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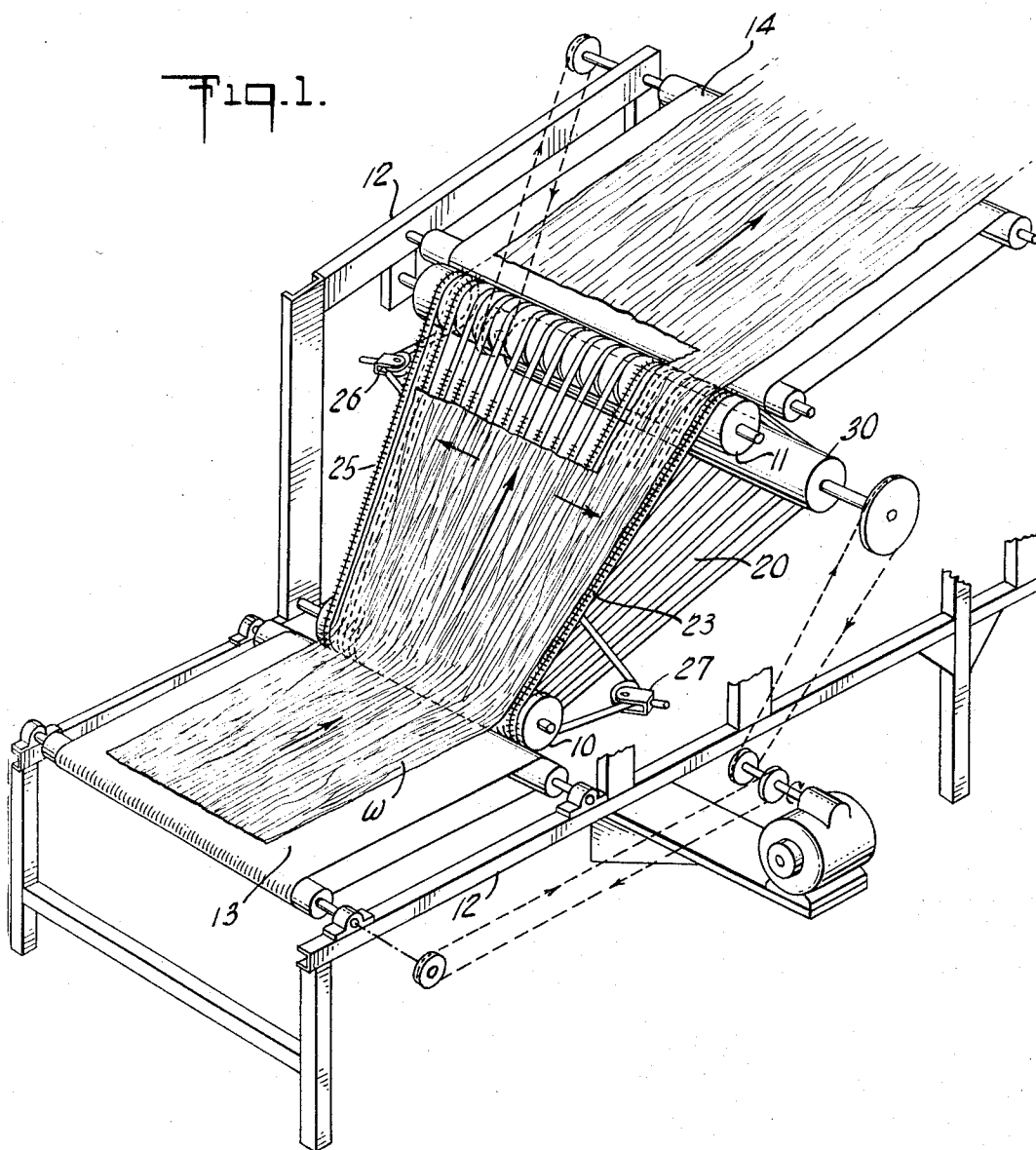
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3,303,547

CROSS STRETCHING MACHINE FOR NONWOVEN WEBS

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2 Sheets-Sheet 1



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2 Sheets-Sheet 2

Fig. 2.

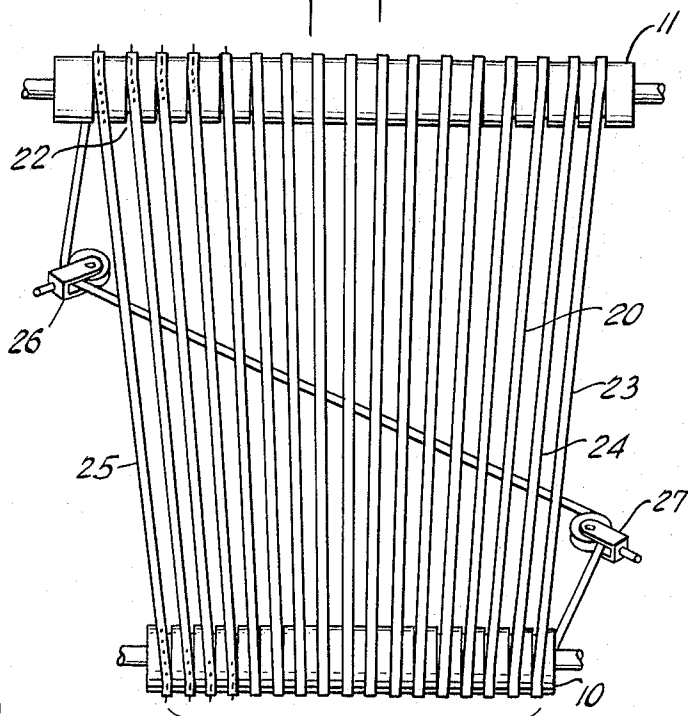


Fig. 3.

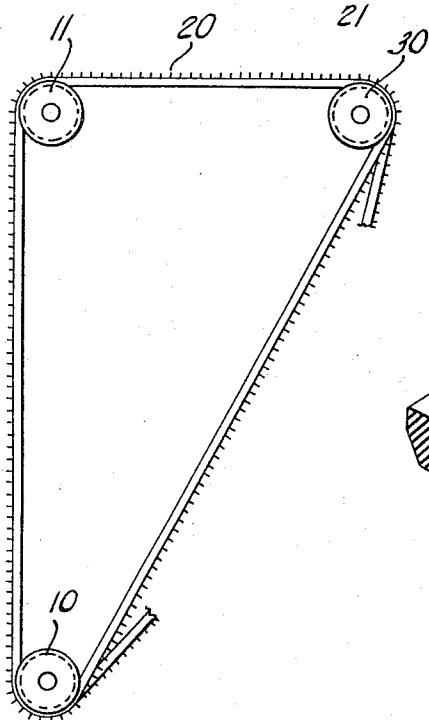
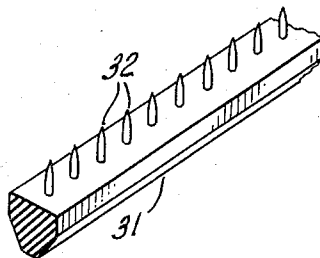


Fig. 4.



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**CROSS STRETCHING MACHINE  
FOR NONWOVEN WEBS**

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3 Claims. (Cl. 28—1)

This invention relates to a machine for transversely stretching webs of fibers, and particularly to such a machine capable of effecting uniform, controlled cross-stretching of a web of fibers in such a way that the fiber distribution in the resultant web is approximately as uniform as it was in the starting fibrous web.

Although the machine of the present invention is primarily designed for uniform cross-stretching of unbonded webs of nonwoven fibers, it can be used to perform this operation on wet prebonded nonwoven webs, dry nonwoven webs, and the like. If desired, the machine may also uniformly transversely stretch a web of fibers while simultaneously longitudinally shrinking the web.

Nonwoven fabrics are conventionally manufactured at the present time by producing a more or less tenuous web of loosely associated textile fibers disposed in sheet form (using any one of a variety of well-known procedures) and then bonding the sheet or web, to anchor or bond the individual fibers together. The conventional base material for such nonwoven fabrics is a web comprising any of the common textile-length fibers or mixtures thereof. The web may comprise natural fibers, such as cotton, wood, wool, jute, ramie, or abaca, or artificial fibers of viscose rayon, cuprammonium rayon, cellulose acetate, nylon, Dynel, or other materials, either alone or in combination with one another. The length of the individual fibers depends upon the ultimate purpose for which the web is intended. Ordinarily the fibers vary from approximately one-fourth to one-third of an inch as the lower limit to approximately two or more inches in staple length.

These fibers are customarily processed into web form by one of two general techniques, i.e., carding or the like to form an "oriented" web, or air-laying to form an "isotropic" web.

"Oriented" webs are made by passing the fibers through a conventional card to form a web or sheet of loosely associated fibers, and then superposing a plurality of these webs to provide a laminated web weighing approximately from 100 to 5000 grains per square yard. This web or sheet of fibers is produced continuously with most of the fibers substantially parallelized or oriented in the "machine direction," i.e., in the direction in which the product moves continuously from the sheet-forming machine. A web possessing substantially uniform density, wherein the fibers are distributed substantially uniformly throughout the area of the web, can be produced at relatively high speeds by this technique.

In a web produced as just described, it is difficult to measure fiber orientation directly because the individual fibers thereof are curled and bent, with various segments of the fibers extending in various directions. However, a kind of average orientation may be ascertained which is helpful in describing the physical characteristics of the web. This characteristic is called the "degree of fiber orientation." The "degree of fiber orientation" is determined by bonding the web uniformly with a material such as starch, drying the bonded web, measuring tensile strengths lengthwise and crosswise of the resulting fabric, and then 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. Thus, when long and cross

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tensile strengths are equal, the degree of "fiber orientation" is 50 percent.

Something more can be said generally about the positions in which the various fibers lie in the plane of the web. In a web wherein most of the fibers are substantially parallelized along the longitudinal axis of the web, the average angle between that axis and the individual fibers of the web is substantially zero. When an individual fiber is reoriented by the method of this invention to be described below, it is generally moved into a new position in which the angle it makes with the longitudinal axis of the web is increased. Thus the combined effect of the movement of all the fibers that are reoriented in the web is to increase the *average* angle between the longitudinal axis of the rearranged web and all the various fibers contained in the web. The frictional resistance between the individual fibers of any unbonded web to be processed in the machine of this invention is preferably low enough to permit rearrangement of the fibers in this way in the plane of the web without rupture of the web structure.

The bonding operation by which an oriented web is customarily converted into a fabric may be accomplished in one of several different ways. For example, one method is to impregnate the web over its entire width with various well-known bonding agents, such as, natural or synthetic resins. Another method is to print nonwoven webs with continuous straight or wavy lines of binder extending transversely or obliquely across the web. Still another method is to imprint on the web a discontinuous binder pattern, consisting of discrete, physically separate areas of binder, arranged in a staggered pattern.

Regardless of the bonding method used in producing a fabric directly from a web of oriented textile fibers, fabrics so formed have been subjected to a major disadvantage: The starting web, and thus also the resulting fabric, are "non-isotropic" in respect to their physical properties. In particular, the tensile strength of the resulting fabric transverse to the direction of fiber orientation (its "cross strength"), is very much less than the tensile strength of the fabric in a direction parallel to the fiber orientation (its "long strength"). As a result, oriented nonwoven fabrics heretofore have been characteristically weak in the cross direction, tending to rip or tear when the web is subjected to even a moderate cross extensional stress.

Various techniques have been proposed for forming webs wherein the fiber orientation is more or less random. These webs may be bonded to form "isotropic" nonwoven fabrics wherein the long and cross strengths are approximately equal. Conventionally, the fibers are dispersed in an air stream which is flowed through a continuously moving foraminous collecting member which in turn separates and removes the fibers from the stream. The fibers are deposited on the collecting member in the form of a web or layer which may be removed therefrom for bonding purposes.

Since, in air-laying, positive mechanical control of the fibers is not maintained during the time they are being carried in a stream or projected to the collecting member, considerable difficulty has been experienced in attempting to obtain a web having a uniform distribution. This is particularly true of light-weight webs wherein lack of uniformity will result in serious local weaknesses and even holes. While attention has been given to this difficulty in connection with the methods and apparatus disclosed in Plummer et al. United States Patents 2,676,363 and 2,676,364, the basic problem of controlling web uniformity is inherent in air deposition systems, particularly at normal economical production speeds for fabrics of this type.

There are also a number of machines for cross-stretch-

ing oriented webs either with or without concurrent long shrinking. Generally, such machines have some type of stretchable carrier which is alternately stretched and relaxed a number of times. Very often the stretchable carrier materials will not resist the repeated stretching and relaxing operation and lose adequate control over the cross-stretching of the fibrous web. Also the lack of control or poor control of the prior art machines do not uniformly cross-stretch the web, but rather over stretch the weak areas, and in fact, sometime rupture the web while failing to adequately cross-stretch the heavy areas of the web.

In accordance with the present invention, an unbonded web having a substantially uniform density throughout the area thereof formed of loosely associated textile fibers, such as, a carded web made from a multiplicity of superposed conventional card webs, which carded web weighs from approximately 100 to 5000 grains per square yard, in which the fibers are predominantly parallelized or oriented in the long direction, is subjected to a cross-stretching operation to move the originally parallelized fibers into a reoriented arrangement with the average angle between individual fibers and the longitudinal axis of the web increased.

The cross-stretching is effected in a direction substantially normal to the original direction of fiber orientation. This operation results in a deformation of the web in the plane thereof, increasing its dimensions transverse to the direction of the originally parallelized fibers. If the original web is overfed to the machine of the present invention, the web while being stretched crosswise will also shrink in a lengthwise direction.

During this web deformation, the fibers in the web are moved into reoriented positions, but in their new positions they still remain individually intermingled, overlapping and crossing other individual fibers in the web in frictional and mechanical engagement therewith.

Furthermore, in accordance with the present invention, the distribution of fibers in the web while being reduced by the crosswise stretching remains substantially uniform. The controlled cross-stretching of the web of the present invention does not allow over-stretching of the weak spots and under-stretching of the heavy spots but rather uniformly cross-stretches the entire web.

The reoriented web formed by the cross-stretching operation of the present invention, and then bonded to form the reoriented, nonwoven fabric of the present invention, brings about in the said fabric an increase in the strength of the fabric in the cross direction (the width), i.e., transverse to the direction of the originally parallelized fibers in the web. In other words, the reoriented web has the potential of being converted by bonding into a nonwoven fabric having an increased tensile strength in the cross direction as compared to the oriented nonwoven fabrics of the prior art.

The term "potential" tensile strength as applied to a web in the following description refers to the tensile strength of the fabric formed by bonding the fibers of a web into a unitary structure. The cross strength of the fabric is increased to the extent that the originally parallelized fibers in the web are moved or oriented away from the parallel.

In the reoriented web the density, while in most instances is reduced, is substantially uniform throughout the area thereof regardless of the thickness of the web or the speed at which it is produced. The preferred reoriented web is one wherein the average angle between individual fibers and the longitudinal axis of the web is increased to the point where the "degree of fiber orientation" is reduced to approximately 50 percent. A web approaching this preferred form in structure is capable when bonded of providing a long-to-cross tensile strength ratio of approximately one. This preferred web may be called a "pseudo-isotropic" web, because its potential tensile strength is of the same general order of magnitude in all directions,

being in fact substantially equal when measured along the two major axes at 90° to each other, i.e., the longitudinal and transverse axes of the web. Thus, the rearranged fiber web acts very much like a true "isotropic" web, and may for this reason be referred to as a "pseudo-isotropic" web.

In one embodiment of the present invention as the fibers of the original oriented web are reoriented to reduce the "degree of fiber orientation," the increased width of the web may be more or less compensated for by an accompanying long shrinking thereof, with the result that the reoriented pseudo-isotropic web may have an area substantially the same as the area of the starting conventional card web. If desired, the amount of long-shrinking may be controlled so as to compensate as nearly as possible for the cross-stretching, so as to keep the web area and web density substantially constant.

In accordance with the present invention and in its preferred form, the machine comprises a series of conveyor surfaces moving in the same plane and in the same general direction and in diverging paths. The conveyor surfaces have pins or points extending therefrom. A fibrous web placed on the narrow end of the conveyor surfaces is grabbed or controlled over substantially its entire area by the pins and as the web is conveyed, the pins move away from adjacent pins, thus cross-stretching the web uniformly over its entire area. The web is removed from the wide end of the conveyor surfaces and in its cross-stretched form moved on for further processing.

In the preferred machine the conveyor surfaces are made from a continuous narrow endless belt which passes a successive number of times about a pair of spaced apart rotating rolls. The surfaces of the belt are spaced closer together at the roller, at the feed end of the machine and diverge from each other as they extend to the roller at the take-off end of the machine. The endless belt allows each surface flight of the belt to be the correct distance as there is a slight difference in the length of each surface flight caused by the diverging paths the surface flights follow. Furthermore, the endless belt allows all surface flights to be placed under uniform tension by simply placing the endless narrow belt under tension. In the preferred embodiment of the machine of the present invention, there is no component which is alternately stretched and relaxed, and hence, the machine is not susceptible to the attending difficulties of change in degree of stretch but rather continually and uniformly cross-stretches fibrous webs over extended periods of time.

The pins or tapered implements on which the web is embedded in the machine of the present invention are spaced very close together in the area of the machine to which the web is fed providing excellent control over the entire area of the web as it is cross-stretched.

In one embodiment of the cross-stretching machine of the invention, the web is fed into the machine by a "wet-out" device comprising a pair of feed rollers, one of which is partially immersed in a water trough, and the web is thus saturated. It has been found that a saturation of about 200 percent to 300 percent with water provides very satisfactory results. The web may be wet with more or less water, as desired.

The water apparently acts also as a lubricant to facilitate movement of the fibers within the saturated web. The diverging paths of the conveyor surfaces with the fibrous web thereon causes the originally parallelized fibers of the web to gradually move angularly towards right angle relationship relative to their original direction. The extent to which the fibers are rearranged depends upon the amount of cross-stretching to which the web is subjected.

The stretching operation may be stopped at a point at which the average angle of the fibers relative to the longitudinal axis of the web is increased to the point where the "degree of fiber orientation" is reduced to approximately 50 percent. This directional rearrangement or reorienta-

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tion of the fibers increase very substantially the cross-strength of a fabric made by bonding the web.

The impaling of the web on the pins or other tapered implements on the diverging conveyor surfaces causes the web to be stretched uniformly through small increments throughout the width of the web. The uniform positive pin control prevents any substantial slippage except between fibers and provides complete control over the full width of the web at all times during the cross-stretching period.

The pins or tapered implements used in accordance with the machine of the present invention may be made of metal or rubber or similar materials. The pins are tapered and may be triangular, circular or other shapes. It is preferred that the pins be as closely spaced as possible and, for example, the conveyor may be covered with standard card clothing or with a pile fabric to give a surface with very closely spaced pins and produce better control of the fibrous web.

The structure by which the above-mentioned and other advantages of the invention are attained will be described in the following specification, taken in conjunction with the accompanying drawings, showing a preferred illustrative embodiment of the invention, in which:

FIGURE 1 is a view in perspective of the machine of the present invention with some portions omitted for the sake of clarity;

FIGURE 2 is a plan view of a machine embodying the invention, with some portions omitted to clarify the illustration;

FIGURE 3 is a side view of the machine shown in FIGURE 2;

FIGURE 4 is an enlarged fragmentary view in perspective showing a portion of the conveyor surface used for holding and guiding portions of the web being stretched.

Referring to the drawings in FIGURES 1, 2, and 3, there is shown a feed roller 10 mounted for rotation in frame 12 and a discharge or take-off roller 11 mounted for rotation in the frame. In FIGURE 1 a feed conveyor 13 brings the web W to be stretched to the feed end of the machine and a conveyor 14 positioned at the discharge end of the machine conveys the cross-stretched web away for further processing. An endless rubber V-belt 20 passes in a series of flights 21 (more clearly shown in FIGURE 2) between the feed roller and the discharge roller. The flights follow a diverging path from the feed roller to the discharge roller. The V-belt rides in a series of grooves 22 in both the feed roller and the discharge roller.

The first flight 23 of the V-belt shown at the extreme right of the machine passes from the feed roller to the discharge roller, around the discharge roller and back to the feed roller. The belt passes around the feed roller and forms the second flight 24 as it passes to the discharge roller and so on across the width of the machine. The flights all lie in the same plane and travel in the same general direction but in diverging paths from the feed roller to the discharge roller. As shown in the drawings, the width of the total flight is substantially wider at the discharge end of the machine as it is at the feed end of the machine.

After the belt has formed the last flight 25, i.e., at the extreme left of the machine, it passes about the discharge roller and then over a pair of pulleys 26 and 27 which direct the belt to the extreme right of the machine to form the first flight at the extreme right of the machine.

It is preferred that the tension roller 30 be the driven roll though any of the other rolls may also be driven or may be driven instead of the tension roller.

Each flight has a length slightly different than the other

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flights and the single endless V-belt conveyor allows for these differing lengths and when the single V-belt conveyor is tensioned, each flight is under a uniform tension thus producing uniform control throughout the area of the fibrous web as it is being cross-stretched.

The conveyor is placed under controlled tension by the tension roller 30.

As is more clearly shown in FIGURE 4, the belt is a V-belt 31 and the upper surface is covered with pins 32. The web is embedded on these pins as it is fed to the narrow end of the machine and as the V-belt surface flights with the pins thereon diverge, the web is cross-stretched over its entire area. The pins being very close together at the narrow end of the machine give excellent control over the entire web as it is being cross-stretched.

The amount of cross-stretching may be varied by removing the web from the conveyor elements at any point along their path or by controlling the amount of divergence of the conveyor elements.

Although the cross-stretching may be continued until the fibers are generally oriented more in a transverse than in a longitudinal direction, it is preferred to limit the stretching to a point where the degree of fiber orientation is approximately 50 percent, as this arrangement provides maximum potential tensile strength for the web.

While I have described a preferred embodiment of my invention in considerable detail, it will be understood that the description thereof is intended to be illustrative, rather than restrictive, as many details may be modified or changed without departing from the spirit or scope of the invention. Accordingly, I do not desire to be restricted to the exact construction described.

What is claimed is:

1. A machine for cross-stretching fibrous webs comprising: first and second spaced apart rotatable rolls, a narrow width endless belt extending in a series of adjacent flights between said rolls, said flights following divergent paths as they extend from the first roll to the second roll and convergent paths as they return from the second roll to the first roll, said flights having pins extending from the surface thereof, a third roll in contact with said convergent flights to apply uniform tension to all flights and means for driving one of said rolls whereby a fibrous web passing from said first roll to said second roll is cross-stretched under uniform tension.

2. A machine in accordance with claim 1 wherein the narrow width endless belt is a V-belt and the pins extend from the broad surface of said belt.

3. A machine in accordance with claim 1 wherein the second rotatable roll is spaced forward of and above said first rotatable roll whereby a retarding force due to the weight of fibers is placed on the fibrous web while it is being cross-stretched.

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