# United States Patent [19]

**Yazawa et al.**

[11] **3,859,156**

[45] **Jan. 7, 1975**


[54] **METHOD FOR LAMINATING WARP AND WEFT OF FIBROUS MATERIALS IN A WET MANNER**


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[30] **Foreign Application Priority Data**

Jan. 18, 1973 Japan .................................. 48-8123

[52] **U.S. Cl.** .................. **156/265,** 28/1 CL, 156/519

[51] **Int. Cl.** .............................................. **B32b 31/00**

[58] **Field of Search** ....... 28/1 CL; 19/163; 156/264, 156/265, 163, 300, 164, 302, 176, 303, 180, 309, 181, 517, 521, 519, 307, 281, 313, 285; 214/6 B; 161/55, 60



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[57] **ABSTRACT**

A laminate of warp and weft is prepared according to an efficient wet process by putting webs of wefts each consisting of a number of fibrous materials arranged in order in a flat layer and in a certain width, and cut to a length corresponding to the width of a warp web consisting of a number of fibrous materials arranged in order in a flat layer and in a certain width, on the surface of a circulating endless belt wetted with water to attach the cut weft webs onto the surface of the belt one by one with a certain spacing during the upper circulating course of the belt while maintaining the original state of the arrangement of the web by the surface tension of water; and dropping the cut webs one by one from said endless belt during the lower circulating course of the belt, upon the warp web, travelling crosswise below the circulating belt with a small gap, by pushing linear edges which are situated inside the back-surface of the cut weft web on the carrying belt thereof, crosswise to the cut weft webs and arranged in a number of rows, downward from the surface level of the belt, to successively attach the cut weft webs onto the warp webs and then bonding both the webs.

**6 Claims, 18 Drawing Figures**

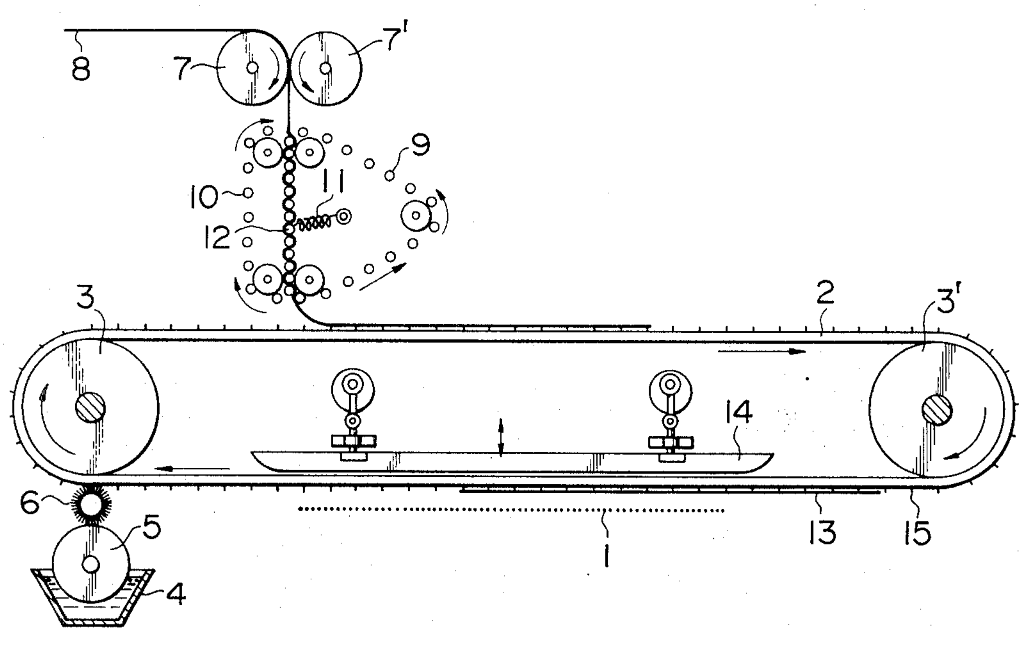
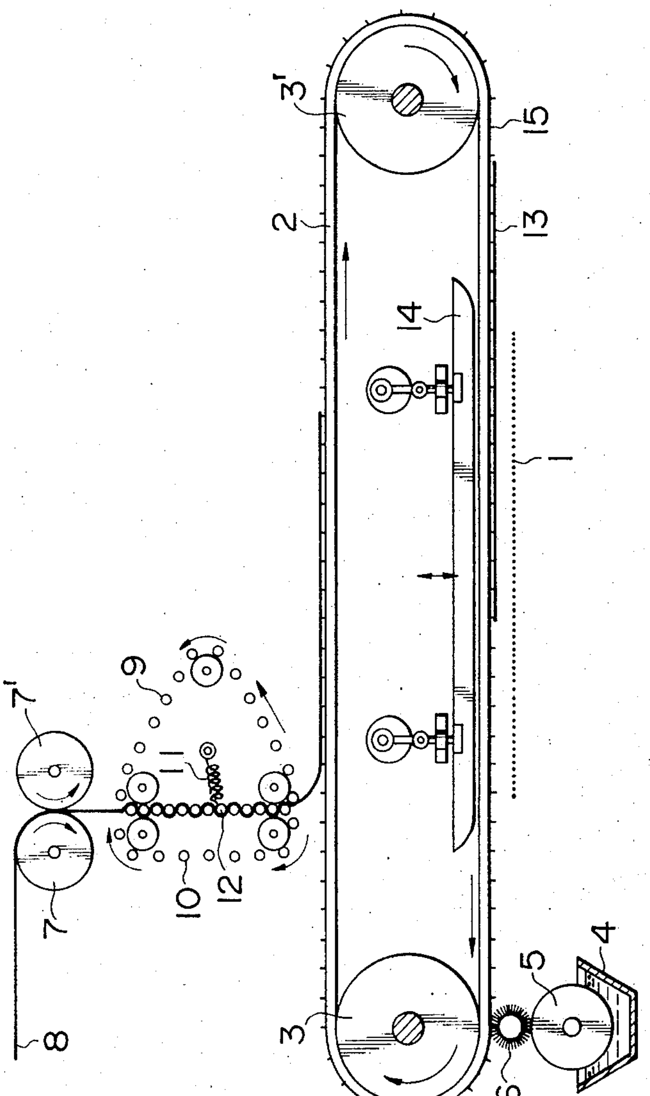



FIG. 1



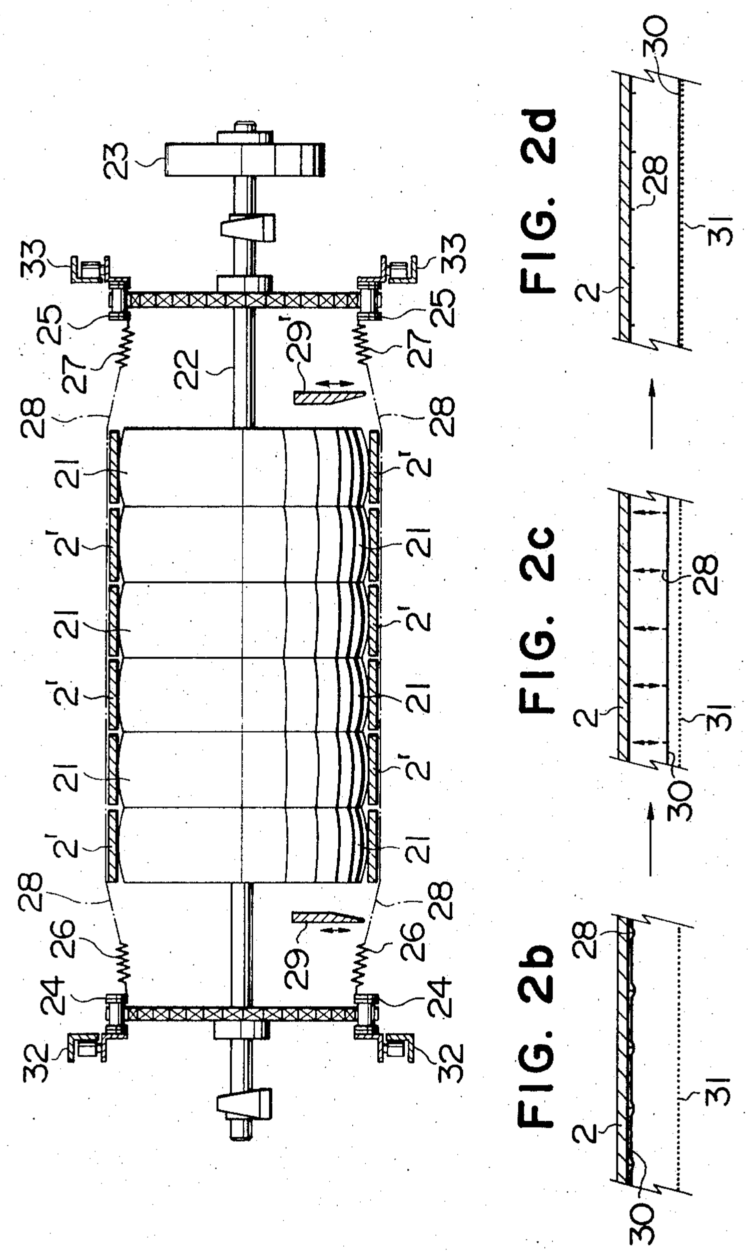



FIG. 2a

FIG. 2b

FIG. 2c

FIG. 2d

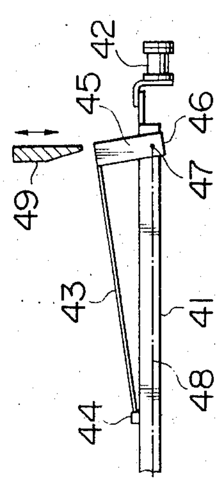



FIG. 3a

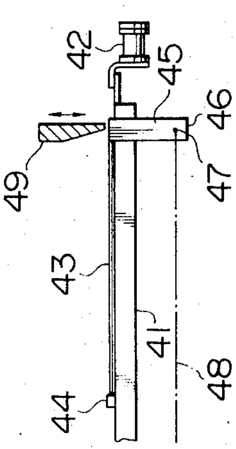



FIG. 3b

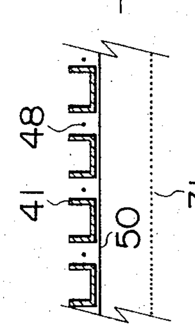



FIG. 3c

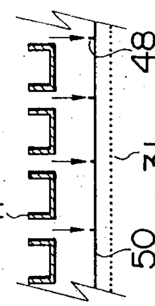



FIG. 3d

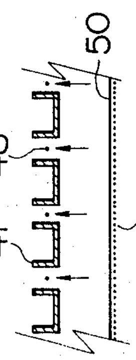



FIG. 3e

FIG. 4a

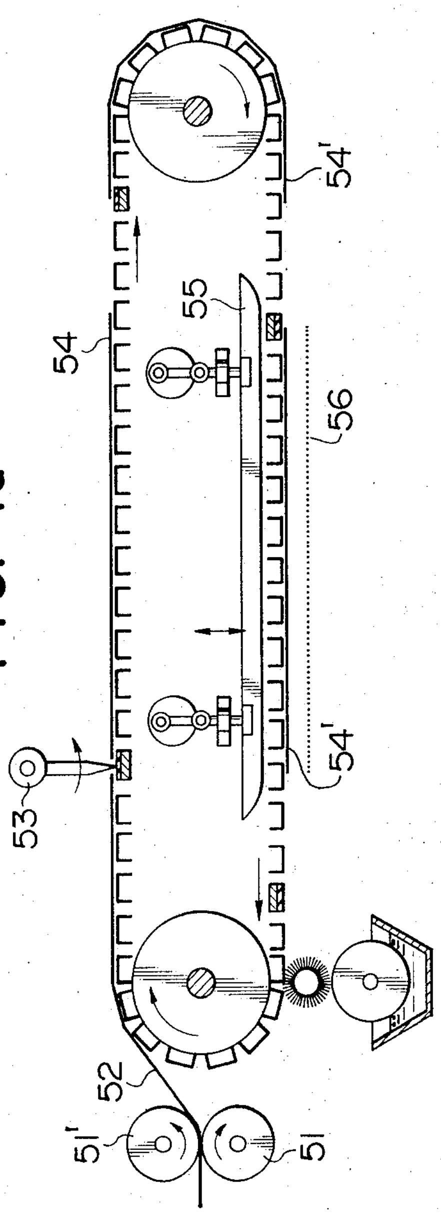



FIG. 4c

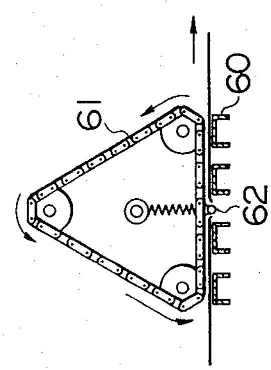



FIG. 4b

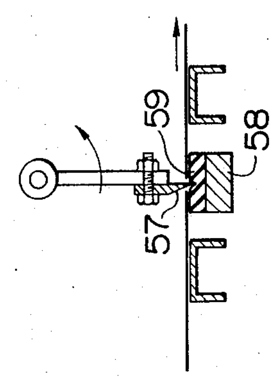


FIG. 5a

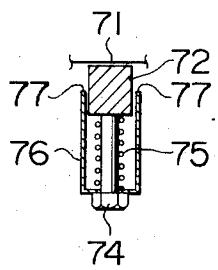



FIG. 5b

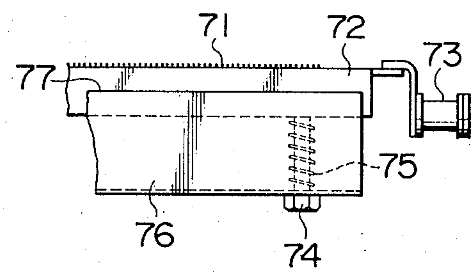



FIG. 5c

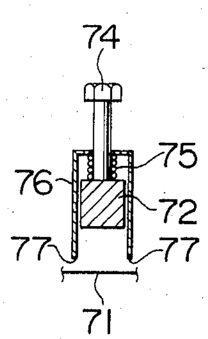



FIG. 5d

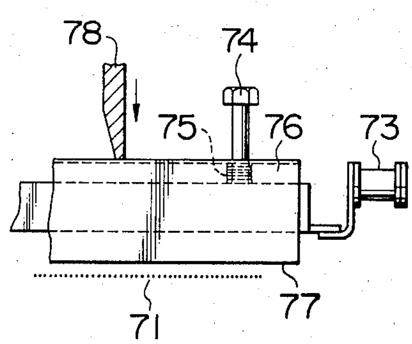
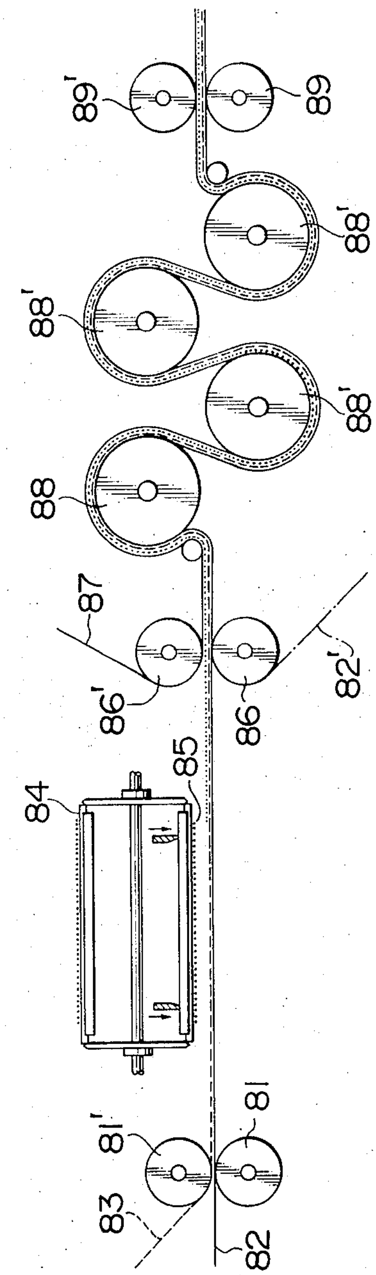


FIG. 6



# METHOD FOR LAMINATING WARP AND WEFT OF FIBROUS MATERIALS IN A WET MANNER

## DESCRIPTION OF THE INVENTION

This invention relates to an effective method for a high speed production of non-woven fabrics of laminated warp and weft webs. More particularly, it relates to a wet process for laminating warp and weft fibrous materials which comprises putting cut weft webs consisting of several hundreds or more of elongated fibrous materials arranged in a broad width, cut into a required weft length and attached on a wet belt, circulating along an upper and a lower horizontal circulating courses at a speed faster than the feeding speed of the weft web, upon a travelling warp web which consists of several hundreds or more of elongated fibrous materials arranged in a certain width e.g., 1 m, by means of pushing down a number of parallel linear edges positioned crosswise to the cut weft web, from the backside thereof, to knock said web off the belt over the whole length and width of the cut weft web towards the warp web, and if necessary while utilizing a suction force from the back-side of the warp web, thereby to overlay each of the cut weft webs one by one crosswise upon the warp web without forming any gap between each of the cut weft webs on the warp web and bonding both the webs, using adhesives, in the manner different from that of ordinary woven fabrics in which case each yarn for weft is filled by a shuttle one by one.

In the specification of the present invention, a thin, flat layer material composed of several hundreds or more of elongated fibrous materials substantially arranged in parallel in a certain broad width, say 1 meter wide, is denoted for simplicity as "a web;" a web used as a warp-side component is denoted as "warp web" and that used as a weft-side component as "weft web;" that of a weft web cut into a required weft length is denoted as a "cut weft web;" and a product obtained by crossoverlaying weft webs on a warp web and bonding both the webs in one sheet of a laminate, is denoted as "laminate of warp and weft" or "non-woven fabrics of warp and weft" case by case.

We proposed once a dry laminating process of non-woven fabrics of warp and weft in which a weft web is gripped at its forward tip end by a gripping means, transported over a warp web, cut at the backward end thereof at the position being wholly overlapped with the warp web and made to fall upon the warp web by a suction force from back side of the warp web to be laminated, but this process had such a drawback that the arrangement of fibers is liable to be disturbed due to the static electricity and turbulence of environmental air at the time of cross-overlaying.

According to the present invention, since the cut weft web adheres to a wet belt, maintaining the arrangement of fibers at the time of feeding by the surface tension of water, and since the warp web also in most cases holds its arranged state by another wetted belt as explained later, there is no disadvantage of disturbance of fiber arrangement caused by static electricity and turbulence of surrounding air at the time of cross-overlaying as often encountered in the dry laminating process, and thus it is a notable feature of the present invention that such a high production rate of non-woven fabrics of warp and weft as about 100 $m^2$/min. can be easily attained with a high accuracy of fiber arrangement.

As a means for knocking cut weft webs off the weft-carrying belt onto warp web, there are provided a number of linear edges which are situated crosswise to the weft web, on the back side of wet cut weft web adhering to the belt and inside the course of circulation of said cut weft web, and circulated at a speed same with that of said belt. The linear edges are pushed down and drawn back over the entire length and entire width of the cut weft web whenever the cut weft web comes to the position exactly crosswise overlapped with the warp web after overlaid.

Several effective examples of feeding method of cut weft webs and kind and fixing manner of linear edges which are varied according to the kind of belt, as explained later, are also the features of the present invention.

The fibrous materials useful in the method of the present invention include spun yarns, filament yarns, bristles, stretched tapes, split yarns, uniaxially stretched films of a broad width, split webs which are composed of narrow tapes or fibers of reticular structure obtained by splitting uniaxially stretched films of a broad width, or webs of spread split webs into several times the original width, fine metal filament yarns, glass fiber yarns, carbon fiber yarns, carded webs having continuity and some extent of orientation of fibers, etc. made of natural or artificial materials of organic or inorganic origins.

Further these fibrous materials are used as one kind of material or as a combination of more than one kind.

When the fiber arrangement of a cross-overlaid product is fixed for uses as non-woven fabrics, they are processed according to several different ways. Namely, fibrous materials for warp and weft webs are sized in advance and subjected to cross-overlaying or adhesive films are placed between warp and weft in the cross-overlaying step and then fixing of fiber arrangement thereof is carried out by heat-pressing adhesion, or warp and weft webs are sized and dried after cross-overlaying and then fixing of fiber arrangement is carried out by heat-pressing adhesion.

When non-woven fabrics of laminates of warp and weft are sized, scattering of a small amount of (2–6g/$m^2$) of pulp fibers having a length of 1–3 mm or natural or aritifical short fibers having a length less than 5 mm onto the non-woven fabrics before winding-up can completely prevent blocking between wound-up layers in case where a soft and tacky sizing agent is used, and at the same time, the non-woven fabrics are strengthened by such scattered and attached short fibers. If carded staple fiber webs of slightly longer fibers are attached, the open spaces of crossed fiber materials of warp and weft layers are subdivided further by short fibers to give non-woven fabrics which do not permit small granular material or powder to come out therethrough.

For attaching fibrous materials of a warp or weft web onto a belt, a liquid, though it does not matter what kind of liquid may be used, generally water or a liquid obtained by adding a surfactant to water to improve the spreading or wetting property of water is used. It goes without saying that water which contains a sizing agent or the like as a viscidity-promoting agent is useful under certain circumstances.

The point is, however, that a web of fibrous materials is attached onto a belt by the surface tension of water to keep the arranged state thereof at the time of feeding on the belt, and in case of a cut weft web, in particular, it would be good if the surface of the belt is wetted with thin water film to get such an extent of adhesion that when a cut weft web placed upon the travelling belt in the upper circulating course, is brought to the lower circulating course, the cut weft web attached to the belt is kept without falling down upon the travelling warp web by its own weight till the attached weft web is peeled off from the belt by the pushing down action of the linear edges which are supposed to knock off the cut weft web from the belt and made to drop upon the travelling warp web.

Several embodiments of the method of the present invention will be described by referring to attached schematic drawings.

FIG. **1** is a schematic view of the vertical cross-section of the apparatus useful for putting one embodiment of the present invention into practice.

FIG. **2** a is a schematic view of the cross-section of a web-carrying multiple belt composed of a number of narrow belts when it is running in the direction perpendicular to the plane of paper.

FIGS. **2***b*, **2***c* and **2***d* are schematic views showing the progress of relative positions of knocking off of water-adhering cut weft web from the belt toward and upon warp web by strings as linear edges.

FIGS. **3***a* and **3***b* are the vertical cross-sectional views of one end part of a lattice element including a device for pushing down and drawing back a string as one of linear edges for knocking off a cut weft web when a belt for carrying cut weft webs is a lattice belt.

FIGS. **3***c*, **3***d* and **3***e* are the vertical cross-sectional views showing the relative positions of knocking off a cut weft web from the belt by the movement of strings as linear edges in case of a lattice belt.

FIG. **4***a* is a vertical cross-sectional view of a lattice belt including pinch rollers, a weft web cutter and a ski edge in the present invention.

FIG. **4***b* is a vertical cross-sectional view of a knife type weft web cutter working upon weft web.

FIG. **4***c* is a vertical cross-sectional view of a melt type weft web cutter working upon weft web.

FIG. **5***a* is a vertical cross-sectional view of one lattice element of a lattice belt and edges of U-form thin plate during the upper circulating course of a belt. FIG. **5***b* is a vertical cross-sectional view of the lattice element of FIG. **5***a* during the upper circulating course of a belt viewed from the direction perpendicular to the section shown in FIG. **5***a*.

FIG. **5***c* is a vertical cross-sectional view of one lattice element of a lattice belt and edges of U-form thin plate during the lower circulating course of a belt.

FIG. **5***d* is a vertical cross-sectional view of the lattice element of FIG. **5***c* during the lower circulating course of a belt viewed from the direction perpendicular to the section shown in FIG. **5***c*.

FIG. **6** is a vertical cross-sectional view of the apparatus useful for an embodiment of the present invention in which cut weft webs are dropped upon an adhesive foil.

In FIG. **1** showing one embodiment of the present invention, belt **2** is situated above warp web which is arranged in a certain width and moving horizontally in the direction perpendicular to the surface of paper, and is circulated along an upper circulating horizontal course and a lower one through guide rollers **3** and **3'** in the wefts direction which is crossing the warps horizontally and mostly at right angle.

The surface of this belt is coated with a uniform thin water layer in an appropriate amount transferred from the bristles of brush roller **6**, contacting with revolving roller **5**, the lower half of which dips in surfactant-containing water vessel **4**.

Weft web which is arranged in a width similar to that of the warp web is continuously fed, through pinch rollers **7** and **7'** and a cutting means, onto the belt at a position in the upper circulating course thereof, which belt is circulating under the feeding course of the weft web at a speed faster than the feeding speed of the weft web.

After passing through the cutting means, at first the forward tip ends of the weft web and then successive parts thereof are caught onto the belt surface by surface tension of the water coating the belt while being slided on the belt. Whenever the weft web passes through the cutting means by the length corresponding to the width of the warp web, the cutting means acts to cut the weft web into a cut weft web so that the fiber arrangement of the weft web at the time of feeding is practically maintained as it was in the cut weft web on the belt. After being cut, the cut weft web is attached onto the belt and travels together with it, leaving a space corresponding to the difference between feeding speed of the weft web and circulating peripheral speed of the belt, between each other.

The cutting means shown in FIG. **1** illustrates one example of such cutting means. It is constructed with a combination of lattice belt **9** having a peripheral length equal to that of cut weft web and another lattice belt **10** whch is circulating in engagement with lattice belt **9**, as shown in the drawing. If it is so arranged that one of the lattice elements forming lattice belt **9** is replaced by a melt cutter, that is, heated rod **12** heated by electric current sent through leading wire **11** from a source, the weft web supplied continuously by roller **7** and **7'** into the part between lattice belts **9** and **10** are cut to a unit length of cut weft web per one revolution of belt **9** and transferred onto belt **2** travelling in the vicinity below belt **9**.

Inside the surface of the circulation course of cut weft web **13** attached onto the belt **2**, strings **15** under tension as an embodiment of linear edges of the present invention, spaced apart by a fixed distance of 20 – 50 mm from each other and further contacting with the belt are circulated at a circulation velocity same with that of the belt and in this embodiment, cut-weft web adheres not only to these strings, but to the belt by means of water.

When the circulating belt is a lattice belt in which a number of lattice elements are arranged in parallel and in the direction perpendicular to the circulation direction of the belt as in case of the embodiments of the present invention which are described in detail later, strings as linear edges can be installed in the gaps between the lattice elements inside the top surface of the lattice elements, and inside the back side of the cut weft webs and slightly apart therefrom. Accordingly, in the former case, unless extremely fine wire materials such as piano wire, bristle or the like is used, in other words if a thick string is used, the horizontal adhesion of cut weft webs to the belt surface is prevented, but, as in the latter case where linear edges are arranged in the gaps between lattice elements, the use of thick wire materials, rubber cords, thin plate edges or the like does not influence the adhesion of cut weft webs onto the belt surface.

Whenever weft web **13** on belt **2** is brought to the position where the web is wholly overlapped with the warp web after overlaid during the lower circulating course of the belt, ski edges **14** which perform a reciprocating movement off and to the belt passage for pushing tensioned strings forming one kind of the abovementioned linear edges are suddenly lowered at an appropriate time interval by way of cam-motion associated with the circulating belt. Then a number of parallel tensioned strings **15** are pushed downwards, and the cut weft web adhering onto the belt is knocked down upon warp web to be overlaid on the warp web. Meanwhile, the warp web is moving continuously, and if its speed is so controlled that a subsequent cut weft web falls just when the warp web has advanced by the distance corresponding to the width of the fallen cut weft web, the cut weft webs are laid side by side over the warp web without forming any gaps or overlappings.

If the fiber density at the edge parts of weft web is made one half of that at other parts thereof at the time of fiber-arrangement, the fiber density at overlapped edge parts can be equalized to that at other parts on the product, when these edge parts of cut weft webs (i.e., forward end and backward end on the warp web) are overlapped with each other. By using this method, the gaps between the forward and backward ends of the cut weft web on the warp web can be made null.

If the cross-overlaying operation is so slow as 10 $m^2$/min. or less, there is no need of using a higher falling velocity and hence the vibration of fibrous materials of warp and weft webs, due to impact of falling cut weft webs is slight and disturbance of arrangement of fibrous materials does not take place. As the velocity of cross-overlaying operation becomes greater, that is, at such a high speed as 30 → 50 → 100 $m^2$/min., more rapid falling of the cut weft web becomes necessary; the energy possessed by falling cut weft webs becomes larger and fibrous materials in the warp web jump and leap due to the impulse at the time of cross-overlaying and the cut weft web is apt to show bouncing, resulting in fiber-disorder in warp and weft webs. The vibration amplitude of the warp web will be reduced if piano wires are stretched and fixed under the warp web at a pitch of about 10 cm so as to touch and cross the warp web at right angle. However if the spaces between the fibrous materials of warp web are large, some parts of fallen weft web on the travelling warp web are disturbed by contacting with the piano wires through these large free spaces between warp fibrous materials.

To overcome this trouble, method hereunder described, showing another embodiment of the present invention, is very effective. Namely if the warp web to be cross-overlaid is arranged to adhere onto a wet belt means travelling at the same speed as that of the warp web, the impact energy of falling cut weft web is absorbed by the belt of a heavy weight and moreover since the belt is wetted with water, the fallen cut weft webs are caught by the surface tension of water on the belt, eliminating the impulsive vibration of fibrous materials at the time of cross-overlaying. Thus cross-overlaying operation of ordered arrangement of fibers becomes possible even at a high speed operation without disturbing the ordered state of fibrous materials of both the warp and weft webs. Particularly notable effectiveness can be attained by laying warp web on a wet belt in case of cross-overlaying fibrous materials of large count having a heavy weight, especially, glass fibers or thin metal wire having a large specific gravity. Namely, laying warp web upon a wet belt is not a necessary condition for a low speed operation but it is necessary for a high speed operation.

Further, constructions of circulating belts carrying cut weft web adhering thereon are described hereunder. As for belt, so long as it has a sufficient width for laying wefts thereupon, and so long as it does not allow cut weft web to become partially apart and dangle therefrom or to fall, their material and construction are not a problem even when there is a rough part or gaps on the belt surface to which some parts of a cut weft web do not adhere.

However, when a belt is of a thin cloth or one sheet of an elastomer, broader width i.e., width broader than 1 m does not give preferable result because a belt under tension is apt to be creased, making the adhesion of weft web not uniform or a belt is apt to meander, making the travelling central line indefinite.

With regard to this point, as shown in FIB. **2***a*, a multiple belt consisting of a number of narrow belts arranged over the width of wefts and each running at the same speed and guided by two sets of crowned pulleys, each set having the same center of axis is used. By this method the central line of each belt is maintained and no crease is formed even when belts of a thin material are used.

When a multiple belt of this kind carries a split web having fibrous materials of reticulate structure, there would be no obstacle with a multiple belt consisting of a number of narrow belts each having a width of 15 to 20 mm, but when weft web having an ordered arrangement of yarns is used, it may be dangerous to load yarns on the parts close to the selvedges of each narrow belt unless (1) a multiple belt consisting of several belts of broader width, e.g., 150 – 300 mm is used and further unless (2) weft web is in such a thin arrangement that the pitch of arranged yarns of the web is greater than 5 mm and about 10 mm and the uniformity of yarn density as a whole is not lost even when yarns can be arranged in order, avoiding the selvedges of the individual belts.

However, in case of lattice belt which is referred to hereinafter, as another embodiment of the present invention, any density of arrangement can be taken irrespective of kinds of fibrous material which are reticulate webs or usual yarns or tapes etc. The advantage of applying such a multiple belt as stated before lies in the simplicity and cheapness of belt construction. However, strings as a number or linear edges on the multiple belt contacting therewith must be fixed to the chains circulating at the same speed as that of the belt on both the sides of the belt. When strong tension is applied to the strings and the strings are pushed out from the belt surface to drop a cut weft web, by lowering merely two ski-edges each onto the parts of the strings close to both sides of the multiple belt, the difference of time of fall between parts of a cut weft web, namely parts close to ski-edges and central parts can hardly be made equal. However, if the tension of strings is made too strong, the chains on both the sides are drawn from each other toward the center of the belt, causing obstacle to the circulation of the chains. If the tension of strings is weakened on this account and ski-edges are lowered only on both the sides of the multiple belt, there is a fear of causing a difference of time between parts close to ski-edges and the central part of multiple belt at the time of separation of the cut weft web wetted with water from the belt surface, and since the cut weft web does not fall and arrive on the warp web surface at the same time, this becomes a cause of disturbance of weft web.

Even in such cases, the pushing out and drawing back of strings can be made uniform throughout the whole surface by allowing a number of sets of ski-edges to descend through gaps between narrow belts constituting the multiple belt at an appropriate distance between each other e.g., a pitch of 150 – 200 mm.

In this regard, in case of lattice belt hereinafter described, ski-edges for pushing out and drawing back strings cannot be provided in the middle part of the belt. Hence it is so arranged that if strings are used for linear edges, string-supporting devices are provided at several positions of the entire width of lattice belt in such a way that adhesion of wefts is not thereby disturbed and the backs of this devices are equally beaten by ski-edges provided for them.

FIG. 2*a* shows one example of the above-mentioned multiple belt. The belt composed of a parallel arrangement of **6** narrow belts **2′**, each of which is made to circulate as shown in FIG. **1**, belt **2** by crowned pulleys **21** fixed to a common axis **22** driven by pulley **23** and pulleys on the other side with a common axis (not shown). Strings **28** are laid on this multiple belt in contact therewith under tension via springs **26** and **27** which are connected to circulating chains **24** and **25**, respectively. The strings are kept always in contact with the surface of the multiple belt and circulate at substantially the same speed with that of the belt surface. At the point where a cut weft web is wholly overlapped with the warp web after overlaid, ski edges **29** and **29′** provided one in each space between the side of the belt and the chain, if necessary, together with a number of ski edges provided between each narrow belts (though not shown in the drawing) are made to fall suddenly. Then the strings descend to a distance very close to the warp web, reverse the course to return rapidly to the belt surface and circulate together with the belt, whereby the strings are separated from the belt surface and cause the cut weft web attached onto the belt surface to drop on the warp web. FIGS. 2*b*, 2*c* and 2*d* show that cut weft web **30** is pushed off from the belt surface **2** together with strings **28**, by sudden fall of ski edges **29** and **29′**, and the strings reverse their course at a distance very close to the warp web, and return to their original positions, while the cut weft web is separated from the strings and cross-overlaid upon warp web **31.**

As chains **24** and **25** between which the strings are tensioned, are pulled each other toward the inside by the tension of the strings, guide rails **32** and **33** are provided in order that strings circulating in parallel are always kept tensioned under a constant tension.

Description concerning lattice belts employed as circulating endless belts will be given by referring to FIGS. 3*a* – 3*e*, FIGS. 4*a* – 4*c* and FIGS. 5*a* – 5*d*.

If the width of weft web is 1 m, the length of lattice elements will be 1,100 to 1,200 mm. The width of individual lattice element **41** is generally about 5 – 30 mm, and as shown in FIG. 3*a*, both its ends, right and left, are connected to circulating chain **42** and another chain (not shown), circulating in parallel to chain **42,** respectively, and a circulating lattice belt is formed with a number of lattice element spaced apart from each other by 5–10 mm. Near to each end of the lattice element spaced apart by an appropriate distance, spring arm **43** is fixed to a lattice element at fixing point **44** which is positioned toward the central part of the lattice element, the tip of the arm takes usually a form rising from the surface of the end of lattice element toward the inside of circulation path, and to each tip of the arm, a string-supporting device **45** is fixed. In the lower circulating course of the belt, lower part **46** of string-supporting device as shown in FIG. 3*a* usually contacts with the surface of the lattice element and sets the moving range of spring arms from the surface. String-supporting point **47** of the string-supporting device is so constructed that string **48** under tension lies inside the circulating course of belt surface and in the gaps of lattice elements (at first in the lower circulating course of the belt as shown in FIG. 3*a*), and when cut weft web **50** comes to a position where it is overlapped wholly with warp web **31** after overlaid, ski-edge **49** rapidly descends on and knocks the rising end of spring arm **43** of the string-supporting device in the direction in which the spring arm comes in contact with the lattice as shown in FIG. 3*b*. Then, tensioned string **48** is lowered by lowering of string-supporting point **47,** and cut weft web adhering on the lattice belt is knocked off through the course of FIG. 3*c* → FIG. 3*d* → FIG. 3*e*. The string descends down to a very close distance to the warp web as shown in FIG. 3*d*, and reverses its course to the original position, and in the upper circulating course, the lattice element takes a form standing upside down to that of FIG. 3 *a*, i.e., the spring arm takes form projecting downwards from the lattice surface.

The characteristic feature of the use of this lattice belt lies in the points that sufficient tension can be applied to strings, because ech string is supported by stiff lattice element; when falling of the central part of string is, nevertheless, liable to be delayed, the falling of cut weft webs over the whole width can be made uniform and horizontal through falling of ski edges by providing string-supporting points with combined spring arm and ski edge, respectively, at several points in the middle part of lattice element with such an arrangement that string-supporting device does not project out above the lattice belt surface and pushing down of string can be made horizontal over its whole length, and that since there is no gap in the direction of width of lattice belt, the method of the present invention is useful not only in case of reticulate webs but also in case of common yarns wherein the pitch of arrangement of yarns i.e., density of yarns can be optionally selected.

As another embodiment of linear edges, in place of the above-mentioned tensioned strings for knocking off cut weft web from a weft-carrying lattice belt, a construction of one lattice element which constitutes the belt where thin plate edges are pushed down and returned to the original position, is shown in FIGS. **5***a*, **5***b*, **5***c* and **5***d*. FIG. **5***a* is a figure of a cross-section of one lattice element to which there is attached a linear edge capable of knocking down and returning to the original position, and travelling in the upper circulating course of weft-carrying lattice. FIG. **5***b* is an elevation showing that one end of lattice element is fixed to a chain. The other end, though not shown, is connected to another chain circulating in parallel to the chain. Cut weft web **71** is transported by square lattice elements **72,** onto the surface of which the web is attached with water. During the upper circulating course, thin plate **76** which surrounds the lattice element in U-form is supported by coil spring **75** inserted around stud bolt **74** set on lattice element **72,** the one end of which is connected to chain **73,** thereby to position the tip of linear edge **77** inside the surface of the lattice belt and in the gap between two adjacent (front or rear) lattice elements. Whenever cut weft web is brought to a position where the web wholly overlaps with warp web after overlaid during the lower circulating course of the belt, ski edge **78** rapidly descends as shown in FIGS. *5c* and *5d* to knock down the backside of U-form thin plate whereby linear edges **77** of the tip of thin plate are pushed down from the lattice surface and cut weft web **71** adhering to the lattice surface is knocked down onto warp web (not shown).

This method for knocking wefts off by linear edges of the tips of thin plate does not cause time-lag of falling at the middle part of wefts which is liable to occur in case where strings are used as linear edges. Accordingly this linear edge gives even in case of broad wefts, a good result in the point that a uniform and simultaneous falling of wefts can be attained and no disturbance of fibers occurs. When fiber density of weft web is higher, a good result can be obtained especially by employing this method for dropping cut weft webs by way of thin plate linear edges, because overall force of adhesion due to surface tension of water becomes larger.

When a weft-cutting apparatus which utilizes the engaging two sets of lattice belt as shown in FIG. **1** is used, the front half part of a cut weft web can hold the state of arrangement of fibers at the time of feed by the pull of surface tension of water on the surface of circulating belt, but the rear end part of cut weft web is liable to fall freely on the circulating belt immediately after being cut.

Even when the circulating course of lattice belt **9** is arranged to come as close to circulating belt **2** as possible, the rear end part of the cut weft web still have some tendency of disturbance of fiber arrangement. This drawback can be completely overcome by the method described hereunder, showing the another weft-feeding method of the present invention.

In this method, as a weft-carrying circulating belt, a lattice belt is used as shown in FIG. *4a*. The whole peripheral length of this belt is adjusted to an integer times of a unit section length which is slightly longer than the length of a cut weft web (four unit sections in FIG. 4a). Weft web **52** fed continuously through pinch rollers **51** and **51'** is caught on a belt by the surface tension of water, and rub-slided on the surface of the belt circulating at a speed slightly faster than the feeding speed of weft web thereby to maintain the fiber arrangement at the time of feed by drawing force of the belt due to surface tension of water wetting the belt. When the length of the weft web reaches a predetermined length of the cut weft web in each section, it is cut repeatedly into a cut weft web by a weft cutter **53,** the cutting edge of which circulates around its own axis at substantially the same speed with that of a belt, and is engaged with the weft web fed at the position at the rear end of each section. The peripheral length of the circulating course of the cutting edge is so adjusted as to have a length substantially equal to that of a cut weft web. Front ends of each cut weft web **54** and **54'**, hitted by the cutter, are made to travel behind the rear part of each preceding section by the distance corresponding to the difference between the feeding velocity of weft web and that of circulating belt; the rear ends travel just at the parts hitted by the cutter on each section. As cut weft webs adhere to the belt by the surface tension of water, thereafter the webs are transferred at the velocity of the belt to the part above warp web positioned in the lower circulating course. On coming to a position where weft web overlaps wholly with the warp web after overlaid, ski edge **55** is rapidly lowered by the method shown in FIGS. *3d*– *3e*. Namely if cut weft web **54'** is knocked off successively onto the warp web **56** at predetermined intervals by pushing a number of linear edges downward over the whole surface of weft web, while holding the arranged state at the time of feed without causing disturbance thereof, and the warp web is also moved by being carried on another wet belt means (not shown), moving at the same or about 1 percent faster velocity than that of feeding of the warp web, it is possible to obtain laminates of warp and weft with a highest grade of accuracy of arrangement.

FIG. *4b* shows that in case where fibrous materials are glass yarns, one lattice element **58,** on which rubber plate **59** is attached, is provided at the rear end of each section and revolving knife edge **57** is made to hit the plate. In this case, glass yarns are cut at the instant when they come to be nipped between the sharp edge of the knife and the rubber plate.

If fibrous materials are organic fibers, as shown in FIG. *4c* there is provided lattice belt **61** which is circulated at the same speed with weft-carrying circulating belt **60** through a triangular or circular course, and one lattice element of lattice belt **61** is replaced by heated rod **62** capable of sending electric current thereto, and if necessary, at the time when the rod is engaged with the circulating belt, this heated rod is forcibly pushed out toward inside belt **60,** whereby wet fibrous materials are at first dried and immediately thereafter melt-cut. Different from the case of the method of FIG. **1** where the wefts are cut by a weft cutter at a position apart from the circulating belt, by the method abovementioned, the fiber-arrangement at the time of feed of the fibrous material for weft web is transferred onto a wet belt and cut while holding its arrangement, as it is. Thus a high accuracy of arrangement can be maintained.

The length of each section is slightly longer than the length of cut weft web, and this percentage of difference corresponds to the difference between the feeding velocity of weft web and the velocity of circulating belt. Within the time of the circulation of the belt by the length corresponding to the part on which no wefts are attached, pushing down and drawing back motion of ski edge i.e., linear edge must be completed. Accordingly, the faster the pushing off and drawing back motion of ski edge is, the smaller the above-mentioned percentage. Usually it is preferable to make the length of each section by 10–20 percent longer relative to the length of cut weft web.

Although cut weft webs adhere onto a belt surface by the surface tension of water, in the method of the present invention, yarns having a high Young's modulus such as glass fiber yarn, thin metal wire yarn, etc., or those yarns of usual organic fibers, spun yarns or filament yarns, having been heavily twisted are liable to show natural twisting back in a free state under no tension. Even in case of hydrophilic fibers whose wet Young's modulus is considerably reduced by soaking, highly twisted yarns are liable to show natural twisting back. If heat-set is applied to them, degree of natural twisting back is reduced especially in case of synthetic fibers, but highly-twisted yarns are still liable to leave some degree of natural twisting back property. When such yarns are used as weft web in the method of the present invention, it is preferable to put one end of S- and one end of Z-twisted yarns together side by side with water and handle as one yarn. The resultant doubled yarns, even when they are not further twisted, are embraced with each other under the influence of the surface tension of water, and properties of natural twisting back of S- and Z-twisted yarns are mutually cancelled, whereby the fiber-arrangement at the time of feed can be maintained without disturbance of cut weft webs. This has been confirmed by the actual experimentation of the present inventor.

Since the warp web is moved under tension between front and back rollers, there is no natural twisting back and hence both S-twisted and Z-twisted yarns can be used separately, but in case where twisted yarns having natural twisting back property are fed as cut weft webs in the cut state, it is necessary to double two kinds of twisted yarns (S- and Z-twist) side by side.

Non-woven fabrics obtained by laminating warp and weft according to the present invention, are presented for actual use in most cases through the steps of removing water with two pressing rollers after cross-overlaying of cut weft webs on the warp web, pasting, drying and fixation of arrangement of fibers of warp and weft. In place of the above-mentioned processing course, it is, of course, possible to use raw fibrous materials, for warp or weft web, or both webs which have been pasted in advance, for subjecting them to cross-overlaying, removing water, drying and heat pressing.

With regard to pasting agents, a suitable one can be selected, but if unstretched and quenched foils of polymers belonging to the same type with the polymer of fibrous materials are used as a pasting material, it is possible to bond the stretched fibrous materials without reducing the strength of the stretched fibrous materials, because the softening point of the former is lower than that of the latter.

For example, when a high density polyethylene stretched material is used as fibrous material for the lamination of warp and weft, use of a low density, preferably quenched polyethylene foil, a foil of ethylene-vinyl acetate copolymer, or the like between warp and weft webs gives preferable result due to the function of the latter as a hot-melt adhesive to the former as well as a function of laminated film without the danger of blocking between each layer when wound into a roll. The same effect can be attained between stretched materials of polypropylene and unstretched quenched polypropylene foil.

Such adhesive foils can not only be used as an intermediate layer of warp and weft webs but also if further additional unstretched quenched foils are fixed onto both the sides, it is possible to prevent fluffing of fibrous materials and also to impart a water-proof effect and reinforcing effect to the resulting products. Moreover this lamination step of foil can be directly connected to the cross-overlaying step of warp and weft webs.

Especially when an adhesive foil is placed upon warp web and wet cut weft webs are arranged to fall on and adhere to the foil according to the weft-feeding method of the present invention, the shock of falling of cut weft webs is absorbed by the foil, and the disturbance of falling cut weft web can be prevented due to the same effect as stated before. In this regard, this method can be regarded as a modification application of the method as stated before. This will be explained by referring to FIG. **6.**

Adhesive quenched foil **83** is fed onto one group of warp web **82** picked up at a regular interval from the whole warps and fed through pinch rollers **81** and **81'** while maintaining the original spacings between each other, and cut weft webs **85** are successively dropped from weft-feeding circulating belt **84** provided above the warp web loading the foil as adhesives thereon, on the foil. As a presser of the cut weft web on the first group of warp web, the rest group of warp web **87,** also maintaining the original spacings in the whole original warp web, is applied on the cut weft webs cross-overlaid on the first group of the warp web carrying the foil between pinch rollers **86** and **86'**. When the resultant product, after dehydrated, is moved successively on hot rollers **88** and **88'** for drying and then passed through pressing rollers **89** and **89'** to effect heat adhesion under pressing, a complete adhesion of warp and weft webs to each other can be attained. Though not shown in the FIGURE, if **2** sheets of quenched foils are separately laminated on the top and bottom sides of the laminate of warp and weft during its course of travel on hot drum **88'** so as to give the fibrous material of warp and weft structure sandwiched between the two foils, a laminate consisting of warp and weft webs, and three layers of foils can be obtained in which fluffing of the fibrous material is completely prevented.

In the method of the present invention, cut weft webs are dropped on an adhesive foil and warp web **82** is travelled together with the foil in contact therewith from the underside in most cases, but a warp web is not necessarily passed through under the weft dropping part. It is possible to arrange to pass only adhesive foil **83** through under the weft dropping part. Namely, after receiving dropped cut weft webs, said adhesive foil is passed through pinch rollers **86** and **86'** and put between tow upper side and underside warp webs there. Underside warp web **82'** is guided on roller **86** and put under said adhesive foil and weft-pressing warp web **87** is guided on roller **86'** to give a sandwich structure consisting of upper warp web, dropped cut weft webs, adhesive foil and lower warp web in this order. Thus entirely the same effect can be attained as in case where warp web **82** is passing through under the weft-dropping part. Both of the above-mentioned cases are intended to be included in the scope of claim of the present application. Thus the process of the present invention is irrespective of feeding position of warp.

The present invention will be further described referring to non-limitative examples hereinafter.

### Example 1

A foil of high density polyethylene having a width of 1,200 mm and a thickness of 0.06 mm was stretched to nine times the original length while it is hot, split with a splitting means, spread to about three times the original width, subjected to pasting with an emulsion of vinyl acetate-ethylene copolymer and dried to give a spread web having a width of 1,200 mm, and the resulting web was used as a fibrous material for both the warp and weft webs.

By using an apparatus of FIG. **1**, warp web guided on a wet belt was moving horizontally at a speed of 72 m/min. Above this course of the warp web, weft web cut into a length of 1,220 mm and having a width of 1,200 mm, as cut weft webs, were charged intermittently on a multiple belt as shown in FIG. **2***a*, (which was wetted with water containing a surfactant, circulating above said warp web in the direction perpendicular to said warp web, consisting of a number of belts each having rough surface and a width of 150 mm and a gap of 5 mm between each other and an overall width of 1,390 mm) and brought to the down-side course of its circulation. At the instant when the cut weft web came to a position overlapped wholly with the warp web after overlaid, ski edges were pushed to lower a number of strings arranged in parallel with a pitch of 30 mm, down to the lowest level corresponding to 10 mm above the warp web and returned to the original position thereby to give cross-overlaying 60 times per minute. Thereafter the resultant product was separated from the warp web-guiding circulating belt and dried after being squeezed to remove water through pinch rollers. Then while it is running in free space, short fibers of cotton linter having been scoured, dried and disentangled, were scattered and attached on it so as to give a loading amount of 3 – 4 g/m$^2$, thereby to strengthen the crossing of the fibers of warp and weft webs, and the resulting product was subjected to adhesion by pressing on heating. Thus, strong non-woven fabrics which have an extremely good adhesion of the fibers of warp and weft to each other at the crossing thereof and a total fiber density of 17 – 19 g/m$^2$, and do not show blocking after wound up, were obtained at a rate of 103 m$^2$/min.

## Example 2

For warps, two hundred and one ends of glass fiber yarns (long fibers) of 100 tex. were divided into two groups having 101 and 100 ends, respectively. The first warp web was prepared by arranging 101 ends of yarns in 1 m width with a pitch of 10 mm, mounted on a circulating wet belt for warp web and moved at a rate of 50 m/min. S-twisted glass fiber yarns of 50 tex. and Z-twisted glass fiber yarns of 50 tex. were doubled to one yarn of 100 tex. so as to cancel their tendency of natural twisting back property. 200 ends of the resultant yarn were passed through a comb and arranged to give 200 ends of wefts in 1 m width which were fed on a wet circulating belt for weft web through pinch rollers **51** and **51'** as shown in FIGS. **4***a* and **4***b*, at a rate of 50 m/min. The weft-carrying belt was installed above the warp-carrying belt in the direction perpendicular thereto.

The belt for weft web was an endless circulating lattice belt of 1,200 mm wide, having a peripheral length of 6,000 mm and divided into 5 sections, each having 48 lattice elements made of stainless steel pipes of 20 mm square, arranged in a 25 mm pitch with gaps of 5 mm between each other. The circulation velocity thereof was 60 m/min. Since the weft web fed on this belt was caught the surface tension of water wetting the surface of the belt and rub-slided on the surface of the belt moving faster than the feed velocity of the fibrous material for weft web, under cancelling of the twisting back property of S-and Z-yarns, the pitch between arranged yarns on the belt was as it was at the time of feed, without disturbance.

When the fed length of weft web became 1 m in each section, the web was cut with a knife cutter into cut weft webs successively as shown in FIB. **4***b*. Thereafter, cut weft web moved at the same speed as that of the belt while being attached onto the surface of the belt. Each section had, in the foreward part thereof, a part of 200 mm distance where no wefts were loaded. When a cut weft web came to a position wholly overlapped with the warp web after overlaid in the down side course of travel, ski edges were suddenly lowered at a rate of 50 times per minute to give cross-over-laying of warp and weft webs without gap. The resulting product was separated from the wet belt on which the first warp web had been loaded, and the second set of warp web warped at a pitch of 10 mm was supplied onto the product during the pass of pinch rollers to be laminated in such a way that each yarn of the second warp web came to a position between yarns of the first running side by side.

After squeezing out water by pinch rollers, the resulting product was pasted with a pasting agent of polyvinylalcohol type and squeezed. Thereafter onto the pasted product, free short single fibers prepared by fully opening short fiber waste formed in spinning mills were scattered and loaded at a rate of 5 g/m$^2$, and the whole was dried with hot air and then on hot drums, whereby non-woven fabrics of warp and weft containing glass fibers in an amount of 40 g/m$^2$ were produced at a speed of 50 m$^2$/min. without any blocking of wound-up layers due to softening of adhesive.

In case of non-woven fabrics of laminate of warp and weft consisting of glass fibers to be used as a reinforcing material for FRP (fiber-reinforced plastics), if adhering pasting agents or organic short fibers are not preferable, it is possible to scatter and load glass short fibers of 3– 5 mm length, as short fiber, and then to burn out the organic pasting agent.

We noticed in this case that the arrangement of glass fibers of warp and weft structure was maintained only with glass short fibers entangled therewith.

## Example 3

320 ends of stretched tapes of polypropylene, each having a width of 6 mm and a denier of 1,000 were used as a fibrous material. The tapes were arranged in parallel and flat, and split into split yarns during their course of travel. The resulting yarns were passed through a comb and thereby the width was narrowed so as to be able to arrange 320 ends in 1 width. They were guided as a weft web onto a wet endless lattice belt consisting of five sections in the total periphery, each having 1.2 m length, during its upper circulating course as shown in FIG. **4***a*. Whenever the fed length of the arranged yarns reached 1 m in each section, the yarns were cut to form a cut weft web by a melt cutter and the cut weft webs were one by one brought to the lower circulating course while being attached onto the belt.

Another 320 ends of polypropylene split yarns for a warp web, obtained in the same manner as above, were divided into 2 sets, each consisting of 160 ends and warped in a width of 1 meter.

The first set of warp web was fed in the manner as shown in FIG. **6**, passing between pinch rollers **81** and

81′, together with a quenched foil of polypropylene, having a thickness of 0.02 mm and a width sufficient to cover the width of the warp web, thereon.

At the time whenever one cut weft web came to a position wholly overlapped with the first set of warp web after overlaid, linear edges of thin plate shown in FIGS. 5a–5d were pushed down to drop the cut weft web on the foil. The second set of warps with 160 ends in 1 meter was laid upon dropped cut weft webs during the pass between pinch rollers **86** and **86°**. After cut weft webs were overlaid on the warp web in such a manner that the weft webs were sandwiched by the warp web of the first and second sets arranged so that each yarn of the second set might come to a position between yarns of the first set running side by side, the resulting overlaid product was dried by squeezing out water and heating on a hot drum and pressed on heating, whereby a non-woven fabric of laminate consisting of warp, weft webs and a foil as adhesive therebetween was obtained at a rate of 50 m/min.

Additionally, two quenched polypropylene foils each having a thickness of 0.03 mm were supplied onto a heating drum so as to sandwich the above-mentioned laminate of warp and weft on both the sides thereof and pressed on heating. The resulting laminate gave a substitute of water-proof heavy duty cloth having a fiber density of 70– 75 g/m$^2$ in both of the warp and weft directions and a strength of 65– 75 kg/**50** mm width in both the warp and weft directions and containing 75–80 g/m$^2$ of the adhesive foil.

In case where stretched tapes are used as a fibrous material as in this embodiment, if tapes 6.0– 6.5 mm wide are to be laminated flatly side by side in both the warp and weft directions in flat form, an arrangement of more than four ends per inch is impossible.

Accordingly, in such cases as there are parts where more than two tapes may be piled up, unless the width of tapes is narrowed by splitting as in the present embodiment or by creasing followed by squeezing, each single fibrous material in both the warp and weft directions is not exposed on adhesion surface of warp web and weft web and there may occur parts of bad adhesion of both webs.

However, if stretched tapes having an adhesive applied thereon and dried in advance are used for each of said tapes, tapes in both the warp and weft directions can be easily bonded firmly as they are in the state of stretched tapes even when they are not squeezed into narrower width.

In general, if fibrous materials are laminated in layers of warp and weft according to the process of the present invention, and then pasted and bonded by scattering and loading short fibers on the resulting product, not only peeling off of warp and weft web from each other can be completely prevented, but also blocking which often occurs during the time of winding-up of pasted non-woven fabrics due to softened pasting agent can be prevented.

Further if carded webs of short fibers which are slightly longer than the above-mentioned are additionally laminated, free open spaces of crossed warp and weft fibrous materials are subdivided or filled with said short fibers, and reinforcement and covering effect are notably increased.

Since short fibers such as pulp fibers of 1–3 mm length, those which have sufficient length to be treated with a carding machine, such as cotton or artificial staple fibers, short fibers for reuse, recovered from waste fibrous materials, etc. are all inexpensive raw materials for above-mentioned usage, they can perform very important roles in the reinforcement of non-woven fabrics of warp and weft and in expanding the utility and adaptability thereof.

When the density of fiber arrangement of webs in the warp and weft directions is small, the air existing between the warp web and cut weft web to be dropped during the falling of cut weft web upon warp web tends to leak through fibrous materials towards upward and downward directions and hence cut weft web drops upon the warp web without disturbance. However, when the density of fiber arrangement of both warp and weft webs is high, the air is difficult in leaking and the escape of air layer between warp and weft webs becomes difficult, resulting in the disturbance of cut weft web at the time of falling particularly in high speed operation. For solving the problem of this drawback, it has been proposed in the prior patent application of the present inventor, to provide a negative pressure chamber beneath warp web to exert a downward suction force through fibrous material of warp web thereby to ease the fall of cut weft web and prevent the disturbance of fiber arrangement thereof. Particularly when utilization of negative pressure is so arranged as to draw down the front end of falling cut weft web obliquely toward forward and the back end thereof obliquely toward backward, notable effect for prevention of wrinkling and for obtaining uniformity of fiber arrangement can be attained. In case of high density of fiber arrangement, even when a wet belt for warp web is not used, only wetting of warp web can afford the same effect with that of using of the wet belt and also the suction force can be effectively exerted from underside the warp web at the time of falling of the cut weft web.

What is claimed is:

**1.** In a method for laminating warp and weft webs of elongated fibrous materials, an improvement in a wet manner, which comprises,

a. cutting a weft web consisting of a number of elongated fibrous materials arranged in parallel in a plane of a given width to a length corresponding to the width of a warp web also consisting of a number of elongated fibrous materials arranged in parallel in a plane of a given width, one by one, to give cut weft webs;

b. attaching the resultant cut weft webs onto the surface of an endless belt wetted with water and circulating along an upper horizontal course and a lower one at a speed faster than the feeding speed of the weft web, successively in said upper circulating course, leaving a predetermined space between each of said cut weft webs, while maintaining the original arrangement of said fibrous materials in the weft web through surface tension of water wetting the surface of the belt;

c. bringing the cut weft webs attached onto the surface of the belt to said lower circulating course one by one;

d. at the instant whenever one cut weft web comes to a position overlapped wholly with the warp web after overlaid, which is travelling horizontally and crosswise below said lower circulating course of the belt at a distance apart therefrom, pushing off and simultaneously knocking off the said cut weft web attached onto the belt, from said belt towards the warp web over the whole length and width thereof, by rapidly pushing down and returning back a number of rows of linear edges which are situated behind the cut weft webs, inside the circulating surface of the cut weft web and crosswise to the circulating direction of the belt and are circulated at substantially the same speed as that of the belt, and thereby successively cross-overlaying the cut weft webs on the warp web one by one without leaving any gaps therebetween; and

e. bonding the whole into a laminate of warp and weft.

**2.** A method according to claim **1,** wherein the weft web is fed and cut into cut weft webs, one by one, at a position close to and above a circulating endless multiple belt consisting of a number of narrow flat belts arranged in parallel in a width corresponding to the width of the weft web, all of which narrow flat belts are guided and circulated by a pair of roller means and made to keep the center line of circulation thereof by at least one roller means of the pair consisting of corresponding number of crowned pulleys of the equal diameter having the same center axis, and the resultant cut weft webs are fed successively onto said belt wetted with water from the forward cut end of the webs to attach the cut weft webs onto the belt and are made to travel together with the belt leaving a predetermined space between each other, while maintaining the arrangement of the fibrous materials of the original weft web and brought to the lower circulation course of the belt.

**3.** A method according to claim **1,** wherein the weft web is fed onto a water-wetted lattice endless belt circulating at a speed faster than the feeding speed of the weft web and consisting of a number of rigid lattice elements arranged in parallel at predetermined intervals, each end of which elements is connected to each one of a pair of circulating chains in parallel, respectively; said lattice belt has an overall peripheral length corresponding to an integer times the length of each of cut weft web-carrying sections having a length longer than that of the cut weft webs, and having at the rear end of each of said sections, a site accommodating parts of a weft-cutting means, and the weft web is cut by the weft-cutting means at the rear end of each of said sections, into cut weft webs one by one while sliding on said lattice belt wetted with water, whereby the arrangement of fibrous materials of the original weft web is kept sufficiently as it was and the resulting cut weft webs are successively attached onto the belt, travel together with the lattice belt leaving a predetermined space between each other and are brought to the lower circulating course of the belt.

**4.** A method according to claim **1,** wherein each one of the cut weft webs attached on the cut weft web-carrying belt wetted with water is pushed and knocked off from said belt by a number of rows of strings as linear edges, in the lower circulating course of the belt.

**5.** A method according to claim **1,** wherein each one of the cut weft webs attached on the cut weft web-carrying belt wetted with water is pushed and knocked off from said belt by a number of rows of linear tip edges of thin plate as linear edges, in the lower circulating course of the belt.

**6.** A method according to claim **1,** wherein the warp web is made to travel while being attached onto a warp web-carrying belt means which is wetted with water and traels at substantially the same speed as the feeding speed of the warp web, thereby to absorb the impulsive force of the falling cut weft webs and to prevent the warp web and cut weft webs from disturbing the arrangement of fibrous materials thereof.

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