individually recited herein. All methods described herein can be performed in any suitable order unless otherwise indicated herein or otherwise clearly contradicted by context. The use of any and all examples, or exemplary language (e.g., “such as”) provided herein, is intended merely to better illuminate the invention and does not pose a limitation on the scope of the invention unless otherwise claimed. No language in the specification should be construed as indicating any non-claimed element as essential to the practice of the invention.

[0034] Preferred embodiments of this invention are described herein, including the best mode known to the inventors for carrying out the invention. Variations of those preferred embodiments may become apparent to those of ordinary skill in the art upon reading the foregoing description. The inventors expect skilled artisans to employ such variations as appropriate, and the inventors intend for the invention to be practiced otherwise than as specifically described herein. Accordingly, this invention includes all modifications and equivalents of the subject matter recited in the claims appended hereto as permitted by applicable law. Moreover, any combination of the above-described elements in all possible variations thereof is encompassed by the invention unless otherwise indicated herein or otherwise clearly contradicted by context.

WHAT IS CLAIMED IS:

1. A magnetically responsive scrim comprising:

a scrim comprising a plurality of yarns;

a magnetically responsive coating covering at least a portion of the yarns of the scrim, wherein the magnetically responsive coating comprises magnetically responsive particulate material and a binder, wherein the magnetically responsive coating is at least about 40% by weight magnetically responsive particulate material, and wherein the magnetically responsive coating has an areal density of at least twice the areal density of the scrim.

2. The magnetically responsive scrim of claim 1, wherein the scrim is a laid scrim.

3. The magnetically responsive scrim of claim 1, wherein the scrim is a woven scrim.

4. The magnetically responsive scrim of claim 1, wherein the scrim is a knit scrim.

5. The magnetically responsive scrim of claim 4, wherein the scrim is a weft inserted warp knit scrim.

6. The magnetically responsive scrim of claim 1, wherein the yarns of the scrim comprise polyester yarns.

7. The magnetically responsive scrim of claim 6, wherein at least a portion of the polyester yarns are texturized polyester yarns.

8. The magnetically responsive scrim of claim 1, wherein the scrim comprises a plurality of yarns in a warp direction and a plurality of yarns in a weft direction defined to be approximately perpendicular to the warp direction.

9. The magnetically responsive scrim of claim 8, wherein at least a portion of the plurality of yarns in a weft direction are polyester texturized polyester yarns.

10. The magnetically responsive scrim of claim 8, further comprises a plurality of stitching yarns in the warp direction.

11. The magnetically responsive scrim of claim 1, wherein the magnetically responsive particulate material comprise ferromagnets or ferrimagnets.

12. The magnetically responsive scrim of claim 1, wherein the magnetically responsive particulate material comprise a material selected from the group consisting of iron oxide, steel, iron, nickel, and aluminum.

13. The magnetically responsive scrim of claim 1, wherein the magnetically responsive coating has an areal density of at least 2.5 times the areal density of the scrim.

14. The magnetically responsive scrim of claim 1, wherein the magnetically responsive coating is at least about 70% by weight magnetically responsive particulate material.

15. The magnetically responsive scrim of claim 1, wherein the magnetically responsive coating is applied onto the scrim from an aqueous mixture.

16. The magnetically responsive scrim of claim 15, wherein magnetically responsive coating is applied by coating.

17. The magnetically responsive scrim of claim 15, wherein magnetically responsive coating is applied by padding.

18. The magnetically responsive scrim of claim 1, wherein the magnetically responsive scrim further comprises a layer of PVC between the yarns and the magnetically responsive coating.

19. The magnetically responsive scrim of claim 1, wherein the magnetically responsive coating is in a pattern.

20. The magnetically responsive scrim of claim 1, wherein the magnetically responsive particulate material has an average particle size range of between about 50 nm to 50 microns.

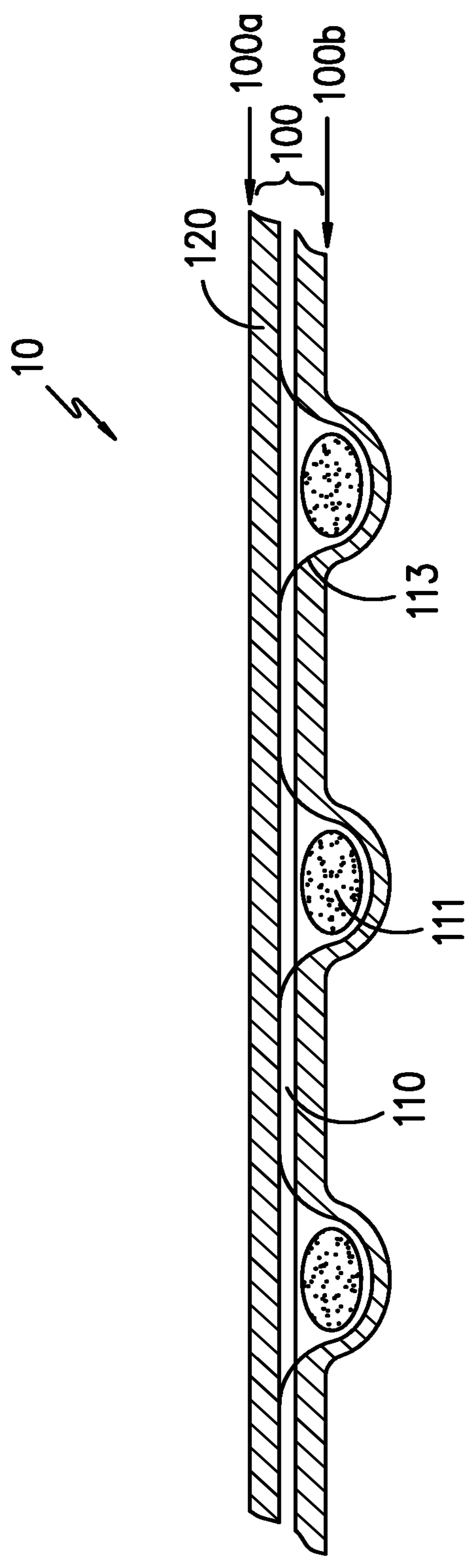


FIG. -1-

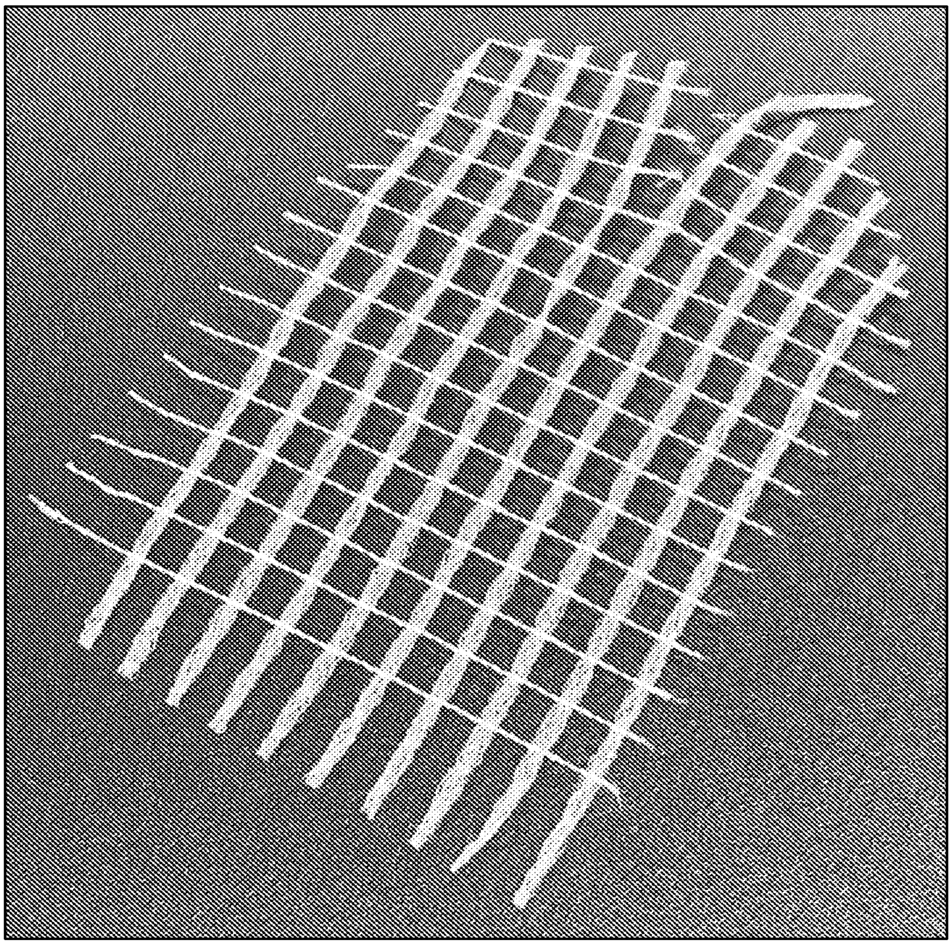

FIG. -2-

# INTERNATIONAL SEARCH REPORT

International application No
PCT/US2020/035890

**A. CLASSIFICATION OF SUBJECT MATTER**
INV. D03D1/00 D03D9/00 D03D15/00 D04B21/10 D04B21/16
D04H3/005 D04H3/04
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)
D03D D04B D04H

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 | JP S61 245372 A (MITSUBISHI PLASTICS IND; ASUTAA INTERNATL KK ET AL.) 31 October 1986 (1986-10-31) the whole document ----- | 1-20 |
| A | EP 1 413 660 A1 (SCHUMACHER ROLF [DE]; ZIEGELE MARK [DE]; STING OLIVER [DE]) 28 April 2004 (2004-04-28) paragraph [0021] - paragraph [0048] figure 1 ----- | 1-20 |
| A | GB 1 123 795 A (VAUXHALL MOTORS LTD; CHELLINGWORTH & SINGER LTD) 14 August 1968 (1968-08-14) the whole document ----- -/-- | 1-20 |

[X] Further documents are listed in the continuation of Box C.

[X] 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)
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