Dec. 23, 1969 C. HARMON 3,485,705

NONWOVEN FABRIC AND METHOD OF MANUFACTURING THE SAME

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Fig. 1.

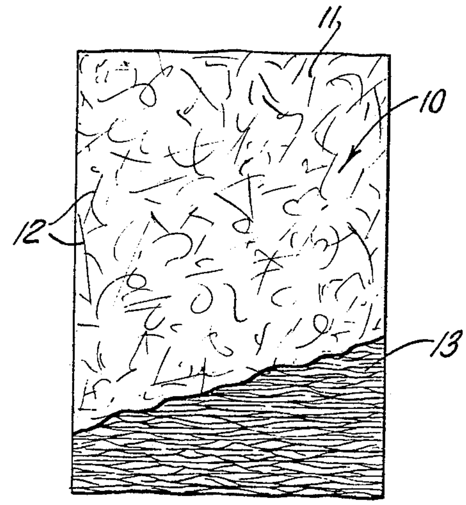
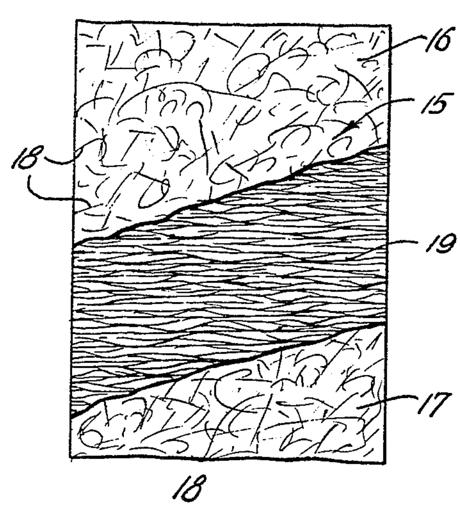


Fig. 2.



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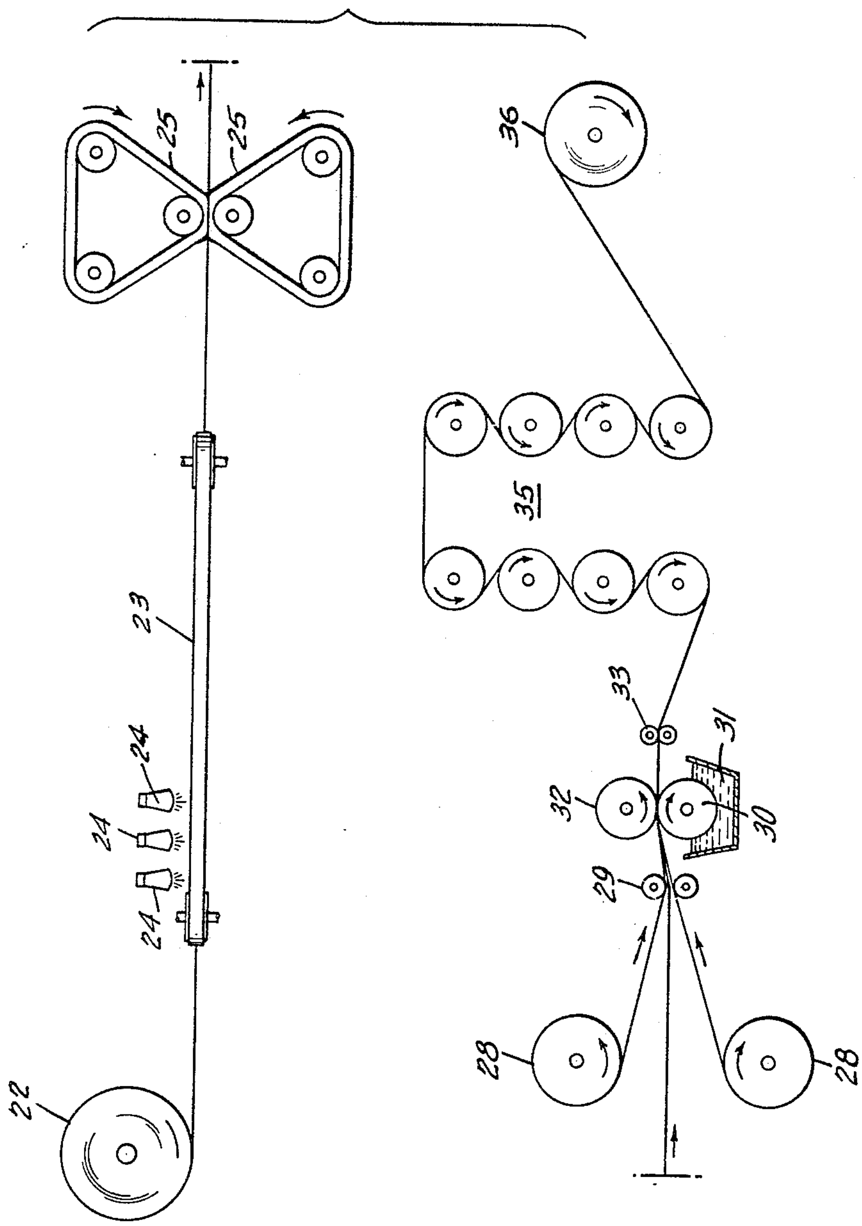

Fig. 3.

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NONWOVEN FABRIC AND METHOD OF MANUFACTURING THE SAME

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U.S. Cl. 161—59 15 Claims

ABSTRACT OF THE DISCLOSURE

A method and the resulting article of forming a nonwoven fabric which include longitudinally splitting a molecular oriented polymer film to form a network of fibers and bonding at least one layer of over-lapping, intersecting fibers to at least one surface of the fibrous network.

This invention relates to new and improved nonwoven fabrics and to methods for manufacturing the same, and more particularly to a nonwoven fabric having good strength in both the long and cross directions and to a simplified method for manufacturing such a fabric.

Nonwoven fabrics have been in use for many years, yet they still suffer from a major drawback in their lack of strength, especially in the cross direction. Generally, the fibrous webs from which nonwoven fabrics are produced have an orientation of fibers in a particular direction, i.e., the machine direction, which produces good strength in that direction, but poor strength in the cross direction. Webs have been produced in which the fibers lie at random so that the web will have equal strength in all directions, however, this equal strength is of a lower total magnitude.

To improve fabric strength webs have been plied together at various angles to give strength in the direction of the various angles, for example, a web with its fibers aligned in the machine direction may be cut into sections, turned 90 degrees and plied to another web having its fibers aligned in the machine direction. This produces an excellent fabric having good strength in both the long and cross directions, however, the machines and techniques for handling such lightweight webs to ply them at different angles are complicated, and expensive, and in most instances cannot operate at suitable speeds to produce economical fabrics.

Another technique to improve the strength of nonwoven fabrics is to place cross yarns between layers of fibrous webs or insert gauze or similar reinforcement material to improve the strength of the nonwoven fabrics. Again, the machines for carrying out these processes are rather complicated and in the final fabric the yarn reinforcing may show through the fabric, producing unevenness in the fabric and through improving strength take away from the general softness, drapeability and conformability of the fabric.

The nonwoven fabric of the present invention overcomes these disadvantages. The nonwoven fabric of the present invention, has excellent strength both in the long and cross direction and does not require the insertion of yarns to produce this strength. It is fibrous in nature throughout and hence, will have all the desirable properties of a completely fibrous product. The nonwoven fabric of the present invention may be manufactured with relatively simple equipment and does not require any complicated machinery in order to provide for cross reinforcement.

The nonwoven fabric of the present invention comprises a laminate of at least one layer of over-lapping, intersecting fibers, and a layer of a synthetic polymer in

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the form of a network of fibers which are continuously interconnected throughout the layer. The network of fibers has a predominant orientation in one direction of said layer. In a specific embodiment of the fabric of the present invention, the layer of intersecting, over-lapping fibers has a major orientation of the fibers in the machine direction of the fabric, while the direction of orientation of the fibers in the synthetic polymer layer is in the cross direction of the fabric so as to produce a fabric having excellent strength in both the machine and cross directions.

The fabrics of the present invention may be readily made from a film of a high molecular weight, long chain molecular structure, crystalline, synthetic, organic polymer, highly orienting the film in the cross direction, and then applying forces in the longitudinal direction of the highly oriented film to fibrillate the film and form it into a network of fibers mutually interconnected and generally extending in the cross direction of the treated film. The film, which is now a fibrous network, has its major strength in the cross direction and is laminated to a standard fibrous web such as a card web or an isotropic web, made from staple length fibers, preferably the fibrous web has a major direction of orientation of the fibers in the machine direction of the web. The two layers may be secured together by various known techniques, such as, the application of an adhesive between the webs, or if thermoplastic fibers are used, by the application of heat in a pattern to soften some of the thermoplastic fibers and to secure them together, or by solvent bonding, needle punching, etc. If desired, one or more fibrous layers and one of more layers of the synthetic, polymer network of fibers may be laminated together or they may be laminated with other sheet materials to produce a wide variety of products having different properties.

The invention will be more fully understood from the following detailed description taken in conjunction with the accompanying drawings, wherein;

FIGURE 1 is a plan view of one embodiment of fabric according to the present invention;

FIGURE 2 is a plan view of another embodiment of fabric according to the present invention; and

FIGURE 3 is a schematic drawing showing one method for producing fabrics according to the present invention.

Referring to the drawings in FIGURE 1 there is shown a fabric **10** of the present invention. The fabric comprises two layers, the upper layer is a fibrous web **11** composed of over-lapping and intersecting staple length fibers **12**. The bottom layer is a split fiber web **13** comprising fibers of a synthetic, polymer with the fibers being mutually interconnected throughout the entire layer and with the fibers all being substantially oriented in the cross direction of the fabric. The two layers are adhered together by an adhesive sprayed onto one of the layers prior to laminating.

Referring to FIGURE 2, there is shown another fabric **15** according to the present invention. The fabric comprises three layers. The outer layers **16** and **17** are composed of over-lapping, intersecting, staple length fibers **18**. The inner layer **19** is a split fiber web of a synthetic, polymer. The fibers are mutually interconnected throughout the layer and have a general direction of orientation in the cross direction of the fabric. The three layers are laminated together by adhesive means.

One of the base starting layers used to produce the fabrics of the present invention is a fibrous web comprising any of the common, textile length fibers or mixtures thereof. The fibers vary in average length from approximately one quarter inch to about two and a half inches. Examples of such fibers are the natural fibers such as cotton and wool; the artificial fibers notably rayon or regenerated cellulose and the synthetic fibers such as the polyoleofins; polyethylene, polypropylene; the polyesters; the polyamides, etc. To these textile fibers may be added a minority by weight of fibers having an average length of less than a quarter of an inch or even shorter. The textile length fibers are customarily processed through any suitable textile machinery, for example, a conventional cotton card or other fiber web producing apparatus to form a web or sheet of loosely associated, over-lapping, intersecting fibers, weighing from about 50 grains to about 200 grains per square yard. This essentially two dimensional web or sheet of fibers is produced continuously with the fibers predominantly oriented in the "machine direction," i.e., the direction in which the web is formed and is moved continuously from the sheet forming machine. In such a web the degree of orientation or the ratio of oriented to non-oriented fibers in the machine direction may be described for purposes of simplicity as varying roughly from about 60 percent to about 90 percent, that is to say, that from about 60 percent to about 90 percent by weight of the fibers are substantially oriented or aligned more or less in the machine direction, and from about 10 percent to 40 percent by weight of the fibers are non-oriented in the machine direction. There are certain machines or certain modifications that can be made to these machines to improve this fiber orientation to above 90 percent. In some sheet making apparatus the fibrous material would be non-oriented such as, for example, air-laid, or water-laid fibrous webs, wherein, the fibers are laid down randomly in all directions in over-lapping, intersecting relationship and form what is called "isotropic" webs.

If desired, the fibrous web may be pre-bonded prior to lamination in accordance with the method of the present invention, so that it is easier to handle. Such pre-bonding may include a light spraying of the web with a polyvinyl alcohol binder or other suitable techniques well known in the art.

The other layer of the fabric of the present invention is a split fiber web which may be produced from any of the orientable crystalline polymers. Usually these are the synthetic, organic polymers having a high molecular weight and a long chain molecular structure. Examples of such polymers are the polyolefins such as the polyethylenes, polyproplylene; polyamides, such as nylon 6, nylon 11, nylon 66; polyesters, polyurethanes; polyacrylics, polyvinyl chloride, polyvinyl acetate, etc., including copolymers of such compounds and mixed polymers of such compounds. These transverse oriented split fiber webs are produced by forming a film of the polymer and highly orienting this film in a direction transverse to its machine direction, that is the cross direction. The orientation must be uniaxial and must be of a high degree. Splitting forces such as brushing, ultrasonics or any repetitive force is then applied to the highly oriented film in the longitudinal direction of the film causing the highly oriented film to fibrillate or disrupt into many small fibers which are mutually interconnected throughout the layer. The forces must not be so extreme so as to disintegrate the film into a mass of fibers but must be sufficient to split the film into fibers leaving the fibers interconnected so that an integral sheet of fibers is produced with the fibers in the sheet substantially all aligned in the cross direction of the sheet.

The fibers produced in this sheet are of varying denier throughout the sheet. The fibers usually have an irregularly round or rectangular cross section and have many sharp edges as compared to fibers produced by standard extruding and drawing processes.

The layers are laminated together with the fibers in the split fiber web lying in the cross direction of the final laminated fabric. The layers may be laminated by any of the techniques well known in the art. Examples of these laminating processes are to spread an adhesive on one of the layers and then pass the two layers through a set of rollers to adhere them together or print bond the layers to secure them together. If thermoplastic fibers are used in the fibrous web, or the thermoplastic nature of the split fiber web may be used to adhere the layers together through the application of heat. In utilizing the thermoplastic nature of the split fiber web as the bonding means for the fabric, care must be taken not to overheat the split fiber web and destroy the orientation of the fibers in the web. One technique for accomplishing this is to coat the split fiber web with a lower melting point polymer so that adhesion is accomplished at lower temperatures which do not harm the orientation of the split fibers. Solvent bonding, as is known in the art, may also be used for laminating layers together. If desired, the layers may be needle punched to secure the layers together.

Virtually, any number of layers may be adhered together from one split fiber layer and one fibrous web to any number of each and, in fact, in some instances other sheet materials may also be incorporated with the two layers such as paper, crepe tissue, wood pulp, cotton linters, etc.

If desired, prior to bonding the layers together, or after bonding, depending on the type of bonding operation the layers may be treated to rearrange the fibers such as described in U.S. Patent No. 2,862,251 issued Dec. 2, 1958 to Frank Kalwaites.

The products of the present invention have many advantages. They have strength in the machine direction of the fabric, especially if carded webs are used and they have strength in the cross direction of the fabric from the transverse orientation of fibers in the split fiber web. The fabrics may be made conformable and drapeable, or if a coarse split fiber web is used, it may be made relatively stiff. The fabrics of the present invention are porous and one or both surfaces may be made absorbent or repellent as desired, or one surface may have the soft hand of loose fibers while the other surface has the smooth hand of a plastic film. As it will be apparent to one skilled in the art, there are innumerable combinations which may be used so that the final fabric is engineered and made adaptable for the desired end use.

The fabrics of the present invention are especially adaptable for sanitary and surgical uses and may be used as an absorbent dressing, a non-adhering dressing, a wrapper for a sanitary napkin, etc. Fabrics of the present invention may also be used for wiping purposes or as interlining members in the manufacture of apparel, etc.

Referring to FIGURE 3, there is a schematic showing of a method for producing fabric according to the present invention. A film **22** is oriented in the cross direction by passing it through a tenter frame **23**. The tenter frame comprises a pair of clip chains which move in diverging paths. The clips grip the opposite edges of the film and as the chains diverge stretch the film in a cross direction. It is preferred that the film be heated such as shown at **24** in order to aid in cross stretching of the film. Depending upon the type of synthetic, polymer film used, the film should be stretched from about 4 to 1 to 15 to 1, or even higher, to highly orient the film in the cross direction. By a high orientation it is meant that the film should be given that degree of orientation necessary to give it fiber type strength.

Splitting forces are applied to the oriented film. The forces are applied transverse to the direction of orientation, hence, with film oriented in a cross direction the splitting forces are applied in the longitudinal direction of the film. The splitting forces may be applied by passing the film through a pair of highly compressed rubber belts **25** which apply forces in the longitudinal direction of the film. These splitting forces disrupt the highly oriented film into individual fibers and leave these fibers mutually interconnected. Though compressive type splitting forces are shown there are other techniques for splitting films which are well known in the art such as passing the highly oriented film about a sharp edge to apply forces transverse to the direction of orientation, or brushing the film to apply forces.

A web of staple length fibers **28** is superimposed on one or both surfaces of the split fiber web. The laminate is pressed together by the rolls **29** and bonded by applying any of the known binders to the surface of the laminate. One technique for applying binder is shown, wherein, a pattern surface roll **30** is partially immersed in a bath of binder **31**. The roll picks up binder on its surface and applies it to the web as the web passes between the nip of the binder roll **30** and a backup roll **32**. The laminate is further pressed together by the rolls **33** and the laminate with the binder thereon dried by any suitable drying means, such as a stack of dry cans **35**. The final fabric is wound on standard wind-up mechanism **36**.

In some instances where it is difficult to bond the fibrous web to the split fiber web, it may be desirable to place a portion of fibers in the fibrous web which are of the same synthetic, polymer composition as the split fiber web and utilize the similarity in composition to aid in the bonding of the laminate.

The following examples will further illustrate how the present invention may be carried out in practice but the invention is not restricted to these examples.

EXAMPLE I

A linear polyethylene film 5 mils thick and five inches wide is heated to a temperature of approximately 230° F. The film is stretched in a cross direction to eight times its original width, or forty inches, to highly orient the film in the cross direction. The film is passed between a pair of soft rubber belts passing between a pair of rollers set a specific distance apart. The distance is less than the thickness of the rubber belts. The action of the belts on the film applies longitudinal forces to the film to form a split fiber web of polyethylene fibers. A card web weighing 100 grains per square yard of one and a half inch long and one and a half denier rayon fibers is superimposed on the polyethylene split fiber web. An acrylic emulsion is print bonded on the laminate in a pattern of horizontal wavy lines and the laminate dried to produce a nonwoven fabric reinforced in the cross direction with polyethylene fibers.

EXAMPLE II

A polypropylene film 10 mils in thickness and four inches wide is heated to a temperature of 300° F. The film is stretched in the cross direction to twelve times its original width to highly orient the film. The oriented film is passed sharply about a knife edge to apply longitudinal forces to the film and split the film to a web of mutually interconnected polypropylene fibers. Two card webs, each weighing 200 grains per square yard and comprising 50% 1½ denier, 1½ inch rayon fiber and 50% cotton linters are laminated to the polypropylene web, one on each side of the polypropylene web. The laminate is passed through a needle loom to intergage fiber in all three layers and produce nonwoven material in accordance with the present invention.

What is claimed is:

1. A laminated, nonwoven fabric comprising: at least one layer of over-lapping, intersecting fibers secured to at least one layer of synthetic, split molecularly oriented polymer fibers, said polymer fibers having a direction of orientation in the cross direction of the fabric and said polymer fibers being mutually interconnected continuously throughout said synthetic layer.

2. A laminated, nonwoven fabric, according to claim **1**, wherein, the layer of over-lapping, intersecting fibers has a major direction of orientation of fibers in the longitudinal direction of the fabric.

3. A laminated, nonwoven fabric, according to claim **1**, wherein, the layer of over-lapping, intersecting fibers are cellulosic fibers.

4. A laminated, nonwoven fabric, according to claim **1**, wherein, the synthetic, polymer is polyethylene.

5. A laminated, nonwoven fabric, according to claim **1**, wherein, the synthetic polymer is polypropylene.

6. A laminated, nonwoven fabric, according to claim **1**, wherein, the layer of over-lapping, intersecting fibers contain a portion of fibers of the same polymer as the layer of synthetic polymer fibers.

7. A laminated, nonwoven fabric, according to claim **1**, wherein, the layers are secured together by an adhesive.

8. A laminated, nonwoven fabric, according to claim **1**, wherein, the layers are secured together by the engagement of fibers of one layer with fibers of another layer.

9. A laminated, nonwoven fabric, according to claim **1**, wherein, there are two layers of over-lapping, intersecting fibers, one on each side of said layer of synthetic polymer fibers.

10. A laminated, nonwoven fabric, according to claim **9**, wherein, the layers of over-lapping, intersecting fibers have a major direction of orientation of fibers in the longitudinal direction of the fabric.

11. A method of producing a cross-reinforced nonwoven fabric comprising: applying repeated longitudinal forces to a transversely molecular oriented synthetic polymer film to split the oriented film into a mutually interconnected network of fibers, applying at least one layer of over-lapping, intersecting fibers to one surface of said split fiber network and treating said layers to secure them together.

12. A method of producing a cross-reinforced, nonwoven fabric comprising: forming a film of a synthetic polymer, streaching the film in a transverse direction to molecularly orient the film in said direction, applying repeated longitudinal forces to the oriented film to split the film into a mutually interconnected network of fibers, applying at least one layer of over-lapping, intersecting, fibers to one surface of said split fiber network and treating said layers to secure them together.

13. A method according to claim **11**, wherein, the layers are printed with an adhesive in a pattern to secure them together.

14. A method according to claim **11**, wherein, the layers are impregnated with an adhesive to secure them together.

15. A method according to claim **11**, wherein, the synthetic polymer is thermoplastic and the layers are heated to secure them together.

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