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[54] **METHOD AND APPARATUS CROSS-DRAFTING FIBROUS NONWOVEN WEBS**

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[52] **U.S. Cl.** ....**19/236,** 19/161 R, 26/54 R, 26/57 R

[51] **Int. Cl.** **D01h 5/00,** D06c 3/00

[58] **Field of Search**......26/54 R, 57 R, 52; 19/161 R, 19/106 R, 236; 38/143; 18/1 FS, 1 FB, 1 FM

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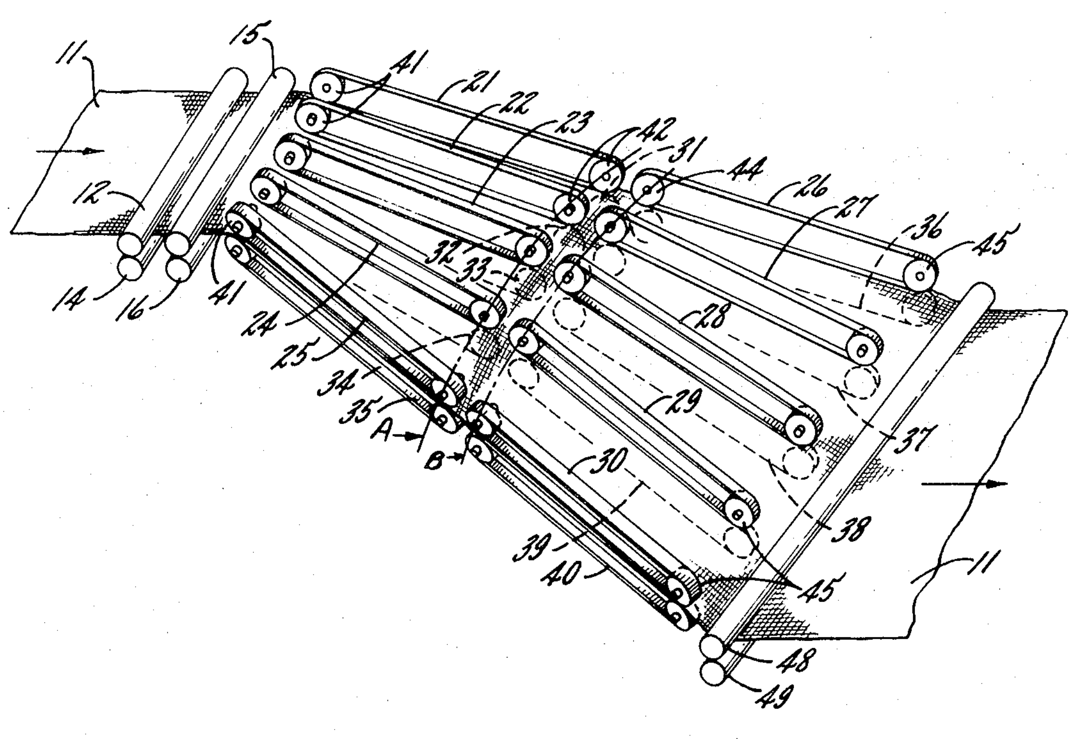
[57] **ABSTRACT**

Apparatus and method are described for cross-drafting fibrous nonwoven webs. A web is grasped by a plurality of endless belts which diverge laterally to stretch the web in a cross-machine direction. Two or more sets of belts are employed to initially grasp the web across a transverse line normal to the length of the web, to stretch each increment of the web by an approximately equal amount, and to release the web simultaneously across a second transverse line normal to the web. The resulting web is of increased width and decreased thickness in comparison to the initial web, and each increment of the web is stretched or cross-drafted by an approximately equal amount.

12 Claims, 4 Drawing Figures



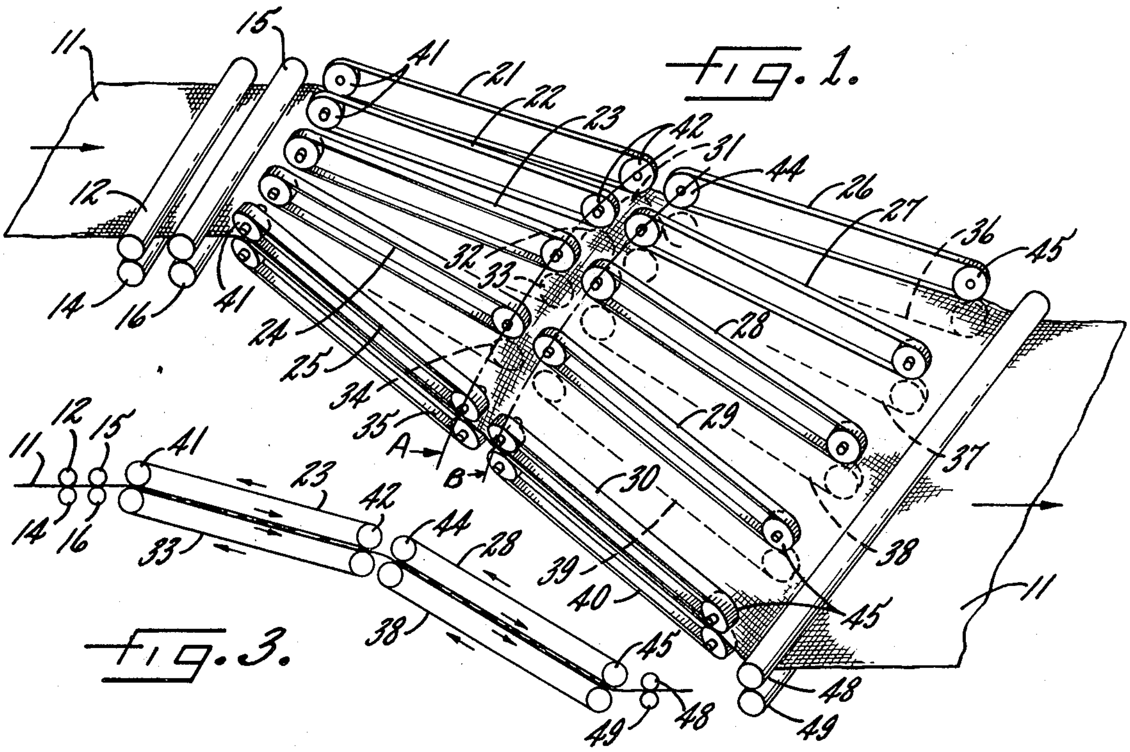


FIG. 1.

FIG. 3.

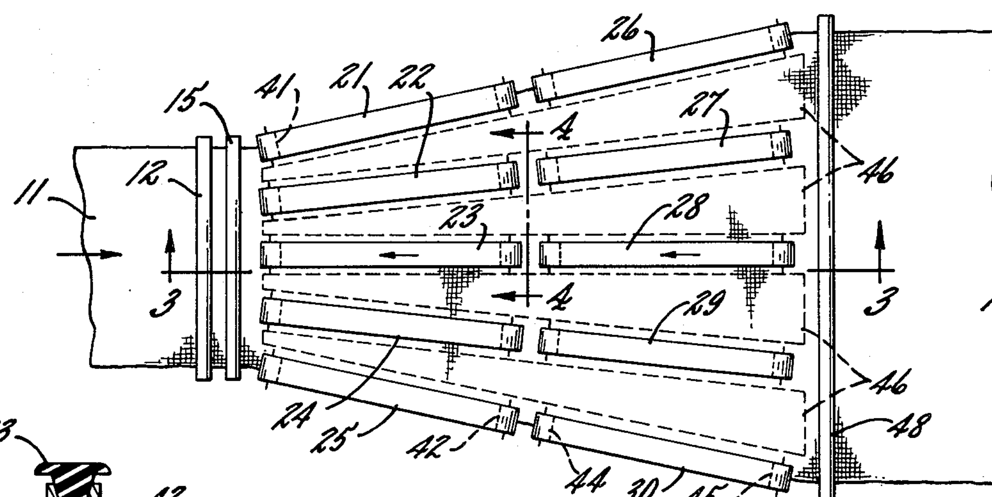


FIG. 2.

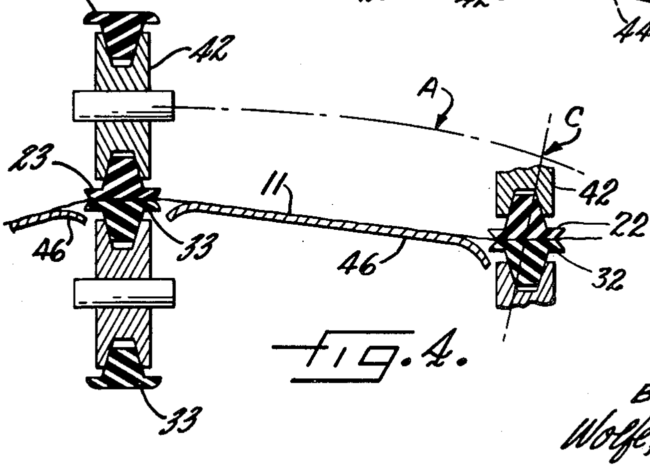


FIG. 4.

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METHOD AND APPARATUS CROSS-DRAFTING FIBROUS NONWOVEN WEBS

INTRODUCTION

This invention relates to the cross-drafting of fibrous nonwoven webs, and more particularly concerns a method and apparatus for drafting or stretching a nonwoven web in a direction transverse to the length of the web.

Nonwoven fabrics, made of bonded or unbonded fibers, are conventionally made by producing a thin web or sheet of natural or synthetic textile fibers and then bonding the web to anchor the individual fibers together in a cohesive sheet. Nonwoven web may be of natural fibers such as cotton, wool, or the like, or artificial fibers of rayon, a nylon, a polyester, an oriented polyolefin, or like material. Fiber length depends on the end use of a web or web laminate, and may range from a few millimeters to staple fibers of several inches average length.

These fibers are customarily processed into web form by one of two general techniques, that is, air-laying to form a random web, and carding or the like to form an oriented web with the fibers more or less alined in the same direction. Random webs characteristically tend to have isotropic characteristics, or in other words, have equal tensile strength in all directions. On the other hand, as the fibers become more and more alined, tensile strength increases in a direction parallel to fiber alinement but decreases in a direction normal to the alinement. In the extreme, where the fibers are all alined parallel to each other, the web has its entire strength parallel to the fibers, that is, in the machine direction; in the cross-machine or transverse direction, its tensile strength is essentially non-existent.

Frequently, and particularly in the manufacture of very thin webs, it is necessary or desirable to form initially a relatively thick random web and then reduce the thickness. The usual procedure for reducing web thickness is to pass the web through successive sets of draw rolls, each set of rolls being driven at a progressively higher speed than that of the preceding roll. This stretches the original web by an amount equal to the relative speeds of the draw rolls, and at the same time alines the fibers in a direction parallel to the path of the web through the rolls. However, when this occurs, the previously described phenomenon of increasing the strength in the machine but simultaneously decreasing it in the transverse or cross-machine direction takes place. As a result, the web may have an undesirably low tensile strength in the cross direction.

Suggestions have in the past been made for stretching an initially thick web first in the machine direction and then in the cross direction. While in theory this approach is capable of reducing web thickness without concurrently producing excessively high fiber orientation in the machine direction, in practice a number of difficulties are experienced. Among these are the problems of undue complexity of apparatus, and the inability to produce webs in which each transverse increment is stretched by an equal amount. More often than not, either the center of the web or the edges of the web is expanded more than the other. As a consequence, the web has a non-uniform thickness across its width, and/or the web exhibits wrinkling or puckering.

An object of the invention is to provide method and apparatus for reducing the thickness of fibrous nonwoven webs without undesirably reducing the cross-machine tensile strength.

Another object is to provide a drafting technique for producing nonwoven webs of substantially constant thickness and tensile strength at each increment across the width of the web.

Still a further object is to provide method and apparatus for cross-drafting nonwoven webs which are relatively simple to operate and which require no complex equipment or controls.

Yet a further object is to provide an element in a nonwoven web drafting apparatus and process which permits substantial reduction in web thickness while maintaining much of the initial isotropic character of random webs.

Still another object is to provide method and apparatus for cross-drafting a nonwoven web in which the web is stretched exclusively in a lateral direction and wherein each increment of the web is stretched by an approximately equal amount.

A general object is to provide method and apparatus for increasing the width of a nonwoven web.

Other and further aims, objects, and advantages of the invention will become apparent from the ensuing description, which is to be taken in conjunction with the included drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of an apparatus embodied in the present invention;

FIG. **2** is a top view of the apparatus shown in FIG. **1**;

FIG. **3** is a schematic partial elevational view taken along lines **3—3** of FIG. **2**; and

FIG. **4** is an enlarged sectional view taken across lines **4—4** of FIG. **3**.

Although the invention will be described in conjunction with a specific embodiment, it is apparent that the invention is not so limited. On the contrary, it is intended to embrace all such alternatives, modifications, and variations as fall within the spirit and broad scope of the invention as defined in the appended claims.

DETAILED DESCRIPTION

Turning first to FIG. **1**, a perspective view of the apparatus according to the invention is shown. In substance, a fibrous nonwoven web **11** is advantageously drafted first in a longitudinal direction by a succession of draw rolls **12**, **14** and **15**, **16**, and then drafted in a cross-machine direction by a plurality of sets of diverging endless belts. The first set is represented by the belts **21** through **25** inclusive for the upper surface of the web **11** and a corresponding set of matching belts **31** through **35** for the lower surface of the web **11**. The second set, only two such sets being used in the depicted embodiment, comprises the belts **26** through **30** inclusive for the upper surface and **36** through **40** inclusive for the lower surface of the web **11**.

In one aspect of the invention, the web **11** is initially a random laid web of natural and/or synthetic staple fibers. The web **11** is drawn continuously, in the indicated direction, by a nip between a first pair of drafting or draw rolls **12**, **14** driven by a suitable drive mechanism, not shown. A succeeding set of drafting rolls **15, 16** driven at twice the linear rate as the first set of rolls **12, 14**, stretches the web **11** in a longitudinal direction and concurrently drafts or partially alines the fiber lengthwise. An illustrative draw ratio, or linear speed ratio of the rolls **15, 16** with respect to **12, 14** is 2:1.

Following the drafting rolls **15, 16**, the web **11** passes to the first of a series of diverging endless vee belts. The incoming sheaves **41** are substantially in axial alinement so that the nips formed by the first set of belts **21** through **25** (and **31** through **35** on the bottom surface) continuously grasps the web **11** at a plurality of spaced regions across an imaginary transverse line normal to the length of the web.

The above is best shown in FIG. 2. There it will be noted that, apart from a necessary angular displacement of the axes of the incoming sheaves **41**, the axes are substantially along a line perpendicular to the web **11**.

As shown in FIG. 4, the belts **23, 33** on opposite sides of the web **11** are flat-top vee belts which form an elongated nip region to grasp the web along opposed faces of the belts. Thus, although alternative belt shapes are permissible, under optimum practice of the invention a portion of the web is always continuously grasped between the adjacent matching belts **23, 33** throughout the entire travel of the respective belts between their incoming sheaves **41** (FIGS. 1 through 3) and their outgoing sheaves **42**.

In keeping with another aspect of the invention, the belts **21** through **25**, etc., of a given set of diverging belts are of equal length. This dictates that flexible drive shafts or the like be used to power the incoming sheaves **41** and/or the outgoing sheaves **42**. Although somewhat more complicated than certain pre-existing progressive diverging belt arrangements, it will be seen that the small cost in complexity is more than compensated for by substantial improvement in product quality.

Observing FIGS. 1 and 2, it will be seen that the succeeding upper set of diverging belts **26, 30**, again each of equal length, is positioned to succeed the preceding upper set of belts **21** through **25**, respectively. Correspondingly, a lower set of belts **36** through **40** (see FIG. 1) contacts the underside of the web **11** following the first belt set **31** through **35** (FIG. 1). Desirably, each belt, e.g. **26**, in a succeeding set is alined longitudinally of the diverging section of the web **11**, as is the preceding belt **21**.

Further in keeping with the invention, the succeeding sheaves **45** (FIGS. 1 and 2) of the final set of belts are substantially in axial alinement across a perpendicular to the length of the web **11**, precisely as was employed for the initial incoming sheaves **41**. Thus, the final outgoing sheaves **45** release the web from the belts **26** through **30**, and **36** through **40** (FIGS. 1 and 2) simultaneously across a transverse line normal to the web length. As will be explained below, this assists in insuring that the cross-drafted web product is free of wrinkles or puckering.

One feature of the invention, best shown in FIG. 2, is that the several belt members radiate outwardly from an incoming position (corresponding to the transverse axis of the incoming sheaves **41**) at approximately equal angles with respect to each other. In other words, the angle between the belts **21** and **22** is substantially the same as that between the belts **22** and **23**. As a consequence, the web **11** is stretched laterally exclusively, and each lateral increment of the web is stretched by an approximately equal amount. According to the preferred embodiment, these respective angles are made as equal as possible, although it will be recognized that some minor degree of non-uniform stretching will occur by reason of the substantial nip between upper and lower belts, as shown in FIG. 4. A similar equi-angular relationship exists for the succeeding set of belts represented by the belts **26** through **30** (FIGS. 1 and 2).

From the requirement that both the initial incoming sheaves **41** and the final outgoing sheaves **45** each be substantially on lines perpendicular to the length of the web **11**, it will be apparent that the initial outgoing sheaves **42** and the final incoming sheaves **44** hump upward and are not in axial alinement but are located at spaced points along an arc A or B, as shown in FIG. 1 and, in part, in FIG. 4. Otherwise stated, although the outer-most, or edge-grasping, belts **21, 31, 26, 36, 25, 35, 30, 40** are positioned in a flat plane, the equal lengths of each set of diverging belts require a vertical displacement, as shown in FIG. 1, of the inward ones of the sheaves **42, 44** and thus the inward portions of the web travel the same longitudinal distance while grasped between the belts as the edge portions of the web to provide substantially uniform stretching laterally exclusively and eliminating wrinkling or puckering of the web during the cross-drafting process. This offers no operational problem, as the initial outgoing sheaves **42** and the final incoming sheaves **44** may be located as dictated by geometric requirement after the initial incoming sheaves **41** and the final outgoing sheaves **45** are mounted.

As further shown in FIGS. 1 and 2, it is desirable in many instances—particularly with extremely thin and weak webs **11**—to include low-friction web support surfaces **46** between adjacent belts. Thus, the web **11** is supported by bottom surfaces **46** (FIGS. 2 and 4) to prevent sagging of the web.

Although shown in the drawings as all being vertically alined, for some web materials it is desirable to position the initial outgoing sheaves **42** and the final incoming sheaves **44** so that their axes are parallel to planes tangential to the arcuate center portion of the progressively diverging web i.e., tilted from the vertical to the plane C so as to be tangential to the arcs A or B rather than essentially parallel to each other as shown in FIG. 2. This however tends to warp the belts somewhat and reduce their service life. Accordingly, the preferred orientation is shown in the drawings.

An additional feature of the invention of special use when very thin webs **11** are being cross-drafted is the downward inclination of the belts, as shown in FIGS. 1 and 3. The force of gravity thus assists in urging a thin web **11** over the surfaces **46** (FIGS. 2 and 4) between the driven belts.

As will be apparent, by stretching the web **11** transversely and uniformly, opportunities for non-uniform product web thickness and for warped or puckered products are minimized or avoided. This in part is accomplished by providing for initial belt contact and for final belt contact of web **11** on substantially straight lines perpendicular to the length of the web. Stretching, of course, occurs beyond the elastic or resilient limit of the initial web, and for optimum practice the stretching is at least 50 percent of the initial web width.

After leaving the final outgoing sheaves **45**, the web **11** is collected and calendered by a nip between the roll **48**, **49**, which may be heated in the event the web **11** contains a thermosetting or thermoplastic bonding agent.

Thus it is evident that the method and apparatus of the invention are capable of providing an unusually advantageous cross-drafted product. One or more additional sets of cross-drafting stages and/or longitudinal drafting stages may be introduced where desired, although this will rarely be found necessary.

It is therefore evident that the aims, objectives, and advantages set forth earlier have been fully satisfied.

I claim as my invention:

1. Apparatus for cross-drafting fibrous nonwoven webs, comprising a plurality of sets of diverging web-grasping belt members for the upper surface of said web radiating outwardly from a web incoming position at approximately equal angles with respect to each other, and a corresponding plurality of sets of matching web-grasping belt members for the lower surface of said web, each of said belt members having an incoming sheave and an outgoing sheave, each of the belt members in a given set being of equal length, the incoming sheaves of the initial sets of belt members being substantially in axial alinement, the outgoing sheaves of the final sets of belt members being substantially in axial alinement, and the outgoing sheaves of the initial sets of belt members and the incoming sheaves of the final sets of belt members, respectively, being not in axial alinement but located at spaced points lying along an arc, such that the inward portions of the web travel the same longitudinal distance while grasped between the belts as the edge portions of the web whereby said web is stretched beyond its resilient limit in an exclusively lateral direction and each increment of said web is stretched by an approximately equal amount to eliminate wrinkling or puckering.

2. Apparatus of claim 1 wherein said belt members are flat-topped vee belts.

3. Apparatus of claim 1 wherein said angles are equal.

4. Apparatus of claim 1 wherein the belt members in successive sets are alined longitudinally with respect to said web.

5. Apparatus of claim 1 wherein said sets of belt members incline downwardly.

6. Apparatus of claim 1 including low-friction web support surfaces between adjacent belt members.

7. Apparatus for longitudinally and transversely drafting fibrous nonwoven webs comprising, in combination,

sets of drafting rolls for longitudinally drafting a web, and

at least two successive sets of upper and lower progressively diverging and longitudinally moving belts mounted to receive the drafted web, grasp the web between the upper and lower belts of each set, and carry the grasped web longitudinally through said sets of belts, the belts of each set being of substantially equal length and angular disposition with respect to the other belts of each set, said belts being mounted not in transverse axial alignment but located at spaced points along an arc such that the inward portions of the web while grasped between the belts travel substantially the same longitudinal distance as the edge portions of the web to stretch each transverse increment of said web laterally by approximately equal amounts and eliminate wrinkling and puckering in the resultant cross-drafted web.

8. A method for reducing thickness while maintaining substantially isotropic strength characteristics of a random web of textile fibers, comprising the steps of

1. longitudinally drafting said random web to stretch each longitudinal increment of said web a given amount, and
2. cross-drafting the longitudinally drafted web to stretch each transverse increment laterally substantially said amount, by

continuously, longitudinally feeding while progressively diverging said drafted web by grasping said web between at least two successive sets of upper and lower longitudinally moving diverging belts of substantially equal length and angular disposition with respect to the other belts of each set, the disposition of said belts being not in transverse axial alignment but located at spaced points lying along an arc such that the inward portions of the web while grasped between the belts travel the same longitudinal distance as the edge portions of the web to eliminate wrinkling and puckering in the resultant longitudinally and cross-drafted web.

9. A method for cross-drafting a web of textile fibers, comprising the steps of

continuously, longitudinally feeding said web,

progressively diverging said web while longitudinally feeding said web by grasping said web between at least two successive sets of upper and lower longitudinally moving diverging belts of substantially equal length and angular disposition with respect to the other belts of each set, the disposition of said belts being not in transverse axial alignment but located at spaced points lying along an arc such that the inward portions of the web while grasped by the belts travel the same longitudinal distance as the edge portions of the web to stretch each transverse increment of the web laterally by an approximately equal amount and eliminate wrinkling and puckering in the resultant cross-drafted web.

10. Method of claim 9 wherein said web is a previously drafted web of longitudinally alined textile fibers.

11. Method of claim 9 wherein said web is a random web of textile fibers.

12. Method of claim 9 wherein said web is stretched by at least about 50 percent.

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