Dec. 4, 1962 H. H. SCHIESS 3,066,358

FIBROUS WEB AND METHODS AND APPARATUS FOR PRODUCING THE SAME

Filed Nov. 18, 1957

2 Sheets-Sheet 1

Fig. 1.

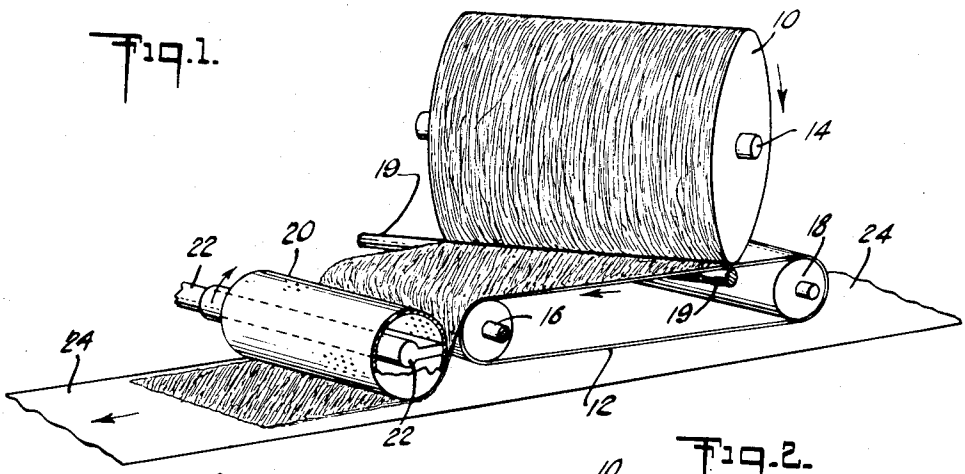


Fig. 2.

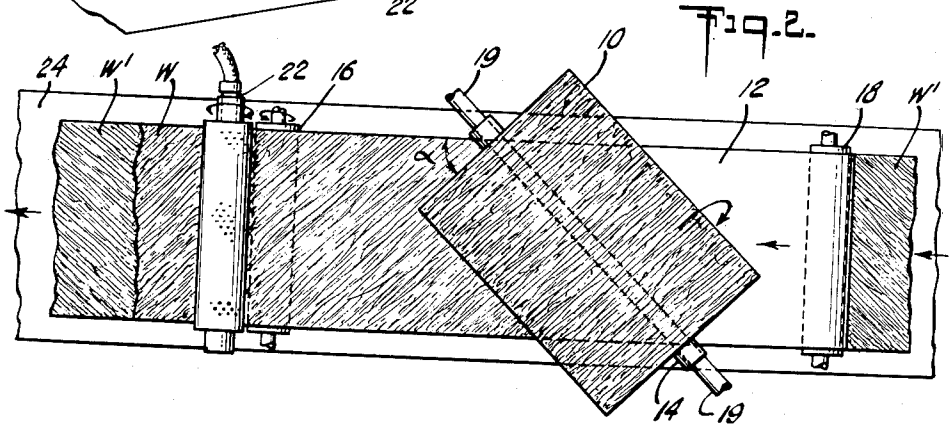


Fig. 4.

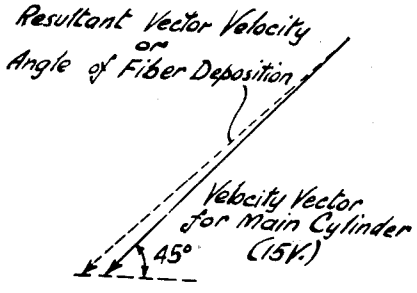
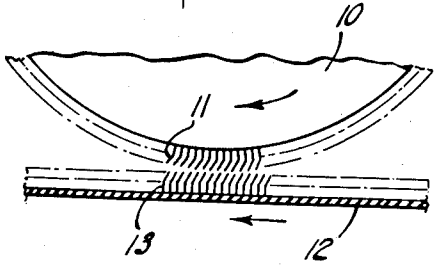


Fig. 3.



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2 Sheets-Sheet 2

Fig. 5.

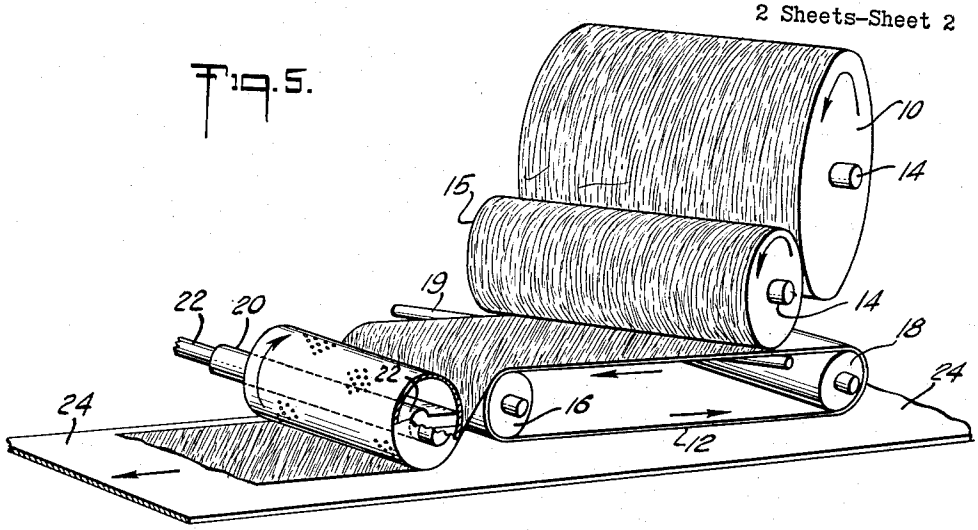


Fig. 6.

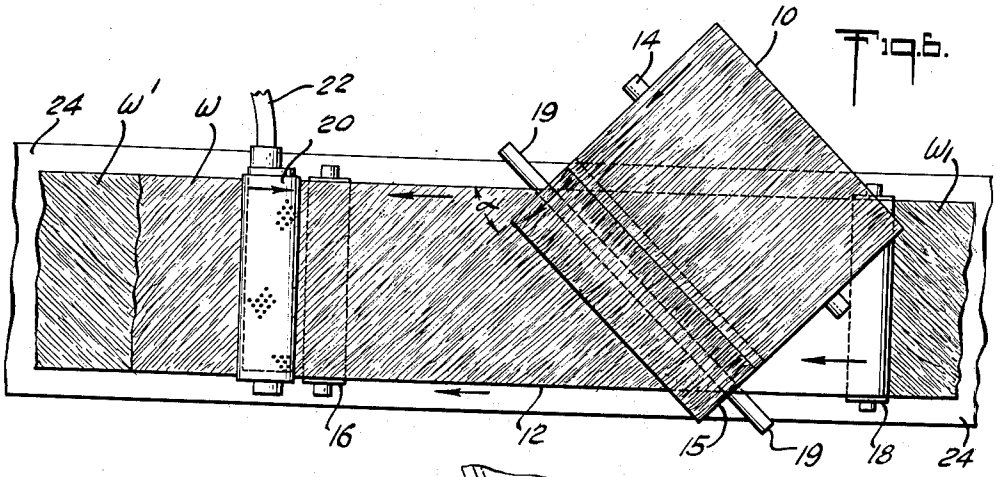
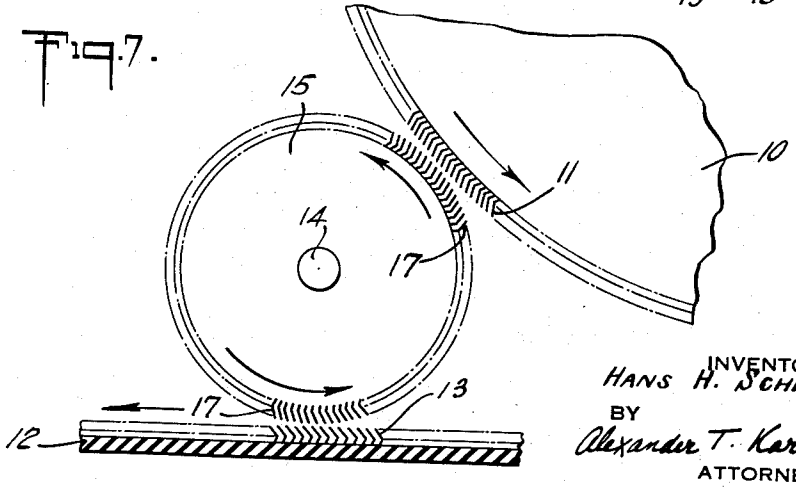


Fig. 7.



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FIBROUS WEB AND METHODS AND APPARATUS FOR PRODUCING THE SAME

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Filed Nov. 18, 1957, Ser. No. 697,138
15 Claims. (Cl. 19—155)

The present invention relates to a nonwoven web of fibrous materials and to improved methods and apparatus for producing the same. More specifically, the present invention is concerned with a nonwoven web of fibrous materials wherein the fibers are oriented predominantly in one direction and lie at an angle to the long axis of the fibrous web.

Nonwoven webs of fibrous materials and nonwoven fabrics made therefrom have become increasingly important in the textile industry during the past decade because of their low cost of manufacture for a given coverage, as compared to more conventional textile fabrics formed by weaving, knitting and felting operations.

Nonwoven fabrics are conventionally manufactured at the present time from a basic starting material comprising a more or less tenuous web of loosely associated textile fibers disposed in sheet form. The conventional basic starting material for nonwoven fabrics is a web comprising any of the common textile-length fibers, or mixtures thereof, the fibers varying in length from about one-half inch in length to about two and one-half inches. Illustrative of such fibers are the natural fibers, notably cotton, the synthetic fibers, notably rayon, cellulose acetate and nylon; or mixtures thereof. These fibers are conventionally processed through suitable textile machinery, such as a conventional card to form a fibrous web or sheet of loosely associated fibers weighing from about 100 grains to about 2000 grains or more 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 major or long axis of the fibrous web, which is the direction in which the web moves continuously from the carding machine. In such a web, the "degree of fiber orientation" in the machine direction may range from about 70% to about 90% or higher.

The two terms employed in the preceding paragraph to describe the fiber orientation in a card web should be explained. It is difficult to determine fiber orientation directly and precisely in a card web because the individual fibers of the web are in fact curled and bent, with different segments of each fiber extending in various directions. However, two kinds of average orientation may be ascertained which are helpful in describing such a web. One of these is called the "degree of fiber orientation" in a given direction. The other may be called the "direction of predominant fiber orientation."

The "degree of fiber orientation" in the machine direction is determined by (1) bonding the card web uniformly with a material such as starch, (2) drying the bonded web, (3) measuring tensile strengths lengthwise and crosswise of the resulting fabric, and (4) computing the percentage of lengthwise or long strength of the fabric to its total strength. Total strength, for this purpose, is the sum of the tensile strengths in the long and cross directions.

It is seen that when long and cross tensile strengths are equal the "degree of fiber orientation" in the machine direction is 50%. If the long tensile strength of the bonded fabric is 90% of the total of the tensile strengths of the fabric in the long and cross directions, the "degree of fiber orientation" in the machine direction obtaining in the card web is 90%.

For simplicity, a web of fibers having a "degree of fiber orientation" in the machine direction of 90% might if desired be thought of in idealized form as having 90% of its fibers substantially parallel to the long axis of the web and 10% substantially parallel to the cross axis of the web.

Another idealized conception of a card web having fibers 90% oriented in the machine direction—which conception is still more helpful in connection with any discussion of the present invention and which leads to a definition of "direction of predominant fiber orientation"—is to think of the card web as comprised entirely of pairs of straight, crossed fibers with each fiber of any given pair lying upon the hypotenuse of a right triangle whose side parallel to the machine direction is 90 units long and whose side lying perpendicular to the machine direction is 10 units long. Each separate fiber of such a crossed pair of fibers is inclined more toward the long axis of the web than toward the cross axis, and thus the fibers as a group are said to be "predominantly oriented" in the machine direction. The term "direction of predominant orientation" of the fibers of a web is thus employed in this specification and claims to mean that direction which bisects the acute angle between any pair of cross fibers in this idealized conception of an oriented web.

The idealized conception of a card web under discussion reflects certain physical measurements that can be made with such a web. Because of the nature of a card web, there will always be two directions of maximum tensile strength in a fabric formed by bonding the web. Except for the special case in which these two directions lie at right angles to each other, there will be an acute angle which can be plotted between them. The bisector of this acute angle is the "direction of predominant orientation" of the card web fibers.

It follows that the "direction of predominant fiber orientation" can be measured by making certain physical determinations in much the same manner as the "degree of fiber orientation" can be measured. The "direction of predominant fiber orientation" can be determined by (1) bonding the card web uniformly, (2) drying the bonded web, (3) measuring tensile strengths in all directions around the compass, (4) plotting the resulting data in a polar diagram, (5) determining the two directions in which maximum tensile strength is exhibited by the bonded fabric, and (6) determining the direction which bisects the acute angle between the two directions of maximum tensile strength.

Because of the drafting action of a carding machine, the fibers in a card web are always "predominantly oriented" in the machine direction. The "degree of fiber orientation" in the machine direction, however, depends upon the severity of the drafting action and the extent to which it is continued during carding.

The webs produced by a carding machine are further processed and bonded by various methods known to the art and which do not relate directly to the present inventive concept. Regardless of the further processing, however, the basic fact remains that the fibers are predominantly oriented in the longitudinal direction of the web, which leads to many advantages and some disadvantages in the bonded fabric.

The most important of these disadvantages is the difference in the physical properties and characteristics, notably the strength, of the bonded nonwoven fabric in the long direction, as compared to the cross direction. This, of course, is due to the fact that the fibers lie predominantly oriented to the long axis and thus give the bonded fabric considerable strength in the long direction whereas they produce little, if any, strength in the cross-direction.

Much effort has been expended, for example, in lami-

nating and bonding several of these webs together with their oriented fibers and long axes at angles to each other to equalize the strengths in the long and cross directions. Such efforts have produced nonwoven fabrics which do not contain the great differences in properties and characteristics measured in different directions which their predescessors possessed, but the expensive nature of their production has rendered them of dubious commercial value.

A principal object of the present inventive concept is to provide a nonwoven web of fibrous materials wherein the fibers lie predominantly oriented to the long axis of the web and at an angle thereto, which web will thereby be a better basic starting material for the manufacture of nonwoven fabrics.

The predominantly oriented fibers may lie at any desired angle to the long axis of the web, a 45° angle being preferred. Nonwoven fabrics having substantially even strength and other substantially uniform properties and characteritics in all directions are obtained by laminating two preferred webs in accordance with the invention, with the oriented fibers in one web at right angles to those in the other, and then bonding the laminate with any desired adhesive.

A further principal object of the present invention is to provide methods and apparatus for making such a nonwoven web.

In the accompanying drawings and the following specification, there is illustrated and described a preferred embodiment of the improved nonwoven web of fibrous materials in accordance with the invention, as well as preferred embodiments of methods and apparatus for producing the same, but it is to be understood that the inventive concept is not to be considered as limited to the embodiments disclosed, except as determined by the scope of the appended claims. Referring to the accompanying drawings,

FIGURE 1 is a schematic perspective view of apparatus for making a nonwoven web of fibrous material embodying the present inventive concept;

FIGURE 2 is a schematic plan view of apparatus such as shown in FIGURE 1 but showing its use in making a two-layer, cross-laid fibrous web;

FIGURE 3 is a schematic fragmentary view of the main card cylinder and doffer belt of the present invention showing the construction of the wires thereon;

FIGURE 4 is a vector diagram showing the velocity vectors of the main cylinder and the doffing belt and the resultant vector velocity or the angle of fiber deposition on the doffing belt;

FIGURE 5 is a schematic perspective view of a modification of the apparatus for making a nonwoven web of fibrous materials embodying the present inventive concept;

FIGURE 6 is a schematic plan view of apparatus such as shown in FIGURE 5 but showing its use in making a two-layer, cross-laid fibrous web; and

FIGURE 7 is a schematic fragmentary view of the apparatus of FIGURES 5 and 6 showing the construction of the wires on the main card cylinder, the doffing cylinder and the doffing belt.

As shown in FIGURES 1 and 2, a main card cylinder **10** is positioned so as to rotate with the plane of its direction of rotation and predominant fiber orientation at an angle α to the direction of travel of a doffing belt **12**. This angular relationship of the card cylinder and the doffing belt may be varied within rather wide limits to meet any desired need, as hereinafter described. For emphasis, the fibers are shown as having a degree of fiber orientation of 95% or so on the main card cylinder.

The main card cylinder **10** is of the conventional type used in the textile industry and comprises a large cylindrical cast-iron shell supported by spiders (not shown) of the usual type. The shell has a width of about 45 inches and an outside diameter of about 50 inches. The surface of the cylinder is covered or helically wrapped in the conventional manner with the usual card clothing (see FIGURE 3) containing many fine, closely spaced, specially bent wires **11** having a diameter of from about 0.009 to about 0.017 inch. The cylinder **10** is mounted on a main drive shaft **14** and during carding operations is driven in the direction indicated at a rotational velocity under normal conditions of from about 150 to about 300 revolutions per minute and preferably from about 160 to about 220 revolutions per minute during carding operations. This is equivalent to a peripheral linear surface velocity of from about 650 yards per minute to about 1300 yards per minute and preferably from about 690 to about 960 yards per minute.

Other conventional parts of the card such as the feed works which include the feed plate and feed roll, the licker-in, the mote knives, the licker-in screen, etc., have been omitted from the drawings for the purpose of clarity. Since the main card is rotating in a clockwise direction with the doffing belt travelling to the left in FIGURES 1 and 2, the feed works would be positioned in front of the main card cylinder rather than to the rear or behind the cylinder, as viewed in FIGURE 1, and so would obscure the view of the main card cylinder if shown. Other conventional card elements, such as the back-plate, the card flats, etc., have also been omitted to show more clearly the predominant orientation of the fibers on the main card cylinder.

The doffing belt **12** comprises an endless belt which is mounted on and is moved continuously by either of the driving rolls **16** and **18** in the direction indicated. The doffing belt **12** may have a width corresponding to the width of the card cylinder but this width may be less depending upon the particular angular positioning of the doffing belt with respect to the card cylinder. The doffing belt may have a width greater than the width of the card cylinder but this is of no moment.

The doffing belt **12** is covered or wrapped with card clothing containing many fine, closely spaced, specially bent wires **13** (see FIGURE 3) of about the same construction and fineness as the card clothing on the main cylinder. The fineness of the wires on the doffing belt may be varied with respect to the fineness of the wires on the card cylinder. Thus, they may be slightly finer or even slightly coarser. The doffing belt **12** is made of rubber, leather, synthetic materials, or other equivalent flexible materials in which the wires **13** are mounted similarly to the mounting of the card wires **11** upon card cylinder **10**.

In the embodiment shown in FIGURES 1–3, the doffing belt **12** moves at a considerably slower linear velocity than the linear surface velocity of main cylinder **10** and, under normal conditions, has a linear velocity in the range of from about 15 yards per minute to about 100 yards per minute and preferably from about 20 to about 70 yards per minute. This is so because in the transfer or doffing of the fibers from the main card cylinder to the doffing belt, the bends in wires **11** should preferably be opposed to the bends in wires **13** and the "hooks" formed by the bends must move in opposition one to the other, when conventional card clothing is employed.

The linear surface velocity of the main cylinder **10** and the linear velocity of the doffer belt **12** may be varied slightly from the ranges set forth above, depending upon the particular conditions involved but, in any event, the ratio of the linear surface velocity of the main cylinder **10** to the linear velocity of the doffer belt **12** should be at least about 10 to 1 for satisfactory commercial operation, assuming the fibers in the resulting fibrous web are to be at about 45° to the longitudinal axis of the web. Preferred ratios of these velocities range from about 20 to 1 to about 60 to 1.

Velocity ratios of less than 10 to 1 may be used, such as down to 5 to 1 or even lower, but, as will be discussed hereinafter, such lower ratios introduce greater discrepancies between the direction of rotation of the main card

cylinder and the actual direction at which the fibers are transferred from the wires 11 of the main card cylinder 10 to the wires 13 of the doffer belt 12.

The main cylinder 10 is so positioned and spaced relatively with respect to the moving upper surface of the doffing belt 12 as to establish substantially a continuous line of close proximity therewith whereby fibrous materials may be doffed from the main cylinder 10 and transferred to the moving belt 12 in the same way as fibers are transferred from the main card cylinder to the doffer roll in the conventional carding machine. The exact angularity and nature of the continuous line of close proximity between the main cylinder and the doffing belt is obtained by making either or both adjustable with respect to each other to control their clearance and spacing and their angularity.

An adjusting or positioning rod or roller 19 may be positioned directly below the upper reach of the doffer belt 12 to adjust its vertical positioning and clearance with respect to the main card cylinder 10. The rod or roller 19 may be adjustable, as desired, and is then capable of being secured in position whereby the clearance between the wires 11 of the main card cylinder 10 and the wires 13 of the doffing belt 12 is maintained. This clearance is the usual clearance conventionally maintained between a card cylinder and a doffing roll and is on the order of from about 0.005 inch to about 0.020 inch and is normally about 0.007 inch for cotton, for example.

Adjustability of the angular relationship between the main card cylinder and the doffing belt is normally obtained by manually positioning the two at the desired angle and securing them in the desired position. In the event that frequent changes of the angular relationship are required, it is preferable to mount the doffing belt in an adjustably rotatable cradle so constructed as to rotate substantially in a plane.

The exact mechanism of the fiber transfer from the main cylinder to the doffing belt is not precisely known but it is believed that the fibers on the wires of the card clothing of the main cylinder make point contact with the wires of the card clothing on the doffing belt and are transferred thereto. The relatively higher velocity of the main cylinder, however, causes the individual fibers to be laid in predominantly oriented relationship on the surface of the doffing belt, tending to keep their original dominant orientation which prevailed on the main cylinder rather than taking the direction of movement of the doffer belt. At the same time, the fibers shift to and move simultaneously with the doffer belt in the new changed direction. As a consequence, the fibers remain substantially in their original predominant orientation but sidle or move sidewise forwardly at an angle to the long direction of the web now on its new carrier, namely, the doffer belt.

More precisely, the actual angles of individual fiber deposition and the resulting predominant orientation of the whole group of fibers on the doffing belt are not exactly the same as the individual fiber angles and predominant orientation that obtained on the main card cylinder. Strictly speaking, the angle of fiber deposition on the doffing belt of a fiber lying on the card cylinder in a position parallel to the direction of rotation of the cylinder is the angle of the resultant vector of (1) the large velocity vector of the linear surface velocity of the main cylinder which is the direction of rotation thereof and (2) the relatively small velocity vector of the doffer belt which is its direction of movement. A vector diagram is shown in FIGURE 4 for the velocities and their directions when the main cylinder and the doffing belt are positioned at an angle α of 45° and the linear surface velocities of the main cylinder and the doffing belt have a ratio of about 15 to 1. It is to be observed that the resulting angle of fiber deposition is about 3° less than the angle of the linear surface velocity vector for the main cylinder under the conditions stated. This angle is, of course, relatively very small and becomes negligible as the ratio of the velocities increases. On the other hand, if velocity ratios of less than 15 to 1, say as low as 5 to 1 or lower, are used, this angle will increase considerably above 3°.

If it is desired to make an adjustment for this increased angle by increasing the angular relationship between the main card cylinder and the doffing belt, this will increase the density and decrease the width of the resulting fibrous web.

The fibers thus hooked by the wires of the doffing belt from the wires of the main cylinder and laid thereon are carried forwardly by the doffing belt in the changed direction in predominant orientation but, as described previously, since they were deposited on the doffer belt with substantially the same predominant orientation and direction which they possessed on the main cylinder, their direction of predominant orientation is now disposed at an angle to the long axis of the doffer belt. This is shown most clearly in FIGURE 2.

The fibers may then be removed from the doffing belt by a second doffing means such as the usual doffer comb but preferably by a perforated drum 20 provided with a suction manifold 22. A device such as illustrated in U.S. Patent 2,077,095, issued April 13, 1937, to E. L. Cady may be employed.

The nonwoven fibrous web W is then deposited on a main conveyor belt 24 upon which has been previously deposited another nonwoven web such as web W' (see FIGURE 2) wherein the fibers are predominantly oriented at an angle of 45° in the opposite angular direction to the long axis of the direction of movement of the web, or in other words with the direction of predominant orientation of the fibers in one web substantially at right angles to the direction of predominant orientation of the fibers in the other web. The resulting composite two-layer, cross-laid nonwoven web possesses more even strength and other physical properties and characteristics in all directions.

In the event that it is desired to have a greater equalization of the strength and other physical properties and characteristics in all directions, up to as many as 8 webs or more may be cross-laid in this way or at angles of 45° to each other to form a composite fabric. If like properties are desired in all directions for the resulting laminated web, the directions of predominant orientation of the fibers in the respective layers should be distributed at equal angular increments around the compass. In the event that unequal strengths are desired in preselected directions and proportions, such can be arranged by merely cross-laying the various webs with their respective directions of predominant fiber orientation at unequal angular spacing to accomplish the desired result. Within the more commercial aspects of the present invention, nonwoven fabrics comprising 4 webs with each web having a direction of predominant fiber orientation at 45° to the predominant fiber orientation of the next web have been found most practical.

Although the present inventive concept has been described and illustrated with the tangential direction of rotation of the main cylinder and the direction of movement of the doffing belt at the line of close proximity therebetween disposed at an angle of 45° to each other, it is to be appreciated that other angles may be selected depending upon the particular circumstances involved. For example, an angle as high as about 60° may be employed, although it must be observed that the greater the angle, the greater is the loss in width and the increase in density of the nonwoven web which is being transferred from the main cylinder. This is, of course, obvious from the geometry of the angular relationship involved inasmuch as the greater the angle, the greater is the degree of condensation of the resulting web. The angular relationship may be decreased below 45°, for example, to 30° or even to 15° whereby the decrease in width is less but wherein the angularity of the fibers in the web with respect to the longitudinal axis of the

web is also less. Decreasing the angle below 15° to about 5° decreases the angularity of the deposited fibers with respect to the long axis of the fibrous web whereby the effect of the present inventive concept becomes less and less noticeable. These angles, of course, relate to the angle between the tangential direction of movement of the fibers on the main cylinder at the line of close proximity between the cylinder and the doffing belt, and the direction of movement of the fibers on the doffing belt.

It is to be observed that, although the width of the web is narrowed during the transfer from the main cylinder to the doffing belt, there is an approximately corresponding increase in the weight per square yard of the web. That is to say, whenever the width of the web is reduced to a given fraction of its original value, the weight per square yard of the fabric increases by the reciprocal of that fraction.

Although the inventive concept has been described with particular reference to the transfer of fibers from the main cylinder to the doffing belt, it is to be appreciated that it is not to be construed as limited thereto. For example, as shown in FIGURES 5 and 6 the fibers can be transferred directly and without any change in their angular direction from a main cylinder **10** to a doffing cylinder or roll **15** of the usual type and then transferred from the doffing roll **15** to the doffing belt **12** with their direction of predominant fiber orientation changed in accordance with the method of this invention. This may require an adjustment of the velocity of the main cylinder **10** and of the doffing roll **15**, so that the required linear surface velocity differential is maintained as explained above between the doffing belt and the doffing roll. It is preferred that the conventional differential be maintained between the linear surface velocity of the main cylinder and the linear surface velocity of the doffing roll, although this is not required. For best results with conventional card clothing, the bends in wires **11** on the main cylinder should be opposed to the bends in wires **17** on the doffing roll, and the "hooks" formed by the bends should move in opposition one to the other, as shown in FIGURE 7.

Similarly, the bends in wires **13** of the doffing belt **12** should be opposed to the bends in wires **17** on the doffing roll, and the "hooks" formed by the bends should move in opposition to each other, whenever conventional card clothing is used. It is also important that there be a relative differential between the linear surface velocity of the doffing roll **15** and the linear surface velocity of the doffing belt **12** that falls more or less within the ranges explained above. Within the more commercial aspects of the present invention, a linear speed differential of at least 10 to 1 should be desirably maintained between the doffing roll and the doffing belt.

The relationship of the main card cylinder **10**, the doffer **15** and the doffing belt **12** may be as illustrated in FIGURE 7. The directions of rotation of the main cylinder and of the doffer and the direction of movement of the doffer belt are as indicated by the arrows, in this embodiment. The fibers are transferred from wires **11** on the main card cylinder **10** to wires **17** on the doffer **15**. The web of fibers so received on the wires **17** of the doffer **15** is then transferred to the wires **13** of the moving doffer belt **12**. The basic doffing principles are, of course, similar to those involved when merely a main card cylinder and a doffing belt are employed.

The invention will be further illustrated in greater detail by the following specific examples. It should be understood, however, that although these examples may describe in particular detail some of the more specific features of the invention, they are given primarily for purposes of illustration and the invention in its broader aspects is not to be construed as limited thereto.

Example 1

A nonwoven web of fibrous materials is prepared with apparatus illustrated in FIGURES 1 and 2 as follows: The main card cylinder is wrapped with 2-inch fillet card clothing. It has a width of 45 inches, an outside diameter of 50 inches and is operated at about 170 revolutions per minute for a linear surface velocity of about 740 yards per minute. The doffer belt is also wrapped with 2-inch fillet card clothing. The belt has a width of 32 inches and a length between driving rollers of about 88 inches. It is operated at a linear surface velocity of about 25 yards per minute. The ratio of the main card cylinder linear surface velocity to the belt linear velocity is about 29 to 1. The fibers used are viscose rayon having an average staple length of about 2 inches. The angle α between the plane of the direction of rotation and predominant fiber orientation of the main cylinder and the direction of travel of the doffer belt is 45°. The clearance between the main cylinder and the doffing belt is 0.007 inch. The fibers are fed to the main card cylinder and are carded into predominant orientation on the main card cylinder in the direction of rotation thereof in accordance with known procedures. The carded fibers are doffed from the main cylinder to the doffer belt and then are transferred by suction means to the main conveyor belt where they are plied with another web containing fibers oriented 45° in the opposite direction. The width of the resulting cross-laid nonwoven fabric is about 31 inches. The weight of the fabric is about 400 grains per square yard and it possesses approximately equal strengths (1:1) in the long and cross direction. The nonwoven fabric is bonded with a dispersion of polyvinyl acetate to deposit about 5% solids by weight (dry basis) thereon. The resulting nonwoven fabric is useful as a dinner place-mat.

Example 2

A nonwoven web of fibrous materials is prepared by the procedures of Example 1, except that the main card cylinder surface velocity is increased to about 190 revolutions per minute or 830 yards per minute. The ratio of the main card cylinder linear surface velocity to the doffing belt linear velocity is therefore about 33 to 1.

Although the fibrous materials on the main card cylinder have been referred to in this disclosure in such terms as to create the impression that a "web" of fibers exists thereon, such is true only in the very broad sense. Precisely speaking, these fibrous materials are in the form of individual fibers but, when considered in gross, may be collectively considered loosely as a "web" of fibers existing in a sort of sheet-like form having long and cross directions.

Although specific examples of the inventive concept have been described, the same should not be construed as limited thereby nor to the specific embodiments shown but to include various other equivalent embodiments as set forth in the claims appended hereto. It is understood that any suitable changes, modifications and variations may be made without departing from the spirit and scope of the invention.

This patent application is a continuation-in-part of my earlier filed pending patent application entitled: "Fibrous Web and Method and Apparatus for Producing the Same," Serial Number 694,642, filed on or about November 5, 1957, now abandoned.

I claim:

1. Apparatus for forming a web of fibrous materials wherein the fibers lie in a direction of predominant orientation at an angle to the long axis of the web which comprises a continuously rotatable card cylinder for orienting the fibers on the surface thereof with their direction of predominant fiber orientation lying in a plane at right angles to the axis of the cylinder, and for conveying said fibers at a relatively high velocity in the direction of their predominant orientation, and a doffing belt bearing card

clothing, said doffing belt being continuously movable at a relatively low velocity in a direction at an angle to said plane and being positioned so as to have a line of close proximity with said card cylinder and diverge from the surface thereof on either side of said line of close proximity, said angle between said plane and the direction of movement of said doffing belt being from about 5° to about 60°, whereby said oriented fibers may be transferred from said card cylinder to said doffing belt with their velocities reduced to a small fraction of their original relatively high velocity, but with substantially the same predominant orientation with respect to the surrounding environment as they had immediately before such transfer, thereby to form a loosely associated nonwoven web in which the fibers lie on said doffing belt at an angle to the long axis of the web.

2. Apparatus as defined in claim 1 wherein said plane containing the direction of predominant fiber orientation and the direction of movement of the doffing belt are at an angle of from about 15° to about 60° to each other.

3. Apparatus as defined in claim 1 wherein said plane containing the direction of predominant fiber orientation and the direction of movement of the doffing belt are at an angle of from about 30° to about 45° to each other.

4. Apparatus as defined in claim 1 wherein supporting means is provided to maintain the card cylinder and doffing belt in accurately spaced substantial line proximity relationship.

5. Apparatus for producing a continuous assemblage of fibers in which the direction of predominant fiber orientation is at an angle to the longitudinal axis of the fiber assemblage which comprises: means for supporting a plurality of fibers in dispersed positions and in substantial parallelism to each other, said fiber supporting means having a circular cross section taken in any plane parallel to a given plane and being rotatable at a relatively high angular velocity in a direction parallel to said given plane; means for rotating said fiber supporting means; movable fiber receiving means having a continuous line of close proximity with said fiber supporting means, said fiber receiving means being movable at a lower linear speed than the linear surface speed of said fiber supporting means and in a direction at an angle to said given plane, said angle being from about 5° to about 60°, said line of close proximity being maintained during simultaneous rotation and movement of said fiber supporting and fiber receiving means, respectively, the surfaces of said fiber supporting and receiving means diverging as they extend on either side of said line of close proximity; and means for moving said fiber receiving means.

6. A method of continuously forming a web of fibrous materials wherein the fibers lie in a direction of predominant orientation at an angle to the long axis of the web which comprises: orienting the fibers predominantly in a given direction in an arrangement defining an orienting surface; conveying them at a relatively high velocity in the direction of their predominant orientation; changing the direction of said fiber movement in an amount from about 15° to about 60°; and simultaneously reducing the velocity thereof to a small fraction of the original velocity, whereby said fibers become loosely associated in a nonwoven web, said fibers, when disposed upon the receiving surface, retaining substantially the same predominant orientation but moving in the changed direction at an angle of from about 15° to about 60° to the long axis of the moving web.

7. A method of continuously forming a web of fibrous materials wherein the fibers lie in a direction of predominant orientation at an angle to the long axis of the web which comprises: orienting the fibers predominantly in a given direction in an arrangement defining an orienting surface; conveying them at a relatively high velocity in the direction of their predominant orientation; changing the direction of said fiber movement in an amount from about 30° to about 45°; and simultaneously reducing the velocity thereof to a small fraction of the original velocity, whereby said fibers become loosely associated in a nonwoven web, said fibers, when disposed upon the receiving surface, retaining substantially the same predominant orientation but moving in the changed direction at an angle of from about 30° to about 45° to the long axis of the moving web.

8. A method of producing a continuous fibrous web in which the direction of predominant fiber orientation is at a desired angle of more than 5° and up to 60° to the longitudinal axis thereof which comprises: moving a fibrous web comprising a plurality of fibers oriented predominantly in a given direction in one direction on a first movable surface, the direction of predominant fiber orientation, the direction of movement of said fibrous web, and the direction of movement of said first movable surface being substantially the same; and transferring said fibrous web from said first movable surface to a second movable surface having a continuous line of close proximity with said first movable surface, said second movable surface moving at a lesser linear speed than the first movable surface and in a direction having a predetermined angle of more than 5° and up to but not greater than about 60° to a plane normal to said continuous line of close proximity whereby the direction of predominant fiber orientation of said fibrous web on said second movable surface possesses said predetermined angle of more than 5° and up to but no greater than about 60° to the direction of movement of said fibrous web and to the direction of movement of said second movable surface.

9. A method of producing a continuous fibrous web in which the direction of predominant fiber orientation is at a desired angle of more than 5° and up to 60° to the longitudinal axis thereof which comprises: moving a fibrous web comprising a plurality of fibers oriented predominantly in a given direction in one direction on a first movable surface, the direction of predominant fiber orientation, the direction of movement of said fibrous web, and the direction of movement of said first movable surface being substantially the same; transferring said fibrous web from said first movable surface to a second movable surface having a continuous line of close proximity with said first movable surface, said second movable surface moving at a lesser linear speed than the first movable surface and in a direction having a predetermined angle of more than 5° and up to but no greater than about 60° to a plane normal to said continuous line of close proximity whereby the direction of predominant fiber orientation of said fibrous web on said second movable surface possesses said predetermined angle or more than 5° and up to but no greater than about 60° to the direction of movement of said fibrous web and to the direction of movement of said second movable surface; and conveying said fibrous web away from said continuous line of close proximity.

10. A method of producing a continuous fibrous web in which the direction of predominant fiber orientation is at a desired angle of more than 5° and up to 60° to the longitudinal axis thereof which comprises: moving a fibrous web comprising a plurality of fibers oriented prodominantly in a given direction in one direction on a rotatable surface, the direction of predominant fiber orientation, the direction of movement of said fibrous web, and the direction of movement of said rotatable surface being substantially the same; and transferring said fibrous web from said rotatable surface to a movable surface having a continuous line of close proximity with said rotatable surface, said movable surface moving at a lesser linear speed than the rotatable surface and in a direction having a predetermined angle of more than 5° and up to but no greater than about 60° to a plane normal to said continuous line of close proximity whereby the direction of predominant fiber orientation of said fibrous web on said movable surface possesses said predetermined angle of more than 5° and up to but no greater than about 60°

to the direction of movement of said fibrous web and to the direction of movement of said movable surface.

11. A method of producing a continuous fibrous web in which the direction of predominant fiber orientation is at a desired angle of more than 5° and up to 45° to the longitudinal axis thereof which comprises: moving a fibrous web comprising a plurality of fibers oriented predominantly in a given direction in one direction on a first movable surface, the direction of predominant fiber orientation, the direction of movement of said fibrous web, and the direction of movement of said first movable surface being substantially the same; and transferring said fibrous web from said first movable surface to a second movable surface having a continuous line of close proximity with said first movable surface, said second movable surface moving at a lesser linear speed than the first movable surface and in a direction having a predetermined angle of more than 5° and up to about 45° to a plane normal to said continuous line of close proximity whereby the direction of predominant fiber orientation of said fibrous web on said second movable surface possesses said predetermined angle of more than 5° and up to but no greater than about 45° to the direction of movement of said fibrous web and to the direction of movement of said second movable surface.

12. A method of producing a continuous fibrous web in which the direction of predominant fiber orientation is at a desired angle of more than 5° and up to 45° to the longitudinal axis thereof which comprises: moving a fibrous web comprising a plurality of fibers oriented predominantly in a given direction in one direction on a rotatable surface, the direction of predominant fiber orientation, the direction of movement of said fibrous web, and the direction of movement of said rotatable surface being substantially the same; and transferring said fibrous web from said rotatable surface to a movable surface having a continuous line of close proximity with said rotatable surface, said movable surface moving at a lesser linear speed than said rotatable surface and in a direction having a predetermined angle of more than 5° and up to about 45° to a plane normal to said continuous line of close proximity whereby the direction of predominant fiber orientation of said fibrous web on said movable surface possesses said predetermined angle or more than 5° and up to but no greater than about 45° to the direction of movement of said fibrous web and to the direction of movement of said movable surface.

13. Apparatus for producing a continuous fibrous web in which the direction of predominant fiber orientation is at a desired angle of more than 5° and up to 60° to the longitudinal axis thereof which comprises: a first movable surface for moving a fibrous web comprising a plurality of fibers oriented predominantly in a given direction in one direction on said first movable surface, the direction of predominant fiber orientation, the direction of movement of said fibrous web, and the direction of movement of said first movable surface being substantially the same; and a second movable surface for receiving said fibrous web from said first movable surface, said second movable surface having a continuous line of close proximity with said first movable surface, said second movable surface moving at a lesser linear speed than the first movable surface and in a direction having a predetermined angle of more than 5° and up to but not greater than about 60° to a plane normal to said continuous line of close proximity whereby the direction of predominant fiber orientation of said fibrous web on said second movable surface possesses said predetermined angle of more than 5° and up to but no greater than about 60° to the direction of movement of said fibrous web and to the direction of movement of said second movable surface.

14. Apparatus for producing a continuous fibrous web in which the direction of predominant fiber orientation is at a desired angle of more than 5° and up to 60° to the longitudinal axis thereof which comprises: a first movable surface for moving a fibrous web comprising a plurality of fibers oriented predominantly in a given direction in one direction on said first movable surface, the direction of predominant fiber orientation, the direction of movement of said fibrous web, and the direction of movement of said first movable surface being substantially the same; a second movable surface for receiving said fibrous web from said first movable surface, said second movable surface having a continuous line of close proximity with said first movable surface, said second movable surface moving at a lesser linear speed than the first movable surface and in a direction having a predetermined angle of more than 5° and up to but no greater than about 60° to a plane normal to said continuous line of close proximity whereby the direction of predominant fiber orientation of said fibrous web on said second movable surface possesses said predetermined angle of more than 5° and up to but no greater than about 60° to the direction of movement of said fibrous web and to the direction of movement of said second movable surface; and means for conveying said fibrous web away from said second movable surface.

15. Apparatus for producing a continuous fibrous web in which the direction of predominant fiber orientation is at a desired angle of more than 5° and up to 60° to the longitudinal axis thereof which comprises: a rotatable card cylinder having a rotatable surface for moving a fibrous web comprising a plurality of fibers oriented predominantly in a given direction in one direction on said rotatable surface, the direction of predominant fiber orientation, the direction of movement of said fibrous web, and the direction of movement of said rotatable surface being substantially the same; and an endless doffing belt having a movable surface for receiving said fibrous web from said rotatable surface, said movable surface having a continuous line of close proximity with the full width of said rotatable surface, said movable surface moving at a lesser linear speed than said rotatable surface and in a direction having a predetermined angle of more than 5° and up to but no greater than about 60° to a plane normal to said continuous line of close proximity whereby the direction of predominant fiber orientation of said fibrous web on said movable surface possesses said predetermined angle of more than 5° and up to but no greater than about 60° to the direction of movement of said fibrous web and to the direction of movement of said movable surface.

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