

Feb. 18, 1969

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3,428,506

METHOD OF PRODUCING A NEEDLED, NONWOVEN FIBROUS STRUCTURE

Filed Jan. 11, 1965

Sheet 1 of 4

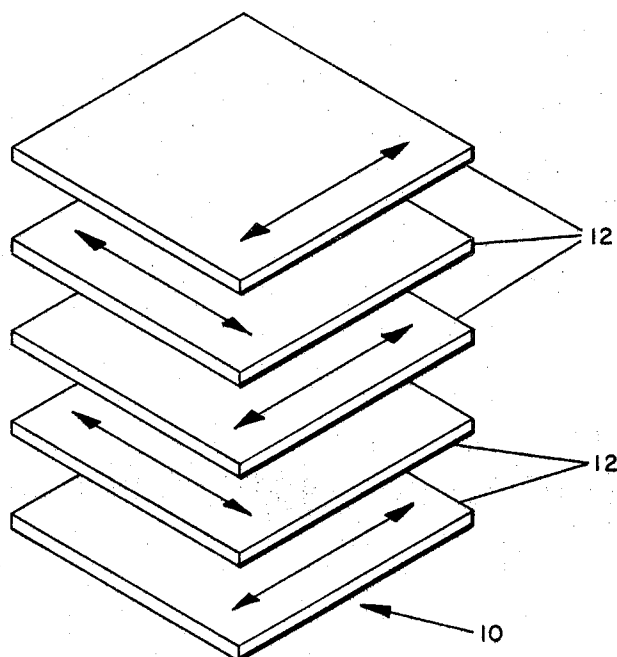


FIG. 1

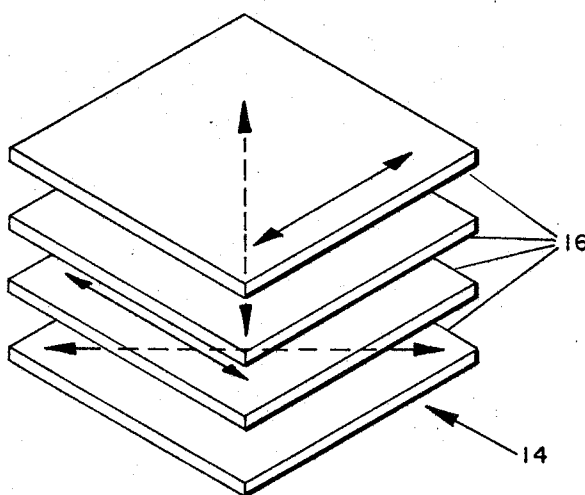


FIG. 2

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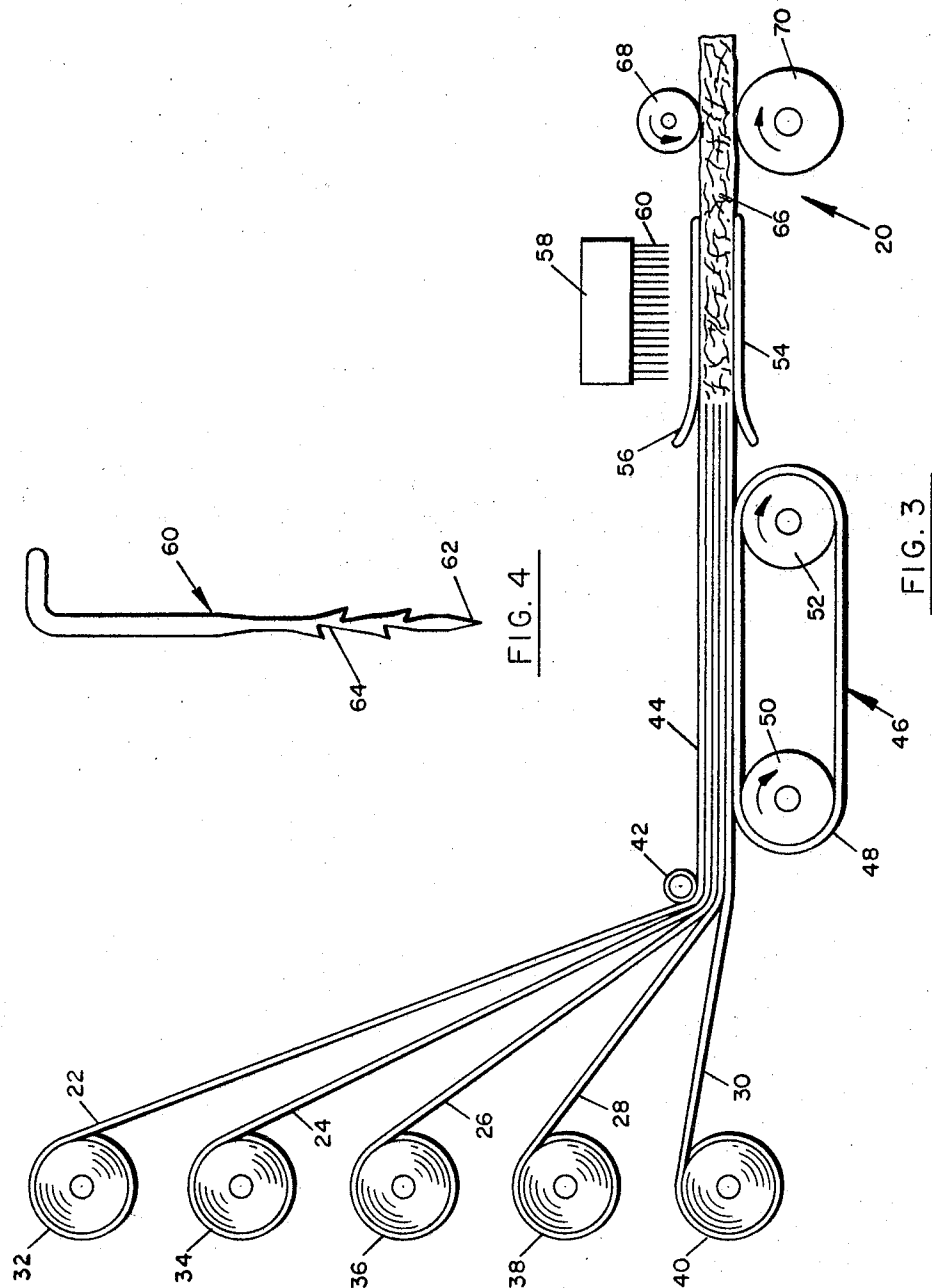
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Sheet 3 of 4



FIG. 6

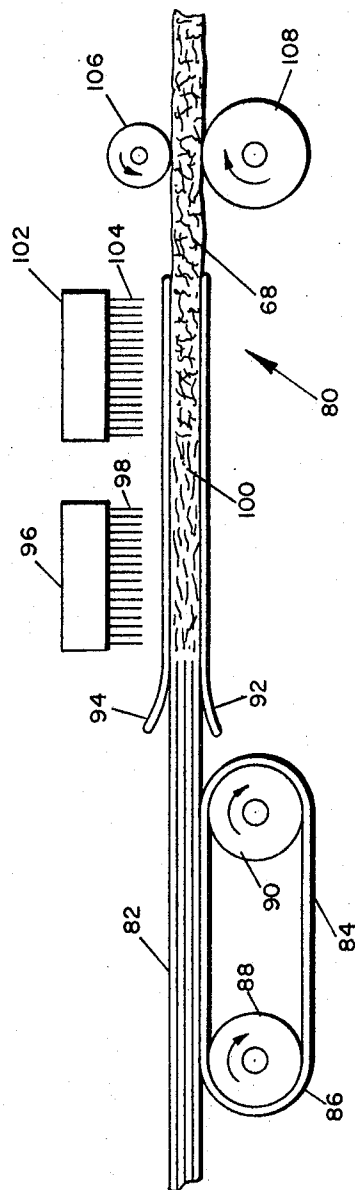


FIG. 5

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Sheet 4 of 4

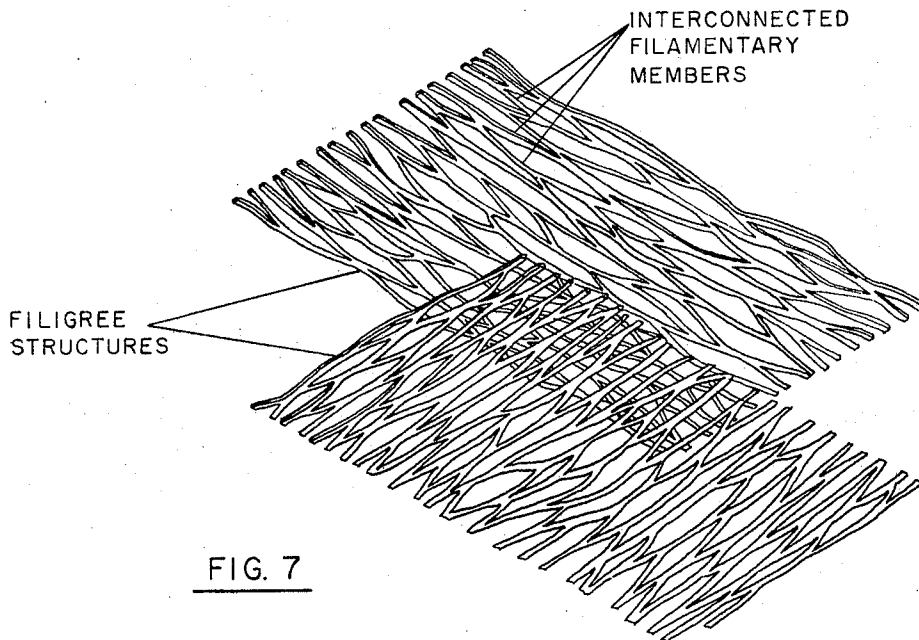


FIG. 7

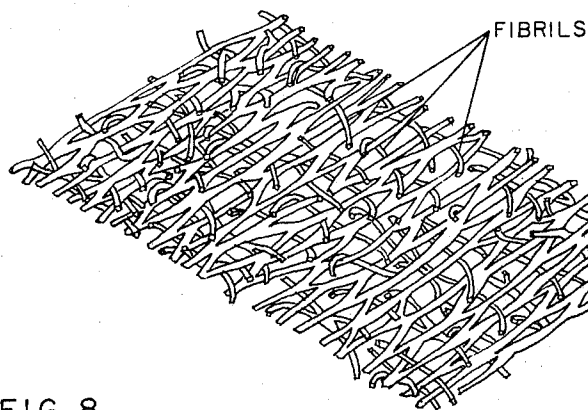


FIG. 8

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1

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METHOD OF PRODUCING A NEEDLED, NON-WOVEN FIBROUS STRUCTURE

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U.S. Cl. 156-148

16 Claims

Int. Cl. B32b 11/00

This invention relates to nonwoven fibrous structures. More particularly, this invention relates to the preparation of nonwoven fibrous structures from a plurality of superposed layers of oriented synthetic polymeric film by needle-punching techniques and to the nonwoven fibrous structures thus produced.

Nonwoven fabrics have become increasingly important in the textile industry, primarily because of their low cost of manufacture as compared to the cost of manufacturing woven fabrics by weaving, knitting, and the like techniques.

Nonwoven fabrics have been prepared by needle punching batts or webs of loosely associated natural or synthetic fibers. Typically, the batts or webs for use in such processes are made by carding staple fibers. The punched or needled nonwoven products are used as carpet pads, papermakers felt, blankets, upholstery fabrics, insulating materials, filters, and the like.

Basically, needle punching comprises piercing an unwoven batt of loosely associated staple fibers with a plurality of barbed needles whereby fibers are rearranged, entangled, interlaced, interlooped, and the like, by the barbed needles during passage through the batt, thereby giving added strength and density to the structure.

Needled, nonwoven fibrous structures can be prepared by passing a batt of loosely associated fibers through a needle loom and subjecting first one side of the batt to needling from a needle board having an array of barbed needles and subsequently subjecting the other side of the batt to needling from a similar needle board. The batt usually is passed through the needle loom a number of times to reorient or rearrange a substantial proportion of the fibers and to attain as much coherence, interlacing, and interlooping of fibers as possible. In some instances a batt is needled simultaneously from both sides.

Needled, nonwoven fibrous structures can be prepared also by passing a batt through a needle loom wherein the batt is alternately punched from one side and then the other side by opposed needle boards each having an array of barbed needles, the needles of one needle board traveling in mirror image paths of the needles of the other needle board. By such an arrangement, the control of the fiber orientation is positive throughout the batt, and chain entanglement of fibers is developed in contiguous rows extending lengthwise of the web, the fibers also being interlocked between rows by interlooping and/or interlacing.

Basically, needle looms are comprised of a large number of closely spaced barbed needles supported in position, as by a needle board, to be reciprocated into and then out of a batt of loosely associated carded fibers and means, such as draw rolls and moving feed aprons, to pass the batt through the loom. The batt is moved intermittently through the loom, being advanced a relatively short distance when the barbed needles are drawn clear of the batt. Typical needle looms and their method of operation are shown and described in patents U.S. 2,845,687, 2,896,302, 2,902,746, 2,930,100, 3,112,548, 3,112,549, 3,117,359, and 3,132,406.

Preparation of batts from synthetic polymeric fibers comprises preparing fibers by melt spinning or solution spinning, crimping the fibers, cutting the fibers into staple,

2

and carding the staple fibers. The process is expensive and time consuming.

Surprisingly, it has been discovered that nonwoven fibrous structures can be prepared from oriented polymeric film by a process which does not require the heretofore used time-consuming and expensive batt preparation process. Furthermore, nonwoven fibrous structures prepared in accordance with this invention have exceptionally good strength properties.

Broadly, in accordance with this invention, a plurality of superposed layers of unbalanced oriented synthetic polymeric film are penetrated by a plurality of closely spaced barbed needles. As the points of the needles penetrate the superposed film layers, each layer is fissured into a filigree structure comprised of a large number of interconnected filamentary members of randomly varying lengths. There is thus provided a laminar structure comprised of a plurality of plies of polymeric filigree structures. The filamentary members are subsequently engaged by the barbs of the needles moving through the laminar structure comprised of a plurality of plies of polymeric filigree structures and are separated completely or partly from the structures to provide a fibrillated filigree structure. The partly and completely separated fibrils are entangled, interlooped, interlaced, and otherwise mechanically and/or frictionally engaged with other fibrils and with filamentary members of the filigree structures to provide a structure of good tensile and separation strength.

For a further understanding of this invention, reference is made to the following detailed description and drawing, in which:

FIG. 1 diagrammatically illustrates, in a perspective view, an arrangement of layers of oriented synthetic polymeric film.

FIG. 2 diagrammatically illustrates, in a perspective view, another arrangement of layers of oriented synthetic polymeric film.

FIG. 3 is a schematic view of apparatus that can be employed in carrying out this invention.

FIG. 4 shows an exemplary form of barbed felting needle with which the process of this invention can be carried out.

FIG. 5 is a schematic view of apparatus that can be employed in carrying out this invention.

FIG. 6 shows an unbarbed needle.

FIG. 7 diagrammatically illustrates, in a perspective view, filigree structures obtained after two superposed layers of oriented film have been fissured by a plurality of closely spaced needles.

FIG. 8 diagrammatically illustrates, in a perspective view, the filigree structure of FIG. 7 after passage thereof of the barbed portion of a plurality of needles.

The film used in carrying out this invention is oriented predominately in one of its two planar directions to an extent such that it will split easily, on sudden impact, in the direction in which orientation predominates and is referred to in the specification and in the claims as "unbalanced oriented polymeric film." Also the expression "axis of orientation" as used hereinafter in the specification and in the claims means the direction in which orientation predominates. In other words, the "axis of orientation" is that film direction having the greatest tensile strength. It is preferred to use oriented film in which its tensile strength in one direction is at least about twice that of the tensile strength of the transverse direction.

Orientation of polymeric film in a manner such that orientation in one direction predominates is known and forms no part of this invention. This can be accomplished by stretching synthetic polymeric film in one direction

only to such an extent that the tensile strength of the film, in the direction of orientation or stretch, is increased substantially, or film can be stretched in both a lengthwise direction and in a widthwise direction in a manner such that orientation in one direction predominates, and preferably predominates to an extent such that the tensile strength in one direction is at least about twice that of the transverse direction.

In carrying out this invention, a plurality of layers of unbalanced oriented polymeric film are superposed one upon another to provide a stack or an assembly, hereinafter referred to as a "film assembly." The layers of unbalanced oriented polymeric film can be so disposed that the axis of orientation of each film layer is substantially in the same direction or at least one film layer can have its axis of orientation at an angle to the axis of orientation of an adjacent film layer. To provide a nonwoven structure having substantially the same strength properties in both its lengthwise direction and its widthwise direction, the layers of polymeric film can be arranged so that each film layer will have its direction of orientation substantially at right angles to the direction of orientation of each adjacent film layer. Film layers can be arranged so that their direction of orientation are at such angles to provide a non-woven fibrous structure having substantially balanced strength in all planar directions.

A film assembly can be prepared by hand lay-up methods, by the use of conventional stacking machines, and the like. Another method comprises bringing together, in superposed relation, a plurality of layers of polymeric film from supply rolls thereof. This method is shown in FIG. 3 of the drawing.

As above set forth, any polymeric film that can be oriented can be employed in carrying out this invention. Polymers, which, in the form of film or sheeting, can be oriented, include the polyolefins such as polyethylene, polypropylene, and poly(butene-1); the polyesters such as poly(ethylene terephthalate) and poly(1,4-cyclohexylenedimethylene terephthalate); the polyamides such as nylon 6/6, nylon 6/10, and nylon 6; polystyrene; copolymers of vinylidene chloride and vinyl chloride; poly(vinylidene chloride); poly(vinyl chloride); the polyethers such as poly(ethylene oxide) and poly(propylene oxide) and the like.

A film assembly can consist only of layers of a specific polymeric film such as polypropylene film. If desired, several different types of polymeric film can be used to prepare a film assembly. Thus, a film assembly can be prepared by alternating layers of polyethylene film and poly(ethylene terephthalate) film; by alternating layers of polyethylene film, nylon film, and polystyrene film; and the like arrangements. The thickness of the film employed can be from about 0.2 mil to 5 mils. Thinner or thicker film can be used if desired. It is not necessary that all the film of which a film assembly is comprised have the same thickness or that the tensile strength in the direction of predominant orientation be the same.

Each layer can be comprised of two or more side-by-side pieces of film to provide a final product of desired width.

If desired, the film assembly, prior to needle penetration, can have associated therewith fibers, both natural and man-made, of staple length, and/or synthetic resin particles having a melting point substantially lower than that of any of the film layers of which the film assembly is comprised. Association of the fibers and/or resin particles can be accomplished by applying either or both to a surface of a film assembly, by sandwiching either or both between at least two film layers, and by similar means. After the desired needle punching has been completed, the resulting structure can be heated to fuse the synthetic resin particles which, upon cooling, bond together certain of the fibrils and filamentary members. Staple man-made fibers having a melting point substantially below that of the film can serve the same bonding

purpose, or any staple, natural or man-made, can be used as an auxiliary mechanical and/or frictional bonding member through entanglement and the like with fibrils and filamentary members.

A prepared film assembly, preferably while under slight tension, is penetrated or pierced by an array of closely spaced barbed needles. As the point of each needle strikes and pierces each film layer, the layer is split along its axis of orientation for a substantial distance either direction from needle point impact. Owing to the large number of needles that make substantially instantaneous impact with each film layer, each film layer is fissured into a filigree structure comprised of interconnected filamentary members of randomly varying length. The interconnected filamentary members are substantially parallel to one another; that is, they all lie in substantially the same direction and in substantially the same plane. Needling densities of the order of from about 300 to 3000 penetrations for each square inch of film assembly surface are preferred in order to fissure each film layer into a filigree structure comprised of relatively fine interconnected filamentary members.

Thus, before being subjected to the action of the barbs of a needle, there is provided a laminar structure comprised of a plurality of plies of polymeric filigree structures. The barbed portions of a barbed needle, being disposed from the needle point, engage certain interconnected filamentary members as the barbed needle moves through the laminar structure and separate the engaged filamentary members either completely or partially from the filigree structure to provide fibrils which, upon displacement, become entangled, interlaced, interlooped, and the like, with other fibrils and with filamentary members whereby there is provided a nonwoven fibrous structure of good tensile and separation strength.

As an optional embodiment of the invention, the film may first be subjected to penetration by an array of unbarbed needles followed by penetration by an array of barbed needles. This embodiment is particularly useful in producing nonwoven fabrics in which the individual fibrils and filamentary members are of finer denier.

The nonwoven structure produced in accordance with this invention is comprised of polymeric fibrils, a plurality of plies of polymeric filigree structures which are comprised of interconnected polymeric filamentary members, the polymeric fibrils being mechanically engaged with other fibrils and with filamentary members to provide a fabric-like structure having good tensile and separation strength.

Referring to FIG. 1 of the drawing, there is shown film assembly 10 comprised of layers 12 of unbalanced oriented polymeric film from which nonwoven structures can be prepared in accordance with this invention. The arrows show the axis of orientation of each film layer. Thus, in the film assembly shown, the axis of orientation of one film layer is at right angles to an adjacent film layer. All film layers can be of the same polymeric film or, if desired, at least one of the film layers 12 can be a film prepared from a polymer different from the polymer from which the other films are prepared.

In FIG. 2 of the drawing, there is shown film assembly 14 comprised of layers 16 of unbalanced oriented film. The arrows shown the axis or orientation of each film layer. Thus, in the film assembly shown, the axis of orientation of one film layer is at an angle of 45° to an adjacent film layer. This arrangement of film layers will provide a non-woven fibrous structure having substantially the same tensile strength in the lengthwise direction, the widthwise direction, and in directions intermediate these two directions.

Referring to FIG. 3 of the drawing, there is shown apparatus 20 for the preparation of nonwoven fibrous structures in accordance with this invention. Unbalanced oriented polymeric films 22, 24, 26, 28, and 30 are withdrawn respectively from supply rolls 32, 34, 38 and 40 and are

5

brought together beneath roller 42 to provide a film assembly 44. The film assembly 44 is advanced by a feed apron 46 which is comprised of endless conveyor belt 48 mounted on rolls 50 and 52. Rolls 50 and 52 are driven by means (not shown) such as an electric motor.

From the feed apron 46, the film assembly 44 passes onto stationary bed plate 54. Spaced above bed plate 54 is stripper plate 56 which, like the bed plate 54, is stationary. The film assembly 44 passes into the space between plates 54 and 56.

Above the stripper plate 56 is needle board 58 carrying a large number of closely spaced barbed needles 60. Barbed needle 60, as shown in FIG. 4 of the drawing, is comprised of a sharp point 62 and barbs 64 disposed above point 62. Needle board 58 is adapted to be reciprocated vertically by suitable means (not shown) such as a crankshaft connected thereto.

As the needle board 58 moves up and down the needles 60 are driven through the film assembly 44. The needles pass through aligned holes (not shown) in the stripper plate, through the film assembly, and through aligned holes (not shown) in the bed plate. Upon initial penetration by the points of the barbed needles, each layer of polymeric film is fissured into a filigree structure comprised of interconnected filamentary members which lie substantially in the same plane and are substantially parallel. There is thus provided a laminar structure comprised of these filigree structures. The barbs of the needles, almost immediately after formation of the filigree structures by the needle points, engage some of the interconnected filamentary members and form fibrils by complete or partial separation of the engaged filamentary members from the filigree structures. The barbs displace the fibrils in a manner such that they become entangled, interlaced, interlooped, and the like, with other fibrils and with other filamentary members which comprise the laminar structure, and there is produced a nonwoven fibrous structure 66.

The nonwoven fibrous structure 66 is intermittently drawn from bed plate 54 by a draw mechanism comprising a pair of rolls 68 and 70. The feed mechanism is driven intermittently by suitable means (not shown) usually during periods when the needles 60 are disengaged from the web. The needles are therefore engaged with the web during the dwell periods between the intermittent advances of the web. The nonwoven fibrous structure 66 can be formed into a roll for storage, cut, or otherwise handled.

While the above method of employing barbed needles for both filigree formation and fibril formation and displacement to provide a nonwoven fibrous sheet is the preferred method for carrying out this invention, it is to be understood that the film assembly can be first subjected to an array of unbarbed or smooth needles to produce a filigree structure followed by needle punching with barbed needles for fibril formation and fibril displacement. This aspect of the invention is described in connection with FIG. 5 of the drawing.

Referring to FIG. 5 of the drawing, there is shown apparatus 80 for the preparation of nonwoven fibrous structures. A film assembly 82, comprised of layers of unbalanced oriented polymeric film, is advanced by feed apron 84 which is comprised of endless conveyor belt 86 mounted on rolls 88 and 90. Rolls 88 and 90 are driven by means (not shown) such as an electric motor.

From feed apron 84, the film assembly passes onto stationary bed plate 92. Spaced above bed plate 92 is stationary stripper plate 94. The film assembly passes into the space between plates 92 and 94. Above the stripper plate 94 is a first needle board 96 carrying a large number of closely spaced unbarbed needles 98 similar to the needle shown in FIG. 6 of the drawing. Needle board 96 is adapted to be reciprocated vertically by suitable means (not shown) such as a crankshaft connected thereto.

As board 96 moves down, needles 98 are driven through film assembly 82, and each film layer is fissured

6

into a filigree structure comprised of interconnected filamentary members to provide laminar structure 100. Needles 98 pass through aligned holes (not shown) in the stripper plate 94 and, after piercing the film assembly, through aligned holes (not shown) in bed plate 92.

Laminar structure 100 is then moved to a second needling station wherein needle board 102, adapted to be reciprocated vertically by suitable means (not shown) such as a crankshaft, carrying a plurality of barbed needles 104 similar to the needle shown in FIG. 3 of the drawing, moves up and down. The barbed needles 104 are first passed or driven through aligned holes in stripper plate 94, through the laminar structure 100 and through aligned holes in bed plate 92, and are then withdrawn.

During passage of the barbed needles through the laminar structure, the barbs engage certain of the filamentary members and separate them completely or partly from the filigree structure to provide fibrils which are entangled, interlaced, interlooped, and otherwise mechanically engaged with other fibrils and with filamentary members to produce a nonwoven fibrous structure.

The nonwoven fibrous structure is intermittently drawn from bed plate 92 by a draw mechanism comprising a pair of rolls 106 and 108. The feed mechanism is driven intermittently by suitable means (not shown) usually only during periods when the needles 98 and 104 are disengaged from the web. The needles are engaged with the web during the dwell periods between the intermittent advances of the web.

The following examples illustrate this invention.

Example 1

A film assembly is prepared by superposing six layers of 0.5 mil thick unbalanced oriented polypropylene film. The film assembly is prepared so that the axis of orientation of each film layer is substantially at right angles to the axis of orientation of its adjacent film layers. The film assembly is fed to a needling apparatus similar to that shown in FIG. 3 of the drawing where it is subjected to repeated penetrations by the barbed needles to provide a nonwoven fibrous structure. Needling density is about 300 penetrations per each square inch of film assembly surface. The strength properties of the non-woven structure are substantially the same in the widthwise direction as they are in the lengthwise direction.

Example 2

A film assembly comprised of three layers of 1 mil thick unbalanced oriented poly(ethylene terephthalate) film and three layers of 1.5 mil thick unbalanced oriented polyethylene film is prepared by alternating one layer of polyethylene film with one layer of poly(ethylene terephthalate) film. The axis of orientation of the poly(ethylene terephthalate) film layers is at right angles to the axis of orientation of the polyethylene film layers. A nonwoven structure is prepared from the film assembly in a manner similar to that of Example 1.

Example 3

A film assembly comprised of six layers of 1.5 mil thick polypropylene film having a melting point of about 165° C. and one layer of 2 mil thick polyethylene film having a melting point of about 125° C. is prepared. The layer of polyethylene film is sandwiched between the polypropylene film, there being three layers of polypropylene film on either side of the polyethylene film layer, and the layers are arranged so that the axis of orientation of all film layers is the same. A nonwoven structure is prepared from this assembly in a manner similar to that of Example 1. The nonwoven structure is heated subsequently to a temperature above the melting point of the polyethylene but below the melting point of the polypropylene. The polyethylene fibrils and filamentary members fuse and, in the fused state, migrate to some of the areas where two or more polypropylene fibrils and/or filamentary members make contact and upon solidifying bond the

polypropylene fibrils and/or filamentary members together at these areas to provide a nonwoven structure of high strength properties.

Example 4

A film assembly comprised of four layers of 1.5 mil thick polypropylene film is prepared so that the axis of orientation of each film layer is at an angle of 45° to the axis of orientation of an adjacent film layer. A nonwoven structure is prepared in a manner similar to that of Example 1.

Example 5

A film assembly is prepared similar to that of Example 1 and treated in a manner similar to the procedure described with reference to FIG. 5 of the drawing. The resulting nonwoven structure has substantially the same properties as that of Example 1.

EXAMPLE 6

A film assembly comprised of two layers of polypropylene film is prepared. One film layer has its axis of orientation at right angles to the other film layers. There is then placed on top of the film assembly a 3 ounce per square yard web of carded 2 inch staple polypropylene fibers having a denier of about 1.5. This assembly is then treated in a manner similar to that of Example 1 to provide a nonwoven fibrous structure of good tensile and separation strength.

Referring to FIG. 7 of the drawing, there is shown a laminar structure comprised of two plies of filigree structures comprised of interconnected filamentary members resulting from the fissuring of a film assembly comprised of two layers of unbalanced oriented polymeric film, the axis of orientation of the film layers being at right angles to one another.

FIG. 8 shows the results of the passage of the barbed portion of barbed needles through a structure similar to that of FIG. 7. The barbs have engaged certain filamentary members of each filigree structure and separated them partly or completely from the filigree structure to provide fibrils which have been displaced and entangled, interlaced, interlooped and otherwise mechanically and/or frictionally engaged with filamentary members and with other fibrils whereby the resistance to separation of the resulting structure is improved.

It will be apparent from the above description of this invention that nonwoven structures can be prepared in a substantially more convenient and economical manner than heretofore. Thus, the heretofore-employed fiber crimping, fiber cutting, and fiber carding steps have been eliminated.

Furthermore, nonwoven fibrous structures having substantial widths of the order of from about 12 feet to 15 feet and higher can be conveniently, easily, and readily produced by the process of this invention from polymeric film of substantially smaller widths by placing pieces of polymeric film in side-by-side abutting relationship until the layer has the desired size.

The nonwoven structures of this invention can be used as carpetbacking, filters, and the like.

It is to be understood that the above description and drawing are illustrative of this invention and not in limitation thereof.

What I claim and desire to protect by Letters Patent is:

1. A method of producing a nonwoven fibrous structure which comprises

penetrating a film assembly comprised of a plurality of superposed layers of unbalanced oriented polymeric film with a plurality of closely spaced barbed needles whereby each film layer is fissured into a filigree structure comprised of interconnected filamentary members and a plurality of fibrils, the fibrils being entangled with other fibrils and with the interconnected filamentary members to provide a unitary nonwoven structure of good tensile and separation strength.

2. The method of claim 1 wherein at least one of the film layers of which the film assembly is comprised has its axis of orientation at an angle to the axis of orientation of an adjacent layer.

3. The method of claim 1 wherein each film layer of which the film assembly is comprised has its axis of orientation at an angle to the axis of orientation of each adjacent layer.

4. The method of claim 1 wherein each film layer of which the film assembly is comprised has its axis of orientation substantially at right angles to the axis of orientation of each adjacent layer.

5. The method of claim 1 wherein the film assembly is comprised of at least one layer of unbalanced oriented polyethylene film.

6. The method of claim 1 wherein the film assembly is comprised of at least one layer of unbalanced oriented polypropylene film.

7. The method of claim 1 wherein the film assembly is comprised of at least one layer of unbalanced oriented poly(ethylene terephthalate) film.

8. The method of claim 1 wherein the film assembly is comprised of at least one layer of unbalanced oriented nylon film.

9. A method of producing a nonwoven fibrous structure which comprises

penetrating a film assembly comprised of a plurality of superposed layers of unbalanced oriented polymeric film with a plurality of closely spaced unbarbed needles whereby each film layer is fissured into a filigree structure comprised of interconnected filamentary members and there is provided a laminar structure comprised of a plurality of plies of polymeric filigree structures and

penetrating the laminar structure with a plurality of closely spaced barbed needles whereby fibrils are formed and subsequently entangled, interlaced, and interlooped with other fibrils and with interconnected filamentary members to provide a unitary nonwoven fibrous structure of good tensile and separation strength.

10. The method of claim 9 wherein at least one of the film layers of which the film assembly is comprised has its axis of orientation at an angle to the axis of orientation of an adjacent layer.

11. The method of claim 9 wherein each film layer of which the film assembly is comprised has its axis of orientation at an angle to the axis of orientation of each adjacent layer.

12. The method of claim 9 wherein each film layer of which the film assembly is comprised has its axis of orientation substantially at right angles to the axis of orientation of each adjacent layer.

13. The method of claim 9 wherein the film assembly is comprised of at least one layer of unbalanced oriented polyethylene film.

14. The method of claim 9 wherein the film assembly is comprised of at least one layer of unbalanced oriented polypropylene film.

15. The method of claim 9 wherein the film assembly is comprised of at least one layer of unbalanced oriented poly(ethylene terephthalate) film.

16. The method of claim 9 wherein the film assembly is comprised of at least one layer of unbalanced oriented nylon film.

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R. L. MAY, *Assistant Examiner*.

U.S. Cl. X.R.

75 161—80, 58, 154, 402; 28—72.2; 156—250