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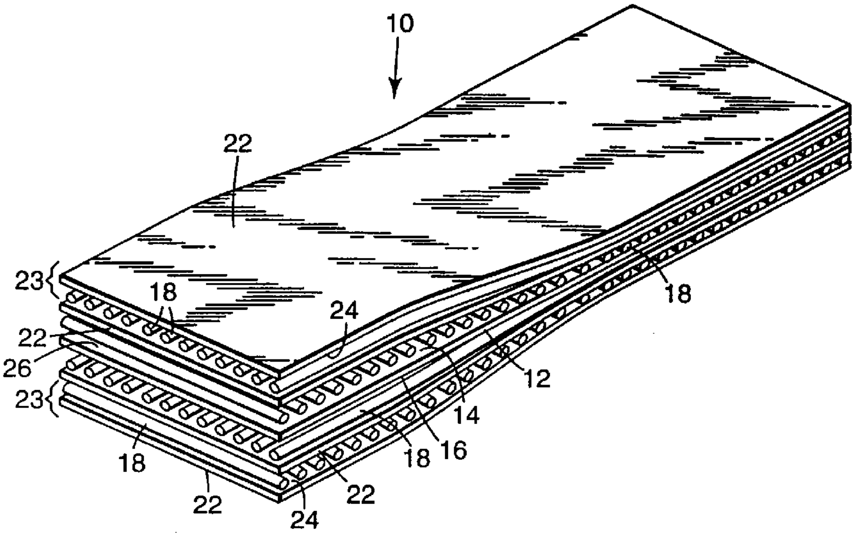
(54) **TISSU POUR AIRBAG**
(54) **AIR BAG FABRIC**



(57) Ce tissu (10) approprié pour former l'ensemble ou une partie d'un airbag comprend une pluralité de couches renforcées (23) liées entre elles pour former une couche unitaire. Ces couches (23) peuvent être formées par des stratifiés unidirectionnels de fibres (18) généralement parallèles liées à un matériau, par ex. un film thermoplastique, une bande de non-tissé, ou un revêtement. Les parties du tissu (10) peuvent être cousues ou liées thermomécaniquement pour constituer l'airbag.

(57) A fabric (10), suitable for use in the construction of all or part of an air bag, includes a plurality of reinforced layers (23). The layers (23) are bonded together, forming a unitary sheet. The layers (23) may be formed by unidirectional laminates of generally parallel fibers (18) bonded to a material, such as a thermoplastic film, non-woven web, or coating. Pieces of the fabric (10) may be sewn or thermomechanically bonded to construct the air bag.

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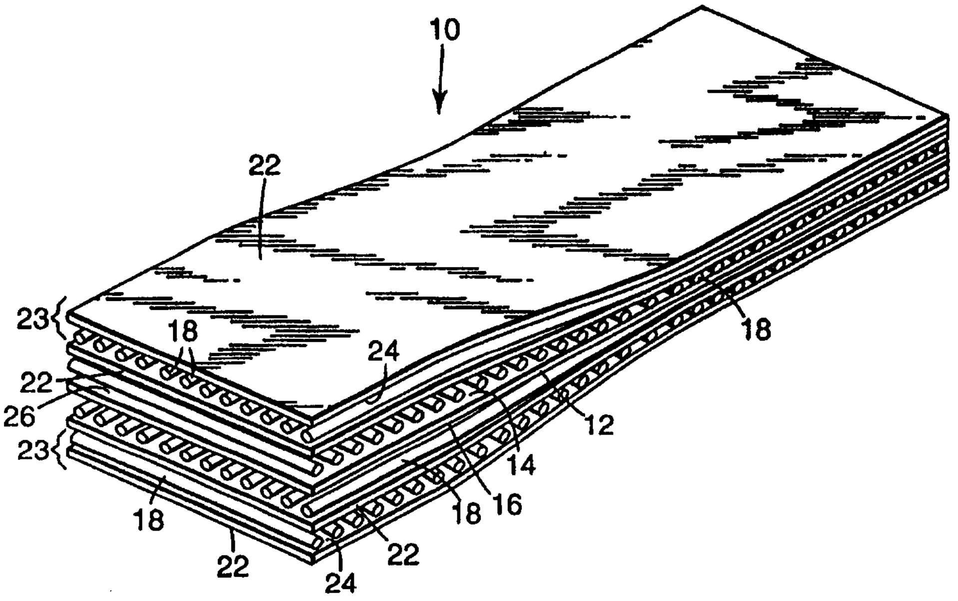

(57) Abstract

A fabric (10), suitable for use in the construction of all or part of an air bag, includes a plurality of reinforced layers (23). The layers (23) are bonded together, forming a unitary sheet. The layers (23) may be formed by unidirectional laminates of generally parallel fibers (18) bonded to a material, such as a thermoplastic film, non-woven web, or coating. Pieces of the fabric (10) may be sewn or thermomechanically bonded to construct the air bag.

AIR BAG FABRIC

Field of the Invention

The present invention relates to composite fabrics suitable for use in inflatable air bag systems.

Background of the Invention

In an era of increased concern with motor vehicle safety, passive restraint systems have moved to the forefront in the eyes of consumers, government agencies, and motor vehicle manufacturers. Inflatable air bag systems are currently the most widely used passive restraint system in the U.S., and are used increasingly in other countries. Early commercialized air bag systems were positioned in the steering wheel to protect the motor vehicle driver in front-end collisions. Air bag systems now include air bags installed in the front dashboard for front-seat passenger protection in front-end collisions. Side impact and back seat systems are also under development. Air bag systems are being evaluated for other applications, such as aircraft passive restraint systems.

Air bag systems include three major components: (1) a crash sensor; (2) an inflation source; and (3) an air bag or cushion. The crash sensor detects a collision by sensing rapid deceleration or by other means. The sensor generates a signal used to trigger the inflation source, e.g., bottled gas or a gas-generating pyrotechnic device. The gas is directed through vents into the air bag, causing rapid inflation of the bag. The inflated air bag cushions the occupants' impact by pneumatic damping effects from the air bag vents.

Because of the importance of air bag systems as a passive collision safety system (and liability issues in the U.S.), fabrics used to construct the air bag must meet a variety of design criteria. The air bag fabric should have a low permeability to allow for rapid inflation. The air bag fabric should be puncture and tear resistant. The air bag fabric should be relatively inflammable in view of the hot gases and hot particulate material generated by a pyrotechnic inflation source. The outer surface of the air bag must have a low abrasive quality so as not to injure the occupant upon impact with the deployed air bag.

Other, more general, criteria also influence air bag design. The air bag must be able to deploy quickly. Also, a smaller pyrotechnic inflation source is desirable. Therefore, the air bag fabric should be lightweight and have a high pack density. These criteria are particularly important in driver-side systems that are incorporated into the steering wheel.

The air bag fabric must have long-term stability (e.g., at least ten years or more) in a variety of environmental conditions in view of the fact that the cars are being kept in service for longer periods. Also, given today's highly competitive motor vehicle market, the fabric should be inexpensive.

Currently, the most commonly used air bag fabric in the U.S. is a woven nylon 6 or nylon 6,6 fabric. All or part of the fabric may be coated, depending on the application (i.e., driver, front passenger, side, etc.). The nylon fabric must be cut and sewn to form the bag. The time and labor required to sew the bag increases the overall price of the air bag.

Other fabrics meet some of the design criteria, but generally do not provide a good balance of many of the design criteria for air bags. For example, cotton fabric may lose strength over longer periods, particularly in a humid environment. Some glass fibers may be brittle, resulting in excessive breakage of the fibers upon bending. Ballistic resistant fibers (e.g., Kevlar®) tend to be stiff, as well as expensive.

Summary of the Invention

A fabric suitable for use in an air bag is provided. The fabric may be used to form all or part of the air bag. The fabric includes a central layer having first and second opposed major surfaces. A plurality of substantially parallel, spaced apart fibers are bonded to each of the first and second opposed surfaces. The fibers bonded to the first opposed surface are oriented at an angle relative to the fibers of the second opposed surface of between about forty-five and about ninety degrees.

In one embodiment, the central layer comprises a thermoplastic film. The thermoplastic film is selected from the group comprising polyesters, polyolefins, polyurethanes, polyamides, polyvinyl chlorides, polyvinyldiene chlorides, fluoropolymers, block copolymer elastomers, polyester elastomers, and combinations thereof. In another embodiment, the central layer comprises a thermally bondable non-woven web, including a blown microfiber, spun bond, spun lace, air laid, or carded non-woven web.

In one embodiment, the fibers are high-tenacity monofilament or multifilament fibers selected from the group comprising polyester fibers, polyamide fibers, polyolefin fibers, aramid fibers, and combinations thereof. The fibers have a denier preferably in the range of about 200 to about 900, and have a tenacity preferably of about 8g/denier or greater.

In one embodiment, the fibers are thermomechanically bonded to the first and second opposed surfaces. In another embodiment, the fibers are bonded to the first and second opposed surfaces by an adhesive applied to the first and second surfaces, the fibers, or both. The fibers are spaced at a density of about 7 to about 16 fibers per centimeter.

In one embodiment, the fabric further includes a first layer bonded to the fibers and the first opposed surface, and a second layer bonded to the fibers and the second opposed surface. The first and second layers, independently, may comprise a thermoplastic film, non-woven web, or a coating.

In one embodiment, the fabric further includes at least one laminate layer bonded to the first sheet. In another embodiment, the fabric also includes at least one laminate layer bonded to the second sheet.

In another embodiment, a material suitable for use in an inflatable restraint is provided. The material includes a plurality of reinforced layers. The layers comprising a plurality of substantially parallel fibers bonded to a layer. The fibers of adjacent reinforced layers are oriented relative to each other at an angle of between about 45 and about 90 degrees.

The fabric may be cut and sewn or thermomechanically bonded to form all or part of the air bag. Thermomechanical bonding is generally faster and more cost-effective than sewing.

By selectively choosing the materials for the different components of the fabric, one can customize the characteristics of the fabric, including the strength profile. By selecting the number of laminate layers, layer materials, denier of the fibers, tenacity of the fibers, and number of fibers, a variety of strength profiles may be generated. These strength profiles can be matched with the needs of a particular air bag application or matched with specific components of an air bag to construct an air bag having desirable characteristics.

Brief Description of the Drawings

Figure 1 is an exploded plan view of a fabric according to one embodiment of the invention.

Figure 2 is an exploded plan view of a fabric according to another embodiment of the invention.

Figures 3A and 3B provide an illustration of the panels used to make a driver's side air bag using the fabric of the present invention.

Description of the Preferred Embodiments

One embodiment of an air bag fabric according to the invention is shown in Figure 1. Fabric 10 includes a central layer 12. Central layer 12 includes opposed major surfaces 14, 16. Generally parallel, spaced-apart fibers 18 are positioned adjacent and bonded to opposed major surfaces 14, 16, respectively. First and second layers 22 are positioned adjacent fibers 18 opposite central layer 12, and are bonded to the plurality of adjacent fibers 18 and to the opposed surfaces 14, 16, respectively, of central layer 12.

Additional laminate layers 23 of fibers 18 bonded to layers 22 may be added to form fabric 10. The inner surface 24 of each layer 22 is bonded to an adjacent plurality of fibers 18 and to the outer surface 26 of the adjacent layer 22 closer to central layer 12.

Central layer 12 is formed from a thermally bondable non-woven web or a thermoplastic film. The non-woven web may be selected from a variety of materials, including blown microfiber webs, spun bond webs, spun lace webs, air laid webs, and carded webs. The thermoplastic film may be selected from a variety of materials, including polyester, polyolefin, polyurethane, polyamide, PVC, fluoropolymer, block copolymer elastomer, and polyester elastomer films. Additionally, central layer 12 may be formed from multi-layer films or film/non-woven laminates. The thickness of central layer 12 is selected for the particular application. For example, central layer 12 thicknesses may range from about .01 mm to about .05 mm, preferably about .01 mm to about .03 mm.

When selecting the material for central layer 12, as well as layers 22, the overall permeability of fabric 10 must be considered. For example, if a less permeable non-woven web is selected for central layer 12, one or more of layers 22 may need to be a thermoplastic film in order to achieve the desired permeability for fabric 10.

The fibers 18 bonded to opposed major surfaces 14, 16 are oriented relative to each other at an angle of about forty-five to about ninety degrees, depending on the desired strength characteristics of the fabric 10. In the embodiment of Figure 1, the fibers 18 bonded to opposed major surfaces 14, 16 are oriented at an angle of about ninety degrees relative to each other. The fibers 18 are bonded to the respective opposed surfaces 14, 16 by thermomechanical methods or by adhesives.

Fibers 18 are selected from high tenacity monofilament or multifilament fibers, e.g., polyester fibers of 220 denier and having 8.3g/denier tenacity. The fibers 18 may have a tenacity of about 8g/denier and above. Fiber materials include polyester, polyamide, polyolefin, and aramid fibers, or combinations thereof. The fibers may have a denier in the range of about 200 to 900. For example, fibers having a denier of 220, 440, 630, or 840 may be used.

Preferably, fibers having a lower denier and higher tenacity are used. Fibers having a higher denier may also be used. A combination of fibers having different denier values may be used.

Layers 22 may be formed from the materials or a combination of the materials described above for central layer 12. Also, layers 22 may be formed by a coating of film-forming materials in solution, such as thermoplastics, adhesives, and hot-melt adhesives.

The number of laminate layers 23 of fibers 18 and layers 22 is selected to obtain the desired characteristics of the fabric 10. The fibers 18 of adjacent laminate layers are oriented relative to each other at an angle of about forty-five to about ninety degrees. The number of laminate layers 23 added on top of the opposed major surfaces need not be the same. For example, fabric 10 may include 3 laminate layers on top of the first opposed major surface 14 and two laminate layers on top of opposed major surface 16.

Additionally, a layer 22 or fibers 18 may be substituted for one or more laminate layers 23. Also, the fibers bonded with each of the various layers 12 and 22 may be selected from different materials, denier, or tenacity.

In another embodiment of the invention, fabric 10 includes a plurality of reinforced layers 23, as shown in Figure 2. As discussed above, reinforced layers 23 include a plurality of fibers 18 bonded to a layer 22, forming a unidirectional, reinforced laminate. The two innermost reinforced layers 30 are positioned so that the fibers 18 of the reinforced layers 30 are positioned immediately adjacent each other. The layers 22 of reinforced layers 30 are bonded to the two layers of fibers 18 and to each other.

As discussed above, the fibers of adjacent reinforced layers are positioned relative to each other at an angle of between about forty-five to about ninety degrees. Also, the same materials or combinations of materials discussed above for fibers 18 and layers 22 may be used.

In one embodiment for constructing of fabric 10. A laminate layer 23 is formed by laying fibers 18 on layer 22. Fibers 18 may be hand-laid or delivered by beam or creel. Typically, a comb is used to keep fibers 18 aligned generally parallel and with a predetermined interfiber distance, e.g., 7 to 16 fibers per centimeter.

In one embodiment, layer 22 and fibers 18 are formed into a unidirectional, laminate layer 23 by thermomechanical means, e.g., heat and pressure. In other embodiments, an adhesive may be applied to the fibers 18, the layer 22, or both, in order to bond the two materials and form a unidirectional, laminate layer 23. Typically, the newly formed laminate layer 23 is wound into large rolls.

Laminate layer 23 may be formed by other means. For example, layer 22 may be extruded directly onto fibers 18 in the case where layer 22 is a thermoplastic film.

In order to form fabric 10, at least two laminate layers 23 are oriented relative to each other so that the respective fibers of one laminate layer are oriented at an angle with respect to the fibers of adjacent laminate layers of between about forty-five to about ninety degrees. The laminate layers 23 are positioned so that the two exposed outer surfaces of fabric 10 have a relatively smooth, non-abrasive impact surface in order to reduce the risk of secondary injury to the vehicle occupant when the air bag is deployed. Once the desired number of laminate layers 23 are positioned together, the laminate layers are thermomechanically or adhesively bonded to form composite, multidirectional laminate fabric 10.

The number of laminate layers 23 and orientation of the fibers 18 provide the general strength characteristic of the fabric 10. A commonly used fabric strength test is the Mullen burst strength test (as determined by ASTM D3786). Suitable fabrics 10 exhibit a Mullen burst strength of at least about 1.8 MPa, preferably at least about 2.4 MPa, and more preferably at least about 3.4 MPa. The orientation of the fibers 18 in each laminate layer 23 may be adjusted to provide strength in a specific orientation for specific portions of the air bag, thereby providing an overall stronger air bag.

Generally, drivers-side air bags are made in circular or square/rectangular shapes. As shown in Figures 3A and 3B, a circular air bag is fabricated from panels 40, 41. A circular inflation aperture 42 is cut into panel 41 to allow for inflation. Holes 43 corresponding to the positions of the bolts for a metal mounting flange of the inflation unit are formed around the circumference of the inflation aperture 42. The panels 40, 41 are joined by either stitching or by thermomechanical methods.

Thermomechanical bonding can be performed relatively quickly and easily. Depending on the application, the thermomechanical bond may be augmented by stitching or other means. The two circular panels 40, 41 may also be sewn together by various stitching patterns and techniques. Typically, a sewn bag is inverted through the inflation aperture, to position the perimeter seam in the interior of the bag.

The fabric may also be cut to form square and rectangular air bags from single sheets of fabric. In either circular or square/rectangular designs, fabric 10 may be constructed with characteristics that meet the localized performance characteristics of the air bag.

Fabrics having selected characteristics may be formed by selecting different sheet materials and thicknesses, fibers materials and densities, orientation of fibers, and number of layers.

The invention is illustrated by means of the following examples.

Example 1

Unidirectional laminates of fibers on film were made in the following manner. Polyester fibers of 220 denier, 8.3 g/denier tenacity, (1/220/50 R02-68, DuPont, Wilmington, DE) were laminated to a spunbond web of 2.4 dtex polyester fibers (#2250 from Reemay Corp., Old Hickory, TN) having a basis wt. of 17g/m^2 using a single-nip calendar available from Webex, Inc., Neenah, WI. Both calendar rolls were steel and were maintained at 150^{0}C. The lamination pressure was 21.8 kN/m and the lamination speed was approximately 1 meter per minute. The fibers were delivered to the nip from a beam and laid generally parallel on the web with the interfiber distance being maintained constant via a comb providing 11 fibers per cm.

Composite, multidirectional laminates were subsequently formed from the unidirectional laminate. Unidirectional laminates were laid up such that the laminated fibers formed a 90^0 orientation with one another with the fiber side of the unidirectional laminates facing the center of the composite laminates. These lay-ups were subsequently bonded by passing them through the calendar nip at 150^{0}C, 21.8 kN/m and 3.3 m/min. Multidirectional laminates of 2, 3, and 4 layers were formed in this manner. The respective thickness' were 0.203 mm, 0.279 mm, and 0.343 mm and the Mullen burst strengths (as measured by ASTM D3786) of 1.8 MPa, 2.6 MPa, 2.6 MPa, respectively.

Example 2

Unidirectional laminates of fibers on film were made in the following manner. Polyester fibers of 220 denier, 8.3 g/denier tenacity, (1/220/50 R02-68, DuPont, Wilmington, DE) were laminated to a sheet of 0.0125 mm thick polyethylene film (SF-40 SP ,CT Films, Chippewa Falls, WI) by spraying the film with 3M #6091 spray Remount Repositionable Adhesive, hand laying the fibers onto the film, and subsequently allowing the adhesive to dry. The interfiber distance was maintained constant via a comb allowing 16 fibers per cm.

Composite, multidirectional laminates were subsequently formed from the unidirectional laminate. Unidirectional laminates were laid up such that the laminated fibers formed a 90^0 orientation with one another with the fiber side of the unidirectional laminates facing the center of the composite laminates. The lay-ups were subsequently bonded by pressing them in a Carver press under 68.9 MPa at 135^0C for 1 minute. Laminates of 2 plies were made in this way; the thickness and the Mullen burst strength (as measured by ASTM D3786) were 0.127 mm and 2.4 MPa, respectively.

Example 3

Unidirectional laminates of fibers on film were made in the following manner. Polyester fibers of 220 denier, 8.3 g/denier tenacity, (1/220/50 R02-68, DuPont, Wilmington, DE) were laminated to sheets of 3M #927 transfer tape by aligning the fibers in a comb, and pressing the fibers into the adhesive. The interfiber distance was maintained constant via a comb allowing 16 fibers per cm.

Composite, multidirectional laminates were subsequently formed from the unidirectional laminate. Unidirectional laminates were laid up such that the laminated fibers formed a 90^0 orientation with one another with the fiber side of the unidirectional laminates facing the center of the composite laminates. Adhesion of the laminate to the press was prevented by applying 0.0125 mm thick sheets of polyethylene (SF-40 SP ,CT Films, Chippewa Falls, WI) or a small amount of baby powder to the lay-up. These lay-ups were subsequently bonded by pressing them in a Carver press under 68.9 MPa at 135°C for 2 minutes. Laminates of 2 plies of fibers were made in this way. The thickness of the laminates with the polyethylene film were 0.356 mm thick and those with powder were 0.203 mm thick. The Mullen burst strengths (as measured by ASTM D3786) were 2.5 MPa and 2.3 MPa, respectively.

Example 4

Unidirectional laminates of fibers on film were made in the following manner. A silicone coated, paper web was coated with a moisture curing, polyurethane adhesive (3M TS-230). The open time of the adhesive was long enough that the adhesive was still tacky when polyester fibers of 220 denier, 8.3 g/denier tenacity, (1/220/50 R02-68, DuPont, Wilmington, DE) were delivered to the web. With subsequent curing, the adhesive cross-linked and crystallized, bonding the fibers to the adhesive. Lamination was accomplished with a three roll, double-nip calendar. The fibers were delivered to the nip from a creel and laid generally parallel on the web with the interfiber distance being maintained via a comb allowing 16 fibers per cm.

Composite, multidirectional laminates were subsequently formed from the unidirectional laminate. Unidirectional laminates were laid up such that the laminated fibers formed a 90° orientation with one another with the fiber side of the unidirectional laminates facing the center of the composite laminates. These lay-ups were subsequently bonded by pressing them in a Carver press under 68.9 - 103 MPa at 149°C for 1-2 minutes either by heat alone or with heat and an additional sheet of 0.013 mm thick polyethylene film (SF-40 SP ,CT Films, Chippewa Falls, WI). Laminates of 2 layers were formed in this manner. The respective thickness' were 0.165 mm and 0.152 mm and the Mullen burst strengths (as measured by ASTM D3786) of 2.3 MPa and 2.4 MPa, respectively.

Example 5

Unidirectional laminates of fibers on film were made in the following manner. Polyester fibers of 220 denier, 8.3 g/denier tenacity, (1/220/50 R02-68, DuPont, Wilmington, DE) from were laminated to 0.0254 mm thick continuous web of polyurethane film (PS8010 from Deerfield Urethane, South Deerfield, MA) using a single-nip calendar available from Webex, Inc., Neenah, WI. Both calendar rolls were steel and were maintained at 177^{0}C. The lamination pressure was 21.8 kN/m and the lamination speed was approximately 1 meter per minute. The fibers were delivered to the nip from a beam and laid generally parallel on the web with the interfiber distance being maintained constant via a comb allowing 11 fibers per cm.

Composite, multidirectional laminates were subsequently formed from the unidirectional laminate. Unidirectional laminates were laid up such that the laminated fibers formed a 90^0 orientation with one another with the fiber side of the unidirectional laminates facing the center of the composite laminates. These lay-ups were subsequently bonded by passing them through the calendar again at 150^{0}C, 21.8 kN/m, and 3.3 m/minute. Multidirectional laminates of 2, 3, 4, and 6 layers were formed in this manner. The respective thickness' were 0.127 mm, 0.191 mm, 0.267 mm, and 0.330 mm and the Mullen burst strengths (as measured by ASTM D3786) of 1.8 MPa, 2.4 MPa, 3.65 MPa, 5.9 MPa, respectively.

Example 6

Unidirectional laminates of fibers on film were made in the following manner. Polyester fibers of 440 denier, 8.3 g/denier tenacity, (1/440/50 R02-68, DuPont, Wilmington, DE) from were laminated to 0.05 mm thick continuous web of polyurethane film (PS8010 from Deerfield Urethane, South Deerfield, MA) using a single-nip calendar. The top calendar roll was silicone rubber and the bottom roll was steel and both were maintained at 150°C while the lamination speed was approximately 1 meter per minute. The fibers were delivered to the nip from a series of four parallel beams and laid essentially parallel on the web with the interfiber distance being maintained constant via a comb allowing 13 fibers per cm.

Composite, multidirectional laminates were subsequently formed from the unidirectional laminate. Unidirectional laminates were laid up such that the laminated fibers formed a 90° orientation with one another with the fiber side of the unidirectional laminates facing the center of the composite laminates. A 0.05 mm thick continuous web of polyurethane film (PS8010 from Deerfield Urethane, South Deerfield, MA) was laid between the unidirectional laminates. These lay-ups were subsequently bonded by pressing them in a Carver press under 68.9 - 103 MPa at 149°C for 1-2 minutes. The Mullen burst strength was 4.48 MPa as measured by ASTM D3786.

Other embodiments are within the scope of the following claims.

WHAT IS CLAIMED IS:

1. An air bag fabric, comprising:

a central layer having first and second opposed major surfaces; and

a plurality of substantially parallel, spaced apart fibers bonded to each of the first and second opposed surfaces;

wherein the fibers bonded to the first opposed surface are oriented at an angle relative to the fibers of the second opposed surface of between about 45 and about 90 degrees.

2. A fabric according to claim 1, wherein the central layer comprises a thermoplastic film, a non-woven web, or combination thereof.

3. A fabric according to claim 1, wherein the fibers comprise high-tenacity monofilament or multifilament fibers selected from the group comprising polyester fibers, polyamide fibers, polyolefin fibers, aramid fibers, and combinations thereof.

4. A fabric according to claim 1, wherein the fibers have a denier in the range of about 200 to about 900 and a tenacity of about 8g/denier or greater.

5. A fabric according to claim 1, further comprising a first layer bonded to the fibers and the first opposed surface.

6. A fabric according to claim 1, further comprising a second layer bonded to the fibers and the second opposed surface.

7. A fabric according to claim 5, further comprising at least one laminate layer bonded to the first outer sheet.

8. A material suitable for use in an inflatable restraint, comprising:

a plurality of reinforced layers, the reinforced layers comprising a plurality of substantially parallel fibers bonded to a layer;

wherein the fibers of adjacent reinforced layers are oriented relative to each other at an angle of between about 45 and about 90 degrees.

9. A fabric suitable for use in air bags, comprising:

a first layer;

an second layer;

a first plurality of generally parallel fibers positioned intermediate the first and second layers, and

a second plurality of generally parallel fibers positioned intermediate the first and second layers;

wherein the second plurality of fibers are oriented relative to the first plurality of fibers at an angle of about forty-five to about ninety degrees, and the first layer is bonded the second layer.

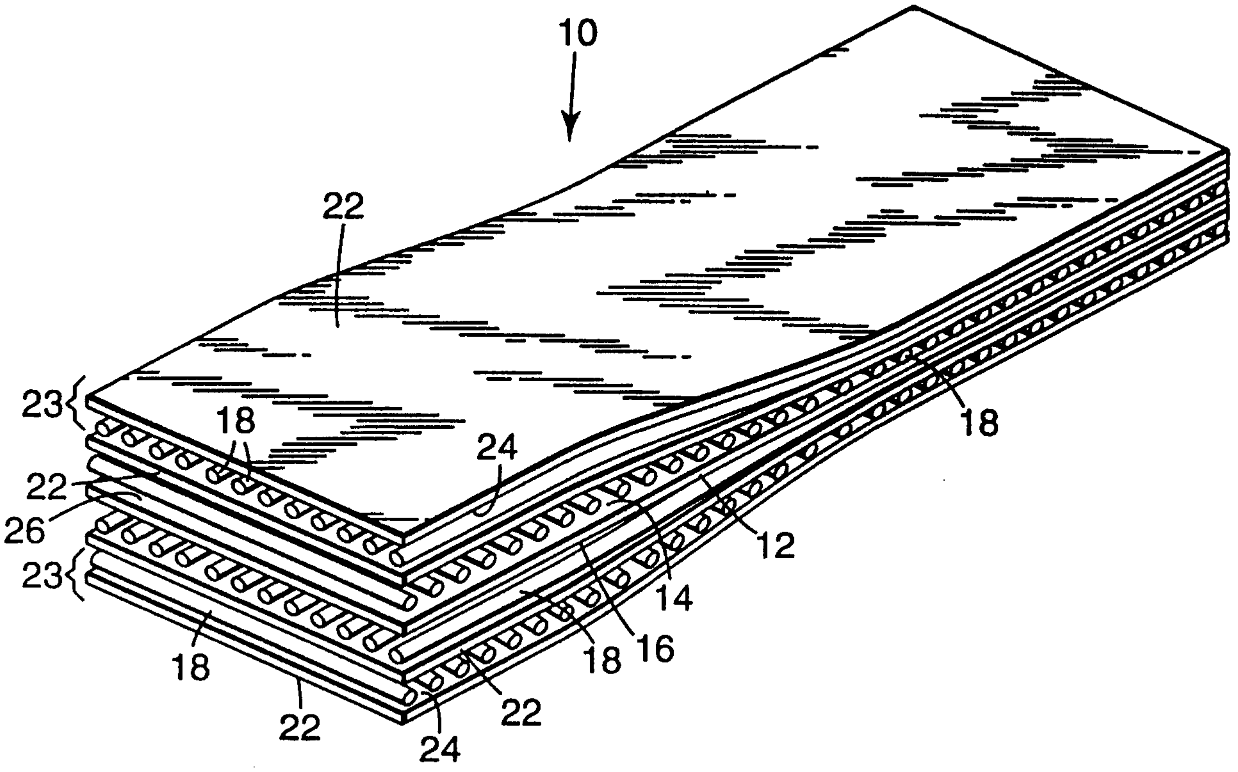
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Fig. 1

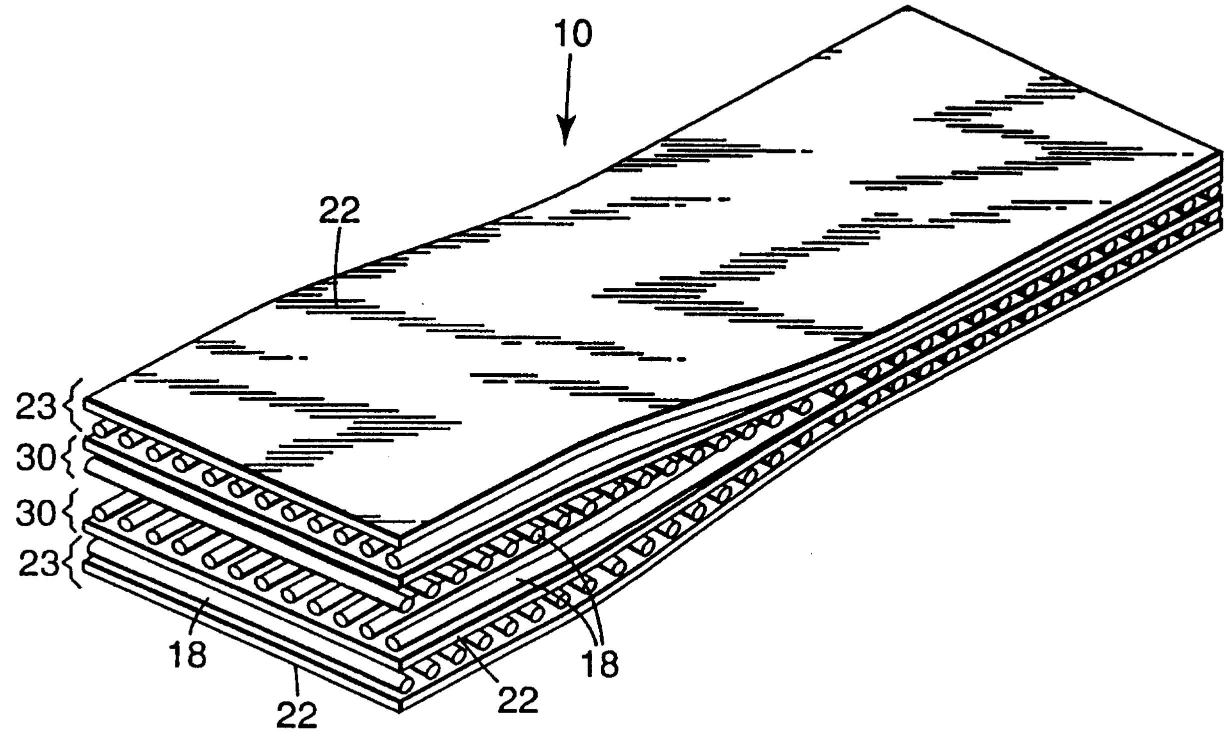
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Fig. 2

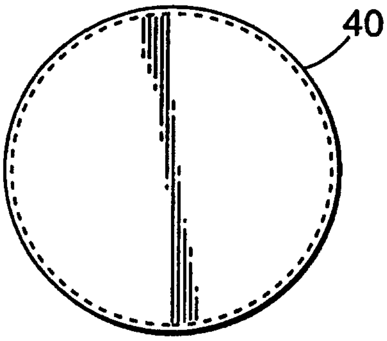


Fig. 3A

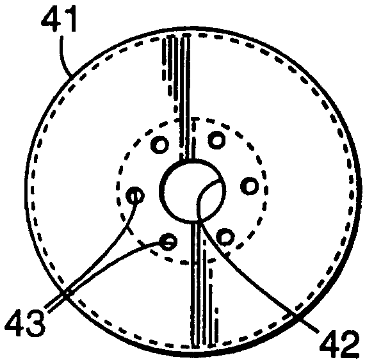
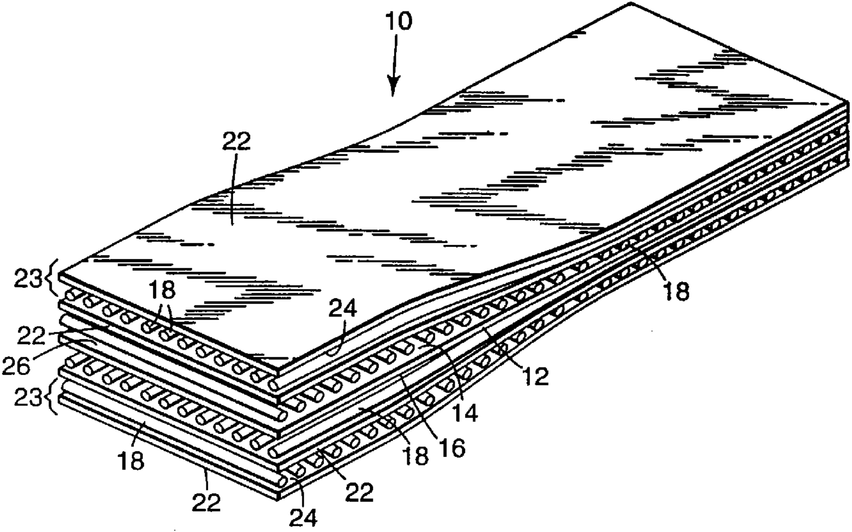


Fig. 3B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