Sept. 29, 1970 R. L. STULTZ, JR 3,531,347

METHOD AND APPARATUS FOR BONDING BATTINGS OF CROSS-LAPPED WEBS OF CONTINUOUS FILAMENTS

Filed Aug. 25, 1966

Fig. 1.

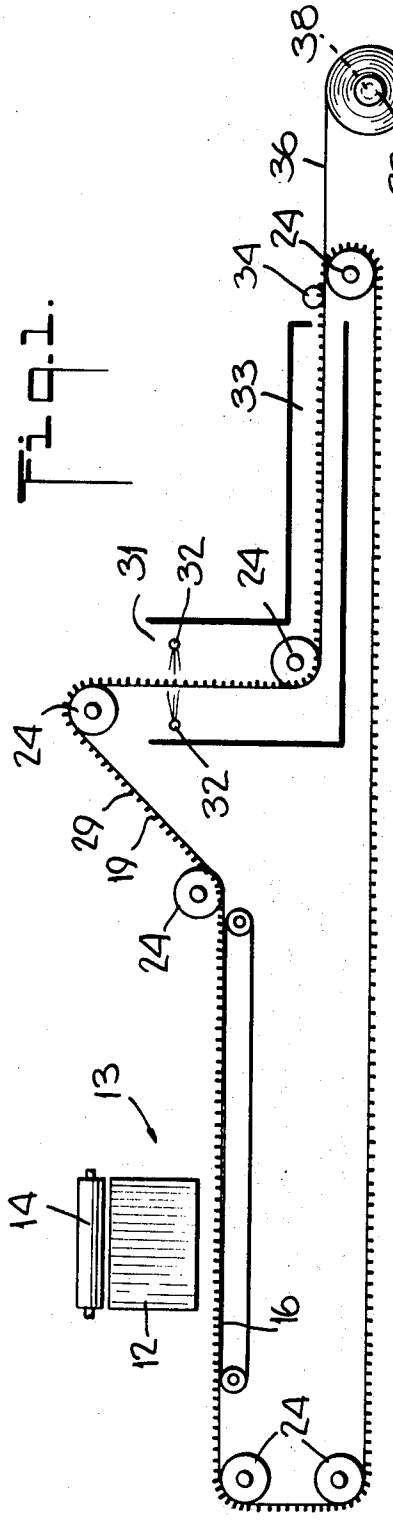


Fig. 3.

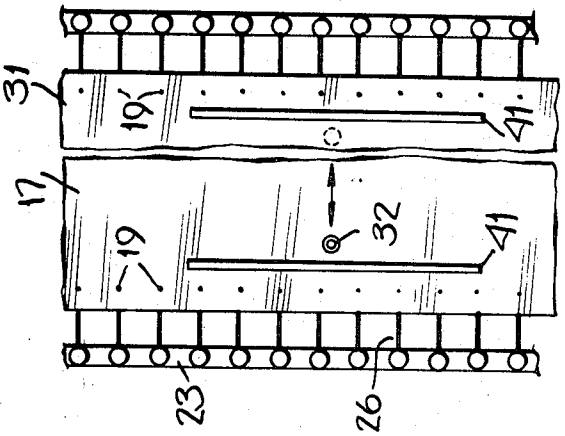
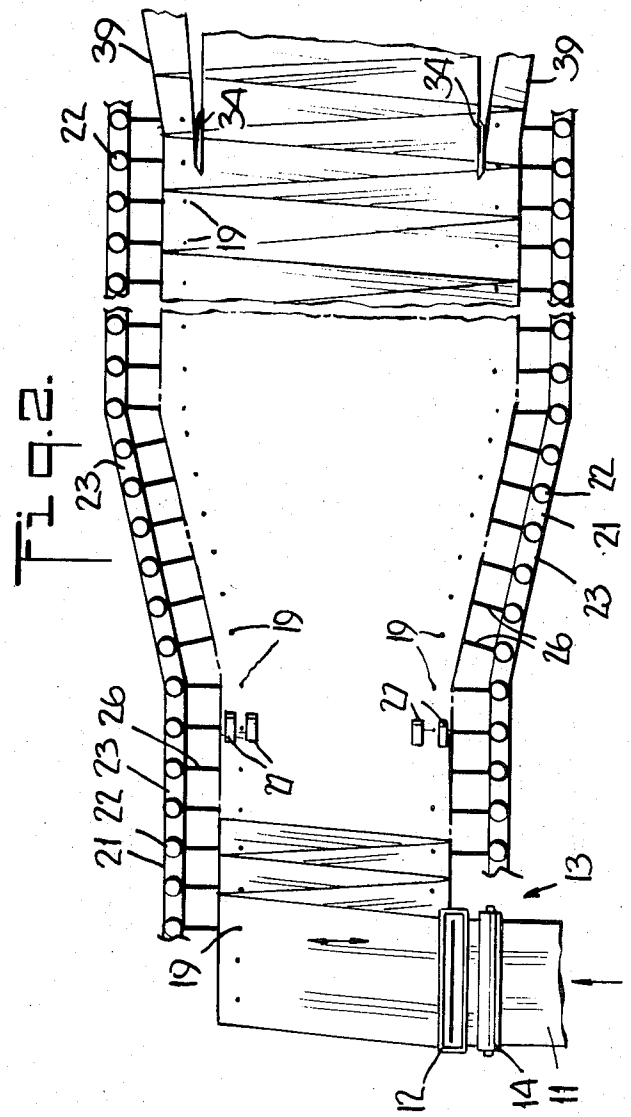


Fig. 2.



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METHOD AND APPARATUS FOR BONDING BATTINGS OF CROSS-LAPPED WEBS OF CONTINUOUS FILAMENTS

Robert L. Stultz, Jr., Charlotte, N.C., assignor to Celanese Corporation, New York, N.Y., a corporation of Delaware

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U.S. Cl. 156—164 10 Claims

ABSTRACT OF THE DISCLOSURE

Process and apparatus for treating cross-lapped batting by holding the batting in a taut condition utilizing edge engaging means, spraying bonding agent onto the batting while precluding deposition of the bonding agent onto the edge engaging means and adjacent portions of the batting.

This invention relates to the treatment of battings of continuous filaments and relates particularly to the application of a binding material to such battings continuously.

The production of battings from webs of continuous substantially parallel filaments by cross-lapping such webs has been described in Belgian Pat. 656,031. In certain cases, as disclosed therein, it is desirable that the batting be treated with a bonding agent, such as a thermoplastic resin, in limited amount, preferably insufficient to have a substantial effect on the porosity of the batting. Such a treatment bonds individual filaments to adjacent filaments of the batting at their points of contact and has the effect of increasing the stiffness and crush-resistance of the batting and giving the batting a crisper feel, which is desirable for many purposes, such as in the production of interlining fabrics, filling for quilted robes, and the like.

Attempts to apply the bonding agent by spraying it onto the batting have met with many difficulties. Thus, the sprayed batting tends to stick to the material on which it is supported, so that removal of the batting from its support often causes tangling or breaking of filaments and distortion and tearing of the batting. This occurs even when belts surfaced with non-stick material, such as polytetrafluoroethylene, are employed.

It is therefore an object of this invention to provide a new and improved method for applying a bonding agent to battings of cross-lapped webs of continuous filaments.

Other objects of this invention will be apparent from the following detailed description and claims. In this description and claims, all proportions are by weight unless otherwise indicated.

The unbonded battings which are treated in accordance with this invention are flexible, limp, flimsy structures of low modulus of elasticity, composed of unbonded layers of substantially parallel unbonded filaments which are loosely held together by fiber-to-fiber friction. They are easily distortable and have slight resistance to penetration even by relatively large bodies; typically holes can be formed in the battings by hand, and a blunt ½ inch diameter circular rod can be pushed through the battings without difficulty. Their uncompressed thicknesses are in the range of ½ inch to ½ foot, more usually about 2–5 inches, and their weight per square yard is usually in the range of about one ounce (for a batting ½ inch in thickness) to about 7 ounces (for a batting about 5 inches in thickness), their uncompressed weight per cubic foot being for example in the range of about 2 to 5 ounces per cubic foot. The battings may comprise, for example, 2 to 40, more preferably about 3 to 20, overlapping layers of the fine web material.

In accordance with one aspect of this invention, a batting of cross-lapped web of continuous filaments is held taut (i.e., under tension) while secured at its edges, preferably while substantially unsupported except at its edges, and is sprayed with a bonding agent while in its taut condition. In a preferred form, opposite edges of the batting are engaged by pins which are moved so as to increase the distance between said opposite edges and thereby place the batting under tension, and the tensioned but otherwise unsupported batting is transported by movement of the pins in a longitudinal direction (e.g. a direction parallel to said edges) to a spraying zone where a spray of the bonding agent is directed simultaneously, or successively if desired, at both sides of the tensioned batting.

One preferred form of the invention is illustrated in the accompanying drawings, largely schematic, in which:

FIG. 1 is a side view illustrating the overall process and apparatus;

FIG. 2 is a plan view showing portions of the apparatus of FIG. 1; and

FIG. 3 is a view in elevation, taken at right angles to FIG. 1 and showing the batting being sprayed.

In the illustrated embodiment, a spread web **11** (FIG. 2) of crimped continuous filaments, all substantially aligned with the direction of travel of the web, is fed continuously to the traversing chute **12** of a cross-lapping device designated generally as **13**. After passing over a driven feed roll **14** at the head of the chute **12**, the web moves down the chute, which is reciprocated back-and-forth (as indicated by the double-headed arrow in FIG. 2) over a continuously moving apron **16**, which may be in the form of an endless belt driven at a predetermined constant speed. The web **11** is thus folded back-and-forth in overlapping layers on the apron **16** to form a continuous cross-lapped batting **17**, the degree of overlap and the thickness of the web depending, of course, on the predetermined relationship between the speed and period of reciprocation of the traversing chute **12** and the forward speed of the apron.

At each longitudinal edge of the apron, there is a series of upstanding pins **19** for penetrating the outer edges of the folded web, the pins being preferably positioned so that they are engaged by the web as it falls onto the apron. These pins are mounted on a continuously driven endless tenter chain **21**, which may be of any suitable structure, such as two spaced series of interconnected wheels **22** riding in tracks **23** and over guide wheels **24**, and carrying pin-supporting arms **26**. The weight of the batting may be sufficient to cause it to be completely penetrated by the pins 19, but it is often advantageous to insure the desired penetration by pressing the batting downward on both sides of the pins, as by the use of spaced rotatable discs **27** mounted on stationary axes above the pins so that the lower part of each disc engages the upper face of the batting. The length of the traversing movement of the chute **12** is preset and coordinated with the lateral distance between the two sets of pins **19** at their line of contact with the batting **17**, so that the pins engage the batting a few inches (preferably less than about 3 inches and still more preferably less than about 2 inches, e.g. about 1 to 2 inches) inwards of the batting.

The apron **16** may be simply a stationary platform, preferably having a smooth surface on which the batting slides while it is moved forward by the engagement of its edges with the pins.

In one typical construction the upstanding pins **19** are 2 or more inches high and are spaced about ½ inch apart.

Downstream of the line of contact of the batting **17**

and pins **19**, the tracks may diverge slightly so as to stretch the batting in a direction transverse to its direction of forward movement; the degree of stretch is generally less than about 50% of the unstretched width of the batting, e.g. about 5 to 20%. It has been found that the batting on the pins surprisingly retains substantially its taut flat character and can be moved in virtually any direction, horizontally, vertically or inclined, for treatment. In the illustrated embodiment, the batting stretched between the pins is carried upwards on an inclined path **29**; then downward through a spraying zone **31**, in which a bonding agent is applied to both sides of the batting by means of a pair of spray guns **32**; then horizontally through a heated oven **33** where the bonding material is dried. The resulting bonded batting is then removed from the pins, as by slitting the batting longitudinally with a pair of suitable cutters, such as knives **34** (see also FIG. 2) engaging the batting along lines close to the pins. The central portion **36** of the batting, now freed of the pins, may then be suitably packaged, as by continuously winding it onto cores **37** mounted on a driven roll **38**, while the edge portions **39** of the batting are removed continuously from the pins **19** in any suitable manner.

In the spraying zone **31** it is preferable to substantially prevent the deposition of the bonding agent onto the pins and the adjacent portions of the batting. This makes it easier to remove the edge portions **39** of the batting from the pins and avoids the need for frequent cleaning of the pins; also, the uncontaminated fibers of the removed edge portions may be employed in a variety of uses, e.g. for the preparation of staple fiber battings or as stuffing material. In the illustrated embodiment there are, in the spraying zone **31** (see also FIG. 3), four vertical shields or baffles **41** (one for each face of the batting at each side) to prevent the deposition of bonding agent on the edge portions of the batting, and the spray guns **32** are mounted for continuous horizontal side-by-side movement across the faces of the batting (as indicated by the double headed arrow in FIG. 3) so as to spray each face uniformly. Although the slitting of the batting cuts substantially all the filaments, the product still basically has the characteristics of a batting of continuous filaments in that the individual filaments extend substantially unbroken across the width of the batting.

When the cross-lapping device illustrated in FIGS. 1 and 2 is used, the filaments of the batting are generally not quite perpendicular to the long axis of the batting, but instead make an average angle well below 10°, generally less than 5°, e.g. in the range of 1 to 3°, to the perpendicular. It is also within the broader scope of this invention to employ cross-lapped battings in which this average angle is about 90°, i.e. battings in which the filaments of the batting run substantially longitudinally of the batting.

While the invention has been illustrated using pins for engaging the edges, it is also within the broader scope of the invention to employ clips, clamps or other suitable edge-engaging devices in place of the simple and economical pins.

The bonding agent is generally applied in amount insufficient to appreciably affect the perviousness (to air) of the treated batting. One suitable range of proportions is about 8 to 50 (preferably about 15 to 20) parts by weight (of the dried bonding agent) per 100 parts by weight of the fibers of the batting. Examples of suitable bonding agents are well known in the art and include polymeric materials, such as homopolymers and copolymers of vinyl chloride, vinyl acetate, acrylates or methacrylates (e.g. butyl acrylate) or butadiene (e.g. rubbery butadiene-acrylonitrile or butadiene-styrene copolymers); polyvinyl alcohol; melamine-formaldehyde resins, etc. The bonding agent is generally applied in liquid condition, preferably dispersed (dissolved or suspended) in a liquid carrier, such as a volatile solvent (e.g. acetone) or non-solvent (e.g. water). The concentration of the bonding agent in the liquid carrier is usually within the range of about 5 to 60%, preferably in the range of about 12 to 25%.

The bonding agent is preferably applied to the batting in such a manner as to penetrate into and be deposited throughout, the thickness of the batting. A forceful, highly penetrating spray can be applied to the taut batting to obtain deep and thorough penetration. Alternatively, as by the use of lower spraying pressures or larger sprayed particles, a less penetrating spray may be applied so that the bonding agent is concentrated at the surface fibers of the batting. The batting may, as illustrated, be sprayed from both sides simultaneously, continuously, in contrast to processes in which the batting is sprayed on one side, rolled up, unrolled and sprayed on its other side. The spray guns may be stationary or they may be oscillated across the faces of the batting; when oscillated they may be aligned, and in phase, so as to face each other (on opposite sides of the batting) or they may be out of alignment.

The fine webs used as the feed material for making the battings in the preferred form of the invention may be produced from tows of crimped continuous filaments by first opening the tow to disalign the crimps of adjacent filaments and then spreading the tow, preferably with an air-spreading device to produce the fine web. An excellent filamentary material for this purpose is polyethylene terephthalate, but it is within the broad scope of the invention to use other filaments, such as those made of other polyesters (e.g. the polyesters of terephthalic acid and other glycols such as dimethylol cyclohexane), linear superpolyamides (such as nylon 6 or nylon 6, 6) polyacrylonitrile and copolymers of acrylonitrile, olefinic polymers and copolymers, e.g. isotactic polypropylene, secondary cellulose acetate (of the usual acetyl content, e.g. about 54–55% calculated as acetic acid), other organic derivatives of cellulose such as esters and/or ethers of cellulose, for example cellulose propionate and cellulose acetate propionate or the like, highly esterified cellulose containing less than 0.29 free hydroxyl groups per anhydroglucose unit such as cellulose tricetate, rayon (regenerated cellulose) etc. The number of filaments of the starting tow can vary within wide limits and may range up to as high as 1,000,000, with a denier per filament as high as 25, e.g. 1 to 20. The number of crimps per inch of tow may range up to as high as about 80, but for most end products to be described herein about 3 to 30, preferably about 8 to 15, crimps per inch of starting tow are found sufficient.

The tow may be conveniently opened, to prepare it for the air spreading steps by subjecting it, while moving in a predetermined path, to a differential gripping action between a plurality of points spaced from one another both longitudinally and transversely of the path, so that certain laterally spaced sections of the tow are positively gripped relative to other laterally spaced sections of the two, alternating with the said gripped sections, which are not gripped at all or are gripped at different relative points. In this manner there is produced, as a function of the differential positive gripping of the tow, a relative shifting of adjacent filaments longitudinally of the tow, whereby the crimps are moved out of registry with one another. Preferably, although not necessarily, the differential gripping action is such that a relative lateral displacement between adjacent filaments of the tow is also effected, so that the combination of two transverse filament movements brings about the complete opening of the tow.

The differential gripping action may be achieved by the provision of at least one pair of rolls, one of which is smooth-surfaced and the other of which is grooved over its entire periphery; if desired, there may be a plurality of such pairs of rolls arranged in tandem. On each grooved roll, the grooves and the ridges alternating there-

with may extend obliquely or helically in opposite senses from its center to its opposite ends. Thus, when the tow passes between the two rolls of any given pair of one grooved and one smooth-surfaced roll, some of the tow sections are gripped between the peaks of the ridges of the groved roll and the outer peripheral surface of the opposed smooth-surfaced roll, while other sections of the tow which are at that time located in registry with the spaces between the ridges of the grooved roll are not gripped between the latter and the smooth-surfaced roll. Generally only one roll of each pair is positively driven while the other is yieldably biased toward it and rotates due to the passing of the tow between the rolls.

The tow-opening process is illustrated in U.S. Pats. Nos. 3,156,016 and 3,032,829.

In the preferred method of spreading the tow is passed through an air spreader in which the moving tow, in flattened condition, is confined between parallel walls while streams of air or other suitable gas are directed at the tow across its full width. Advantageously, the air spreading is effected in a plurality of stages in each of which the tow is spread to a greater width than in the preceding stage. For best results the tow in any one stage is isolated from the effect of the following stage as by passing the tow between stages firmly in contact with a surface moving at a controlled rate, e.g. around and between a pair of driven nip-defining rolls.

By air spreading it is possible to spread the tow readily, and very evenly, to great widths to produce webs of extreme fineness, such as webs containing less than about 500, e.g. 100 filaments per inch of width, and in which the average air space per fil has a positive value, preferably appreciably greater than the diameter of the filaments. The average air space per fil is the average space between the filaments of the web measured on a line in the plane of the web, perpendicular to the longitudinal direction of the filaments of the web, said space being calculated on the assumption that all the filaments are arranged in a single plane, with no filaments crossing other filaments. It may be calculated simply from a knowledge of the average diameter of the filaments (D_F), the width (w) of the substantially uniform web and the number of filaments (n) in said width, according to the formula: Average Air Space Per

$$\text{Fil} = (w - nD_F) \div n.$$

In the preferred forms of the invention, the average air space per fil is a plurality of times (e.g. 2, 5, 10 or more times) as great as the average filament diameter, and the density of the web is at most about one ounce per square yard and most preferably well below one ounce per square yard, e.g. 1/10 to 1/4 or 1/2 ounce per square yard.

The air spreaders themselves advantageously have air-delivery slits or other suitable openings in one or both of the parallel walls between which the tow passes, said slits leading from a plenum chamber supplied with air at constant pressure. In one highly effective construction there are a series of slits, each running in a direction transverse to the direction of movement of the tow and so arranged that all portions of the tow are subjected to the air streams from said slits. It has been found that even when the width of the air spreader is 8 feet or more, the tow spreads uniformly and the outer edges of the tow, where the resistance to the air would be expected to be less, attain substantially the same density as the central portions of the tow.

In cross-section the air-delivery slits are preferably tapered, narrowing toward their outlets. The tapering may be symmetrical about an axis perpendicular to the face of the web so that the air is blown straight at said face, or the slits may be inclined so that the air imparts a forward or backward force to the moving tow.

The pressure in the plenum chamber may vary, one suitable range being about 1 to 5 p.s.i.g.; higher pressures may be used, e.g. 100 p.s.i.g. but these are economically wasteful. The pressure in the tow-confining zone, between the parallel walls, is believed to be a little less than atmospheric. When the air is blown straight at the face of the web, the air generally leaves the tow-confining zone from both ends of said zone. Little air is needed to expand the tow. Despite the fineness of the webs, the walls of the tow-confining zones of the air spreaders need not be correspondingly close together; thus very good results have been obtained with tow-confining slots 1/10 inch in width.

In the preferred fine webs all the continuous filaments are substantially parallel; that is, they run in the same general direction, lengthwise of the web. However when one does not look at the whole of the long length of any particular filament, but looks instead at the individual crimps thereof, it will be seen that most portions of the filament do not run in this general lengthwise direction but instead zigzag back-and-forth across such general direction. The amplitude of the crimps is such that, for any particular filament, the portion of the crimp at one side (hereafter termed the "crest" of the crimp) overlaps one or more neighboring filaments while the portion of the crimp at the other side (hereafter termed the "valley" of the crimp) overlaps one or more of its neighboring filaments on said other side. This overlap helps to give the webs their cohesiveness. For example, the filaments in the web may have a crimp whose amplitude (from a median line running in the same direction as the filament) is in the range of about 1/128 to 3/16 inch, said amplitude being measured from said median line to the top of a crest, or to the bottom of a valley. Since there may, for example, be several hundred filaments per inch of web width, and since the crimps are not in registry, there will be considerable overlapping of filaments in the web.

When one turns from an examination of the crimps and takes a somewhat larger, though still relatively short, view of the portion of any particular filament which contains several crimps, and which may be for example 1/2 inch to several inches long, it will be found that these portions are not perfectly parallel to the longitudinal direction of the web, but make small angles therewith, which angles change in direction and magnitude along the length of the filament; generally these angles are less than 20°, although for very short portions (e.g. 1/2 inch long) the angle may be larger at times.

It is believed that the overlapping of the crimps and the overlapping due to the presence of the angularly disposed short portions, just described, contribute to the cohesiveness of the web so that, despite its fineness, it can be readily handled as a unitary structure. The degree to which the individual filaments meander by virtue of the presence of said crimps and angularly disposed short portions is not, however, very great; typically, the ratio of the straightened lengths of the individual filaments to the lengths of the same filaments in the web is less than about 1 1/2:1 and, preferably, greater than 1.1:1, e.g. about 1.2:1 to 1.4:1. This ratio may be measured by cutting a predetermined length of the web, removing the individual filaments of the cut portion and measuring their lengths while under a tension just sufficient to remove the crimp; the results are then expressed as the ratio between the measured lengths of the individual filaments and said predetermined cut length.

In specifying denier per filament and total denier, the number given herein, with respect to tows and webs, is the denier for the filaments prior to crimping, i.e. the weight of 9000 meters of straight filaments; the weight of 9000 meters of crimped, unstraightened filaments or tow will naturally be greater than these values.

The following example is given to illustrate this invention further:

EXAMPLE

A 5 denier per filament 140,000 total denier tow of polyethylene terephthalate filaments having about 10 crimps per inch is deregistered on grooved roll equipment as described above, then spread to a width of 50 inches (and a weight of about 0.3 ounce per square yard) with a series of air spreaders, as described previously, and cross-lapped onto a continuously moving apron at each of whose sides is a series of upstanding pins moving with the apron. The two series of pins are spaced about 40 inches apart, across the apron. In each series the pins are about 2½ inches high and spaced about 2 inches apart. The cross-lapping is conducted so that the batting has an uncompressed thickness of about 3½ inches and a weight of about 3 ounces per square yard. As the cross-lapped structure moves horizontally with the apron, the two series of pins diverge so as to increase the distance between them by 10%; very little force is required to do this and negligible distortion of the batting occurs, but the divergence causes the batting to be held very firmly on the pins (so that the two series of pins can even be turned upside-down without the taut batting falling off the pins). The batting, taut on the pins, is then carried thereby to a spraying station, where an aqueous polybutyl acrylate latex is atomized thereon by means of opposed spray guns, and then to a drying oven. A well-bonded product, in which the fibers are bonded together at their cross-overs by the polybutyl acrylate resin, is obtained.

When the divergence is 50% instead of 10%, much of the crimp in the filaments is removed and linear openings extending transversely of the taut batting began to appear. When the divergence is increased to 100% the force required to move the two sets of pins apart is considerably greater and the batting is very non-uniform, a significant realignment of the filaments having taken place.

It is to be understood that the foregoing detailed description is given merely by way of illustration, and that variations may be made therein without departing from the spirit of this invention.

The embodiment of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. Process for the treatment of a batting comprising a cross-lapped nonwoven web of substantially parallel filaments, said filaments extending across the width of said batting, said batting being a flexible, limp, flimsy, easily distortable, unbonded structure whose filaments are loosely held together by fiber-to-fiber friction, said process comprising engaging the opposite longitudinal edges of said batting and supporting said batting in taut condition by said engagement, spraying a bonding agent onto said batting in a treatment zone in said taut condition while simultaneously substantially precluding the deposition of said bonding agent onto the edge engaging means and adjacent edge portions of the batting.

2. Process as in claim **1** in which a bonding agent is sprayed onto said taut batting in said treatment zone in an amount from 8 to 50 parts by weight of the dried bonding agent per 100 parts by weight of the fibers of the batting.

3. Process as in claim **1** in which the batting carrying the bonding agent is dried in said treatment zone.

4. Process as in claim **1** in which said filaments are crimped and make an average angle of less than 5° with a line perpendicular to the length of said batting.

5. Process as in claim **4** in which said web is cross-lapped continuously on a surface continuously moving transversely to said web, the cross-lapped material is continuously penetrated by edge engaging means adjacent its edges, and said engaging means are then moved apart to make said batting taut, said batting in said treatment zone being substantially unsupported except at said edges.

6. Process as in claim **5** in which a bonding agent is sprayed onto said taut batting in said treatment zone, said batting is dried in taut condition, and said batting is severed longitudinally adjacent said edges to remove the portions of said batting engaged by said elements.

7. Process as in claim **5** in which the extent to which said elements are moved apart is less than 20% of the unstretched width of the batting.

8. Apparatus for the production of treated battings comprising means for supplying a nonwoven web of substantially parallel continuous filaments, means for cross-lapping said web to form a cross-lapped batting, said batting being a flexible, limp, flimsy, easily distortable, unbonded structure whose filaments are loosely held together by fiber-to-fiber friction, means providing a batting-treatment zone, said treatment zone also including vertical baffle means for substantially preventing the deposition of bonding agent onto said engaging means and adjacent edge portions of said batting, and means for engaging the opposite longitudinal edges of said batting and for transporting said batting through said treatment zone in taut condition, including means for increasing the distance between said edge engaging means after said engaging means are engaged in the batting.

9. Apparatus as in claim **8** in which said means for engaging the edges comprise two series of batting-penetrating pins at said opposite edges.

10. Apparatus as in claim **9** and including means for severing said taut batting longitudinally adjacent said edges to remove the portions of said batting engaged by said pins.

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PHILIP DIER, Primary Examiner

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