United States Patent [19]
Farrington

[11] 3,740,797
[45] June 26, 1973

[54] **METHOD OF FORMING WEBS AND APPARATUS THEREFOR**

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[73] Assignee: **Johnson & Johnson,** New Brunswick, N.J.

[22] Filed: **Jan. 21, 1971**

[21] Appl. No.: **108,545**

[52] **U.S. Cl.** **19/156.3**
[51] **Int. Cl.** **D01g 25/00**
[58] **Field of Search** 19/155, 156–156.4, 19/88, 89, 204, 205; 156/62.2–62.8, 369, 370–374

[56] **References Cited**

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2,535,187	10/1970	Wood	156/372 X
2,911,684	11/1959	Hunter	19/205 X
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FOREIGN PATENTS OR APPLICATIONS

1,202,192	9/1965	Germany	19/89

Primary Examiner—Dorsey Newton
Attorney—Michael Q. Tatlow, Harold L. Warner and Robert L. Minier

[57] **ABSTRACT**

A process and apparatus for forming an air-laid, nonwoven web from separate supplies of individualized fibers, such as textile and papermaking fibers. Supplies of fibers are fed to oppositely rotating lickerins that are rotated at speeds which are optimum for the fibers being individualized by the lickerins. The individualized fibers are doffed from the lickerins by centrifugal force and high velocity air streams directed against the fibers clinging to the lickerin clothing. The fibers from each supply are entrained in their respective air streams, which are impelled at high rates of speed toward each other, and the air streams come together in a mixing zone. The doffed fibers are given an initial trajectory as they leave their respective lickerins, and the inertia of the fibers in the air streams is sufficient to bring the fibers to the mixing zone and effect blending of at least a portion of the fibers from each supply in the mixing zone. In communication with the mixing zone is a suction actuated condensing means where the fibers are deposited to produce a nonwoven web of fibers, for example, an isotropic nonwoven web.

The process and apparatus can be varied to form a variety of nonwoven webs, using as the fibers of these webs two different fibers of the same, or of different lengths. A variable that can be introduced to vary the web construction includes a baffle that can be interposed between the two separate air streams to control the location where the two air streams are intermixed.

17 Claims, 11 Drawing Figures

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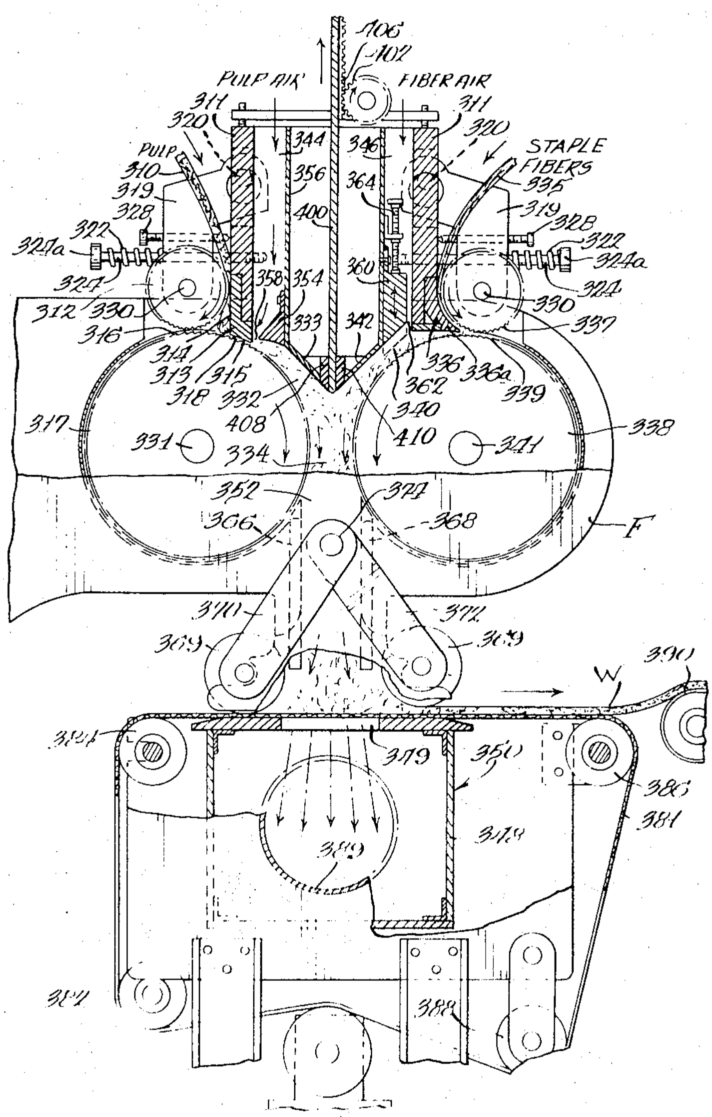
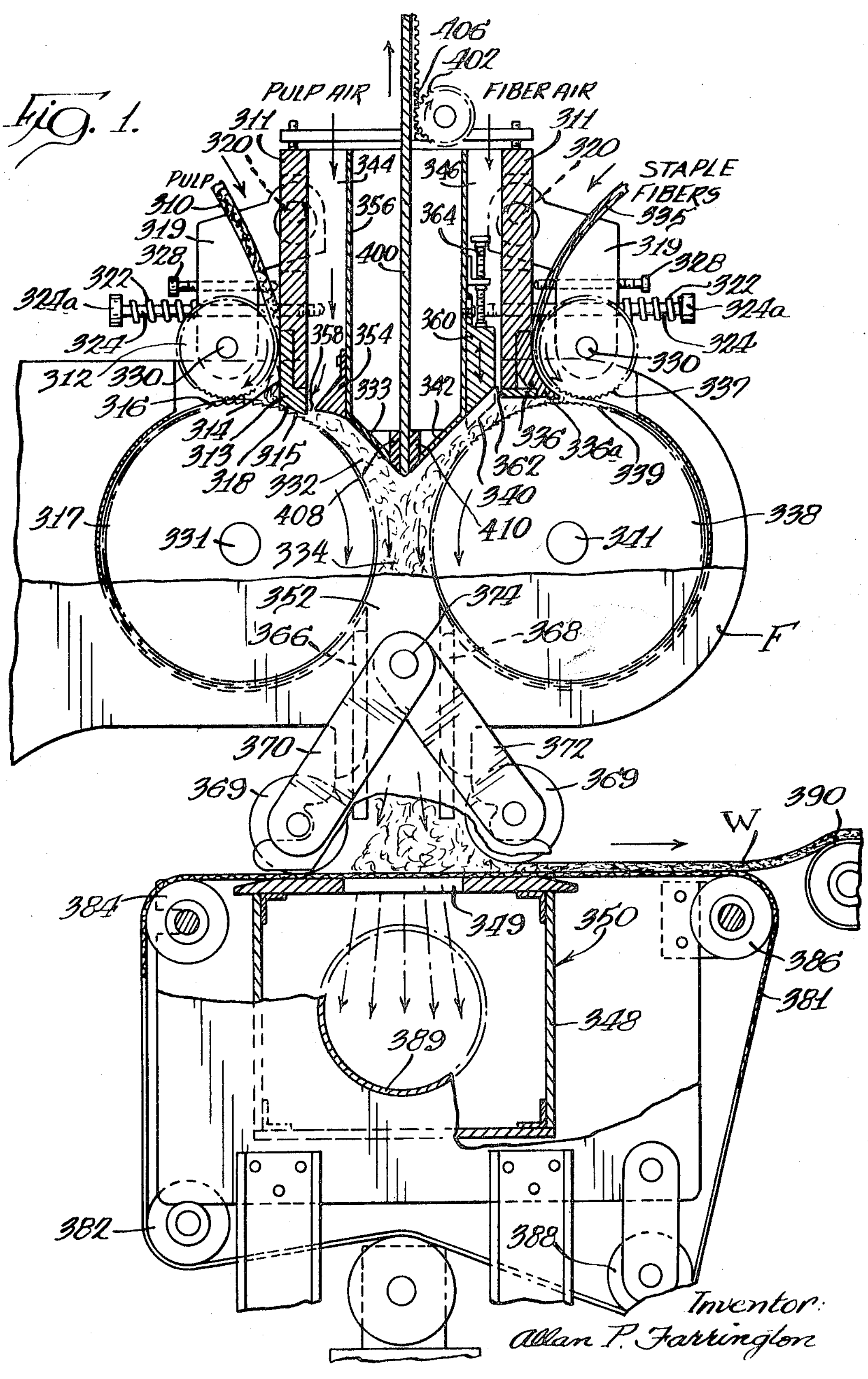


Fig. 1.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Inventor:
Allan P. Farrington

Fig. 2.

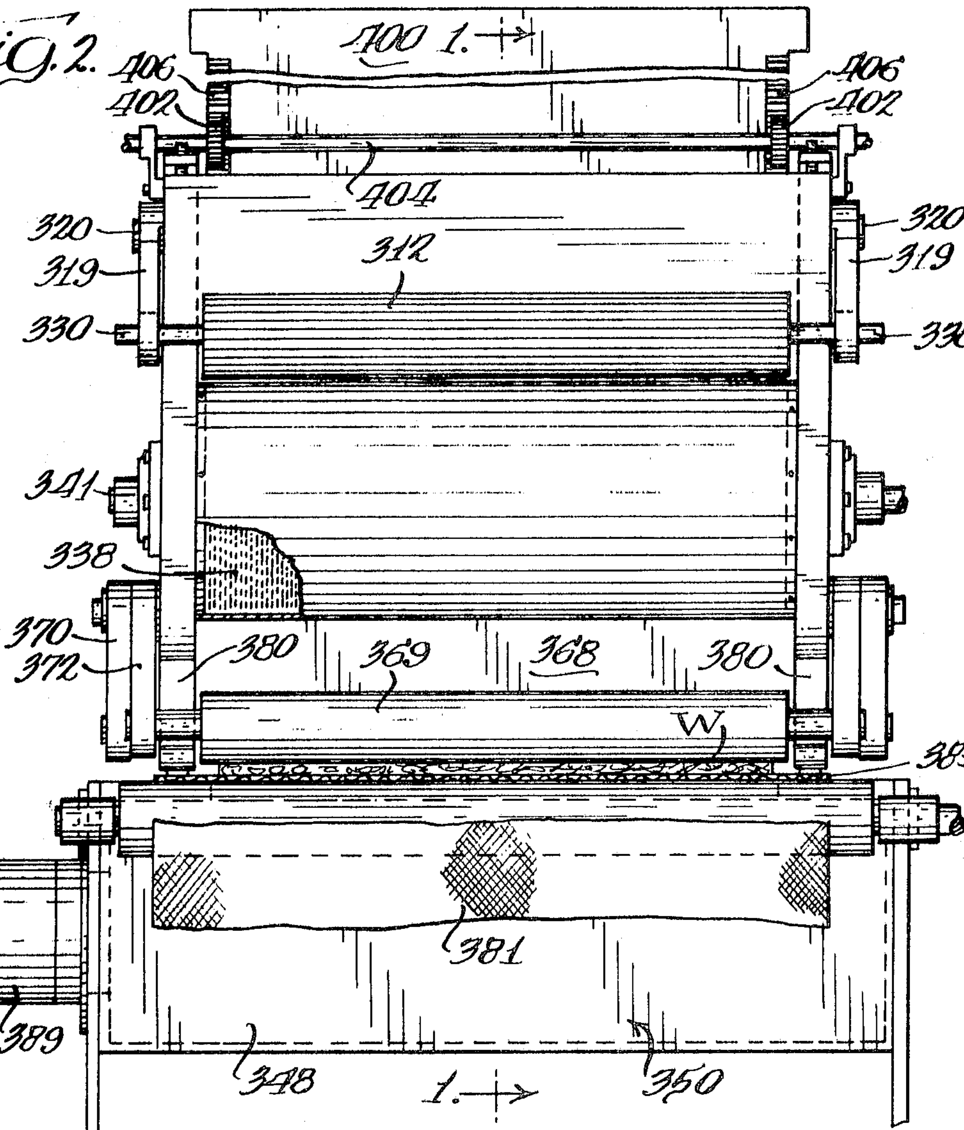


Fig. 3.

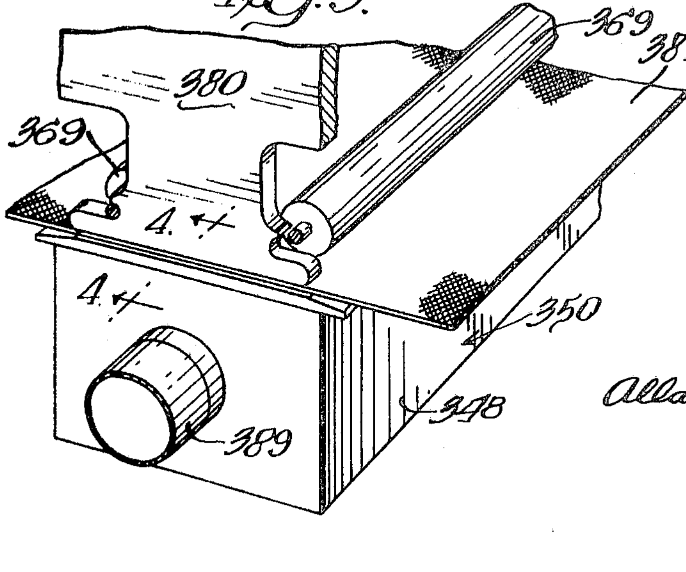
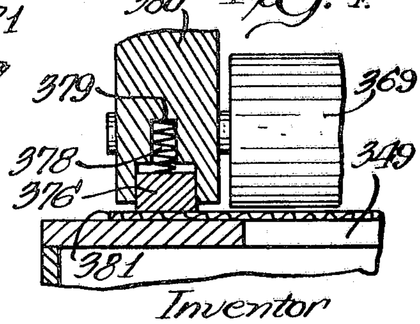


Fig. 4.



Inventor

Allan P. Farrington

Fig. 5.

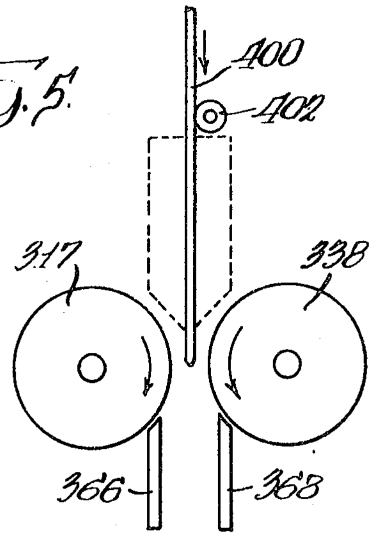


Fig. 8.

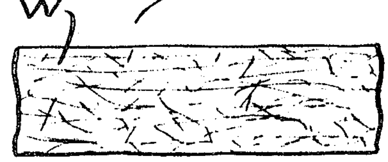


Fig. 9.

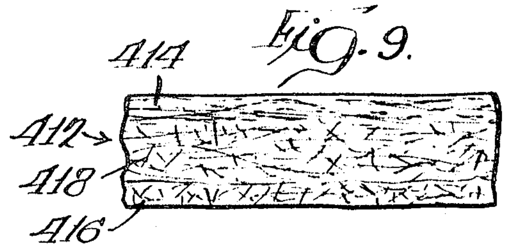


Fig. 6.

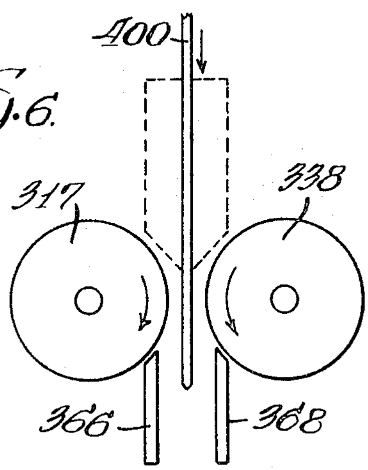


Fig. 10.

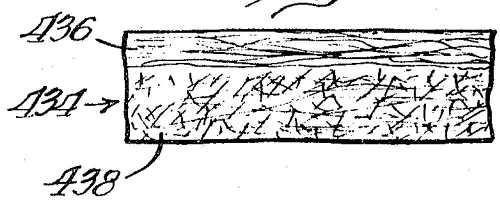


Fig. 11.

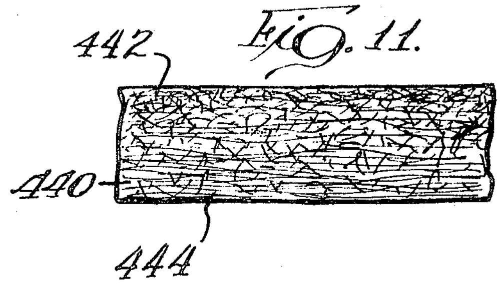
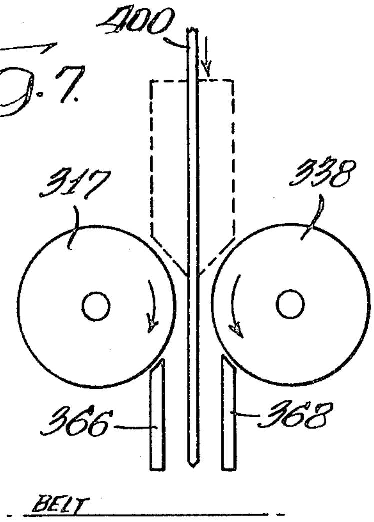


Fig. 7.



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METHOD OF FORMING WEBS AND APPARATUS THEREFOR

This invention relates to an improved apparatus and process for air-laying fibers to produce nonwoven webs consisting of a more or less uniform intermixture of randomly oriented fibers. It is particularly directed to producing a substantially homogeneous blend of long and short fibers, i.e., textile length and paper-making fibers.

Fibers are usually classified according to length, with relatively long or textile length fibers being longer than about one-fourth inch and generally between ½ and 2½ inches in length. The term "long fibers," as used herein, refers to textile fibers having a length greater than one-fourth inch, and the fibers may be of natural or synthetic origin. The term "short fibers," as used herein, refers to papermaking fibers, such as wood pulp fibers or cotton linters having a length less than about one-fourth inch. While it is recognized that short fibers are usually substantially less costly than long fibers, it is also recognized that for some uses it is desirable to strengthen a nonwoven web of short fibers by including a blend of long fibers therein.

Nonwoven fabrics are structures consisting of a random assemblage or web of fibers which are bonded together with an adhesive to provide the desired strength. Nonwoven fabrics have gained considerable prominence within the last two decades because of their low cost to manufacture, as compared to the cost of making more conventional textile fabrics by weaving or knitting. This has come about since nonwoven fabrics can be made with physical properties and appearance more or less comparable with the more expensive woven fabrics. Nonwoven materials have been used for hand towels, table napkins, curtains, hospital caps, draperies, etc. They are usually available in a wide range of fabric weights of from as little as about 100 grains per square yard to as much as about 4,000 grains, or more, per square yard.

Nonwoven fabrics may be made up of webs in which the fibers are either more, or less oriented, or randomly disposed. Webs in which the fibers are oriented generally have the major proportion of their fibers aligned in one direction, i.e., in the "machine," or long direction, with the result that these webs are anisotropic. Such webs are relatively strong in the machine direction. On the other hand, isotropic webs are made up of randomly disposed fibers which extend in all directions and thus have substantially uniform strength in all directions.

There have been many different processes and apparatuses for producing nonwoven webs. One of the well known ways for producing nonwoven webs of textile length fibers is by employing a conventional carding process which results in an anisotropic web, since the fibers are aligned predominantly in the machine direction. Another method that could be used is a garnetting process, in which the fibers have less orientation than carded webs. These webs are generally of unsatisfactory uniformity and are also limited to textile length fibers. The ways in which webs can be produced by either of these techniques is limited, and these techniques do not lend themselves for use in making very low cost nonwoven fabrics, especially embodying the use of relatively inexpensive wood pulp fibers.

Another current way for producing a random web of textile length fibers is the "Rando-Webber" process, wherein pre-opened textile length fiber material is delivered as a loose mat to a web-forming unit. The web is brought into contact with a lickerin that further opens the fibers and introduces them into a high velocity, low pressure air stream. The fibers are subsequently deposited in random fashion on a condensing screen to produce a substantially isotropic web. While this process is generally satisfactory to provide a relatively uniform random web of textile length fibers, it is generally not suitable for use with short fibers, nor with blends of short and long fibers. Also, this machine has limited throughput capacity.

As described in Langdon U.S. Pat. No. 3,512,218, granted May 19, 1970, air-laid, isotropic, nonwoven webs may be formed by placing two lickerin and rotary feed condenser assemblies in parallel. In the process of this patent, individual fibers deposit as a mat on the condenser and are then fed to the lickerins, where the fibers are individualized. These parallel systems use a single air stream that is split into two parts to doff the fibers from the lickerins and deposit them as streams of fibers onto a suction box where the final web is formed. The same fibers are processed in each assembly and there is no blending of the fibers in advance of the suction box. While the apparatus of this patent doubles the flow rate that can be obtained with a similar single system, it has deficiencies in that it cannot be employed to homogeneously blend two streams of fibers.

Wood U.S. Pat. No. 3,535,187, granted Oct. 20, 1970, discloses an apparatus for producing a nonwoven web comprised of two or more separate layers of different randomly oriented fibers apparently joined at the interface of adjacent layers by a relatively small mixture of the fibers. The webs produced by this apparatus are comprised essentially of textile length fibers, although the patent contemplates that continuous filaments and wood pulp fibers can also be included. In the webs produced by the process of this patent, textile length fibers extending generally perpendicularly between the opposed faces of the web serve to knit or tie the fiber layers together.

The apparatus of the Wood patent, as in the apparatus of Langdon U.S. Pat. No. 3,512,218, includes two lickerin and rotary feed condenser assemblies. Individualized fibers from each lickerin are deposited as layers on separate cylindrical condenser screens, each related to a lickerin. The two condenser screens are positioned closely adjacent one another and the layers of fibers on the condensers are compressed between the condensers to form a composite nonwoven web having some blending of the fibers at the interface between the layers.

In the process of the Wood patent, the fibers are doffed from their respective lickerins by high-speed turbulent air streams that move faster than the peripheral speeds of the lickerins. The fibers are entrained in the air streams moving past the lickerins. The velocities of these air streams are controlled so that when they are in the vicinity of the condensers, the velocities are reduced to where the entrained fibers will not be forcibly impacted on the condensers. A balance must be achieved in the air flows in each of the condensing chambers so that the individual fibers have only just enough kinetic energy to deposit themselves in isotropic web formation. Due to the low velocity of the air streams carrying entrained fibers from the lickerins to the condensers, there is a minimum of blending of the fibers in their passage in the regions adjacent the condensers, and hence the resulting composite nonwoven web has only a minimal region of intermixed fibers.

The method and apparatus of the present invention can be used to form nonwoven webs that are a blend of randomly oriented long and short fibers. This is in sharp contrast to the prior art processes and apparatuses that were capable of forming nonwoven webs made up of only all short fibers or all long fibers, or a composite web made up of layers of both long and short fibers.

In general, the desired characteristics of the nonwoven end product, as well as its utility dictate the type of fibers and the relative proportions of long and short fibers to be used. Thus, for example, the product may require one or more characteristics, such as tear resistance, abrasion resistance, washability, and stretchability, burst strength, absorption or nonabsorption to different liquids, heat sealability, ability to resist delamination, etc., all of which will influence the type of fiber or mixture of fibers to be used. Thus, by way of specific example, absorbent products requiring strength characteristics may be a combination of two or more different fibers, such as wood pulp fibers and rayon, or similar fibers in varying percentages.

Likewise, again depending on the nature of the fabric desired, the mixed fibers in the fabric may possess substantially random characteristics as opposed to oriented fiber characteristics in order to provide for balanced properties in both the machine and cross direction of the fabric. For example, in the case of products intended for surgical, or similar, uses requiring absorbency characteristics, such as covering layers for sanitary napkins, absorbent layers for surgical drapes, etc., mixtures of randomly oriented short and long fibers are required to provide improved mechanical characteristics; while in the case of nonwoven materials suitable for use as disposable items in the field of diapers, short fibers are generally employed.

Typical of the short fibers in the mixtures of fibers obtained by the process of the present invention are wood pulp fibers from various types of woods, cotton linters, asbestos fibers, glass fibers, and the like; with wood pulp fibers being those which find most frequent use in a large variety of products due to their ready availability and economical attributes. Wood pulp fibers are commercially available in the form of pulpboards, which come in varying thicknesses and lengths.

Typical of the long or staple length fibers are synthetic fibers, such as cellulose acetate fibers, vinyl chloride-vinyl acetate fibers, viscose staple rayon, and natural fibers, such as cotton wood or silk.

In the case of staple or long length fibers, such as rayon, for example, they are normally commercially available in bale form in various fiber lengths. In the present invention, the staple fibers are generally introduced in a pre-opened oriented condition, such as in the form of a "carded web" or "carded batt," but these fibers may be presented to the machine by other means, such as a chute. If desired, in place of using a carded batt of only rayon, a mixture of rayon and other fiber, or fibers, or for that matter, a mixture of any two, or more different long fibers can be employed.

Combinations of any of the short and staple or long fibers may be employed in this invention. The denier of the fibers used may vary over a wide range and may be from one-half to 100, depending on the type of fiber employed and the requirements of the nonwoven material. Commonly, when using staple fibers, such as rayon, the denier will vary from 0.75 to 5 or 6 denier.

Those skilled in the art have long recognized the need for a process and apparatus that can economically produce a non-woven web of a mixture of long and short fibers, especially one wherein the mixture of long and short fibers is randomly oriented more or less uniformly throughout the web, so that the web has substantially uniform strength characteristics lengthwise and crosswise thereof. Of particular interest has been the desire to obtain an air-laid nonwoven web of homogeneously blended, randomly oriented short and long fibers which combines the cheapness of short fibers with the strength of long fibers together with substantially uniform strength characteristics throughout the long and short dimensions of the web. There has also been the need for a single apparatus that is flexible enough to produce air-laid nonwoven webs of a mixture of long and short randomly oriented fibers in which the webs have a variety of fiber distribution patterns, including, (1) webs that have outer layers made up each of two different fibers and an intermediate layer that is a homogeneous blend of the two fibers, (2) webs that have a predominance of one fiber at one face of the web and a predominance of a second fiber at the other face of the web and a mixture of the two fibers in a transition zone between the faces, wherein the fiber which predominates at one face diminishes progressively from that face towards the other face, and vice versa, and (3) a web made of two separate layers of different fibers that are interlaced only at the region of their interface.

There have been a number of attempts to produce non-woven webs made of a homogeneous mixture of randomly oriented short and long fibers, but these webs, while generally satisfactory for some uses, are not of sufficiently high quality to permit them to be used without an outer facing layer. The reason for this is that in the apparatus used, clumps or hardened particles of broken or compacted fibers commonly referred to as "salt," were formed and remained distributed throughout the web. With these clumps and "salt," the webs were not suitable for making products, such as surgical towels, dressings, disposable diapers, sanitary napkins, cloths, cosmetic pads, and the like, although in some instances they could be used in conjunction with a high quality facing layer.

One apparatus used to make a nonwoven web of a homogeneous mixture of randomly oriented long and short fibers includes the use of a milling device, such as a hammer mill, to individualize the short fibers and a lickerin to individualize the long fibers. The individualized short fibers are entrained in an air stream leading to a mixing zone into which the long fibers are introduced, where the fibers are intermixed. The mixture of fibers is deposited on a condenser to form a web of a random mixture of long and short fibers. In these webs, the intermixed fibers are not homogeneously blended; in fact, in such webs, there is more or less of a stratification of the fibers in layers, with the long fibers predominating on one side of the web and the short fibers predominating on the other side. A particular disadvantage of this apparatus was that the hammer mill did not completely individualize the wood pulp fibers and, in consequence, clumps of fibers and/or "salt" resulted.

Another method used to blend a mixture of long and short fibers into a nonwoven web of randomly oriented fibers involves the step of introducing a mixture of preopened long and short fibers to a single lickerin where the mixture of long and short fibers is individualized. The individual fibers, but still in admixture, are introduced into an air stream and conveyed to a condenser where they were formed into a web. This method has a significant disadvantage in that in order to prevent degradation of the long fibers, it is necessary to operate the lickerin at the optimum speed for the long fibers, which is much below that which is optimum for short fibers. This necessary compromise seriously limited the rate at which the fibers could be processed through this system and this economic disadvantage militates against its use.

A recent development in this field of air-laying webs has overcome a number of the aforementioned problems in the apparatus previously used and makes possible production of a non-woven web of a homogeneous mixture of long and short fibers, free from consequential amounts of clumps and "salt." The apparatus and method of this development are described and claimed in a commonly owned application Ser. No. 108,547 filed in the name of Ernest Lovgren on even date herewith.

In the Lovgren apparatus and process, long and short fibers to be blended are individualized separately and simultaneously by separate high speed lickerins, one for each type of fiber, that are operated at speeds optimum for the specific fibers acted upon. For example, in the case of pulpboard, the lickerin is operated in the order of 6,000 rpm. to individualize the wood pulp fibers, and the long fibers, the staple length fibers, for example, rayon, are individualized by the lickerin acting on these fibers, operated at a speed in the order of 2,400 rpm. At a speed of 6,000 rpm., rayon fibers are damaged.

In the Lovgren apparatus, individualized fibers are doffed from their respective lickerins by separate air streams. The fibers are entrained in the separate air streams and the air streams are subsequently intermixed in a mixing zone to homogeneously blend the fibers entrained therein. The homogeneous blend of fibers is then deposited in random fashion on a condenser disposed in proximity to the mixing zone. The air streams generated by the high speed operation of the lickerins and by a suction fan located in the condenser, which acts to draw air past the lickerins, convey the fibers to the condenser.

While the Lovgren apparatus represents a substantial advance in the art, the apparatus has limitations in that it does not lend itself for use in making a wide variety of webs.

In accordance with the present invention, there is provided a novel method and apparatus that can be practiced to produce a wide variety of nonwoven, air-laid isotropic webs made up of a substantially uniform mixture of long and short fibers, or of two different kinds of long or short fibers. Included in these webs are webs which cannot be made in the Lovgren apparatus, such as, for example, (1) webs that have outer layers made up of each of two different fibers and an intermediate layer that is a homogeneous blend of the two fibers, (2) webs that have a predominance of one fiber at one face of the web and a predominance of a second fiber at the other face of the web and a mixture of the two fibers in a transition zone between the faces, wherein the fiber which predominates at one face diminishes progressively from that face towards the other face, and vice versa, and (3) a web made of two separate layers of different fibers that are interlaced only at the region of their interface.

An embodiment of the present invention illustrates an apparatus in which two sources of fibers, such as pulp and rayon, are individualized by separate lickerins and formed into a web. Each of the sources of fibers is guided by a nose bar into engagement with its respective lickerin, each being rotated at a high speed suitable for the fibers it is to act on, to individualize the fibers directed thereto. The lickerins are disposed parallel to each other and are rotated in opposite directions, i.e., toward each other. When the web is to be made up of long and short fibers, the lickerin for the short fibers is rotated at the maximum speed it can be operated without damaging the short fibers. The lickerin used for individualizing the long fibers is, of necessity, operated at a much slower speed to prevent degradation of the fibers. The nose bar and lickerins are set to obtain the optimum opening relationship for the fibers being processed, by known techniques.

The fibers that are individualized by the lickerins are acted on by separate high-velocity, turbulent air streams that are directed against the lickerin clothing at a junction adjacent its respective nose bar. The flow of air to each lickerin is regulated to control the quantity and uniformity thereof. The high velocity air streams are directed past the lickerins at a faster speed than the peripheral speed of the lickerins to assist the centrifugal forces imposed on the fibers by the lickerins in the doffing of the fibers from the lickerins, and entrain and convey the individualized fibers. The separate air streams are impelled toward one another and are subsequently brought together into a common high-speed air stream in a centrally disposed mixing zone defined by and between the spaced lickerins. In the mixing zone, the entrained fibers, still under the inertia set up by the high-velocity air streams and the centrifugal forces imposed on the fibers due to the high speed operation of the lickerin, are intermixed uniformly, so that they can later be air-laid into a nonwoven web of intermixed, randomly oriented, long and short fibers.

In the process of the present invention, the fibers entrained in the separate gaseous streams have a trajectory including a component impelling them toward one another, as well as a component directing them toward the mixing zone. Although the fibers are transported by the separate gaseous streams to the mixing zone, the fibers have sufficient kinetic energy by virtue of their mass and velocity, so that the fibers continue to travel at least in part in the direction of the initial trajectory because of their inertia. In consequence of this, the component of motion of the fibers toward one another causes them to combine in an intimate mixture of fibers when the air streams collide and intermix in turbulence into a common stream.

The common air stream is produced by the cooperative action of the fast moving air streams drawn through the system by a large suction generated within a fiber condensing means located at the terminal end of the mixing zone plus the air generated by the rotary action of the oppositely rotating high-speed lickerins. The combined stream in a state of turbulence transports the mixed fibers through the mixing zone to a condensing means where the fibers are deposited to build up a web of the desired thickness.

Different types of webs can be obtained with the apparatus of the present invention by introducing a baffle into the flow paths of the separate air streams in advance of the intermingling thereof. The baffle may be positioned to partially block the intermixing of the air stream and thus affect the blending of the entrained fibers in the mixing zone.

In one embodiment of the instant invention where the apparatus is fed wood pulp and rayon fibers and the air volume to fiber volume ratio in the common air stream is in the order of 5,000 to 1, and the baffle does not block the separate air streams, a nonwoven web of randomly oriented pulp and rayon fibers, in substantially homogeneous intermixture is formed. With the same operating parameters, except with the baffle partially blocking the intermixing of the separate air streams, a web is formed having a layer of randomly oriented wood pulp fibers on one side, a layer of randomly oriented rayon fibers on the other, and an intermediate layer that is a homogeneous blend of randomly oriented wood pulp and rayon fibers.

The position of the baffle in the fiber mixing region determines the thickness of each of the aforementioned layers. It is possible to operate the apparatus of the present invention with the baffle fully extended, i.e., into a position immediately adjacent the condenser. With this arrangement, there will be no intermediate layer of homogeneously blended fibers and a web made up of two separate layers of different fibers that are interlaced only at the region of their interface will be formed.

The apparatus of the present invention can also be used to form still different types of webs, depending on the ratio of the volume of air to the volume of fiber in the duct carrying the common air stream through the system and the position of the baffle. It has been found that with the apparatus of this invention used with the baffle retracted, i.e., so that it does not block the mixing of the fibers, and a volume of air to volume of fiber ratio in the order of 12,000 to 1, or greater, a web is formed that has a predominance of one fiber at one face and a predominance of a second fiber at the other face of the web and a transition zone between the faces, wherein the fiber, which predominates at one face diminishes progressively from that face towards the other face, and vice versa. When the baffle is introduced into the system and the volume of air to volume of fiber ratio is in the order of 12,000 to 1, or more, homogeneously blended, and other types of nonwoven webs can be formed. The process utilizing such high volume of air to volume of fiber ratios, i.e., 12,000 to 1, or more, and the novel products formed thereby are disclosed and claimed in an application entitled "Web Forming Process and Product Produced Thereby," filed Jan. 21, 1972, in the names of Messrs. Ruffo and Goyal, Ser. No. 108,546, which application is assigned to the assignee of the present invention.

It is thus seen that by the practice of the instant invention, one is able to produce a wide variety of nonwoven webs of randomly oriented fibers, including one that is a homogeneous mixture of long or short fibers, or one which has opposed faces having selective properties, such as cohesiveness, cohesive strength, abrasion resistance, absorption characteristics, nonabsorbent characteristics, and so forth. The thickness and weight of the nonwoven products being produced by the novel apparatus and method disclosed herein can vary depending on conventionally commercial requirements, but typically they will in the order of 700 grains to several thousand grains per square yard and with a thickness of from about one thirty-second to about 1 inch, or more, prior to any post-treating operation. The web thickness will vary depending on the feeding rate of the fibers and the speed at which the web is removed from the condensing zone.

The foregoing advantages and numerous other features and advantages of the invention will be more readily understood and appreciated in light of the following specification, taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a cross-sectional view showing the main components of the apparatus forming part of the instant invention as taken along line 1—1 of FIG. 2;

FIG. 2 is an end elevational view of the apparatus illustrated in FIG. 1;

FIG. 3 is a fragmentary perspective view, partially in section, showing a portion of the condenser;

FIG. 4 is an enlarged sectional view taken along line 4—4 of FIG. 3;

FIG. 5 is a schematic view of the apparatus showing the baffle partially extended;

FIG. 6 is a view showing the baffle in a more fully extended position;

FIG. 7 is a view showing the baffle in the fully extended position wherein it is located immediately adjacent a condenser;

FIG. 8 illustrates a randomly oriented, fully homogeneous web;

FIG. 9 shows a web having outer layers made of separate fibers and an intermediate homogeneous mixture of the two fibers;

FIG. 10 is a view showing a two-layered web; and

FIG. 11 is a web having a preponderance of a different type of fiber on each of the faces and a transition zone, such that the fiber type which predominates at one face diminishes in predominance from the face at which it predominates to the face at which the other fiber type predominates.

DETAILED DESCRIPTION OF THE INVENTION

While this invention is susceptible of embodiment in many different forms, there are shown in the drawings and will herein be described in detail only preferred embodiments of the invention and modifications thereof, with the understanding that the present invention is to be considered as an exemplification of the principles of the invention and is not intended to limit the invention to the embodiments illustrated. The scope of the invention will be pointed out in the appended claims.

Referring first to FIG. 1, there is illustrated a cross-sectional view of the web forming apparatus with parts broken away to show the relationship between the various components thereof. The apparatus will be illustrated and described as being used for blending wood pulp fibers and rayon, but it could obviously be used to blend two different fibers, or identical fibers.

In the drawings, the apparatus includes a main frame and subframe components, which, for the sake of simplicity and brevity, will be identified by reference letter F.

Reference will first be made to the left-hand, or wood pulp side of the system.

Wood pulp is introduced into the system in the form of a pulpboard **310**, which is directed between a plate **311** and a wire wound feed roll **312**. Connected to the lower part of the plate **311** is a nose bar **313** for providing an anvil against which the pulpboard is directed during the individualizing step. The nose bar **313** has a sidewall **314** that can be made relatively flat, since, due to the integrity of the pulpboard, it is unnecessary that the nose bar **313** be designed to more precisely direct the pulpboard to the lickerin **317** that is used to individualize the pulpboard into short fibers. The bottom wall **315** of the nose bar **313** is angularly disposed relative to the sidewall **314** and is spaced a short distance from the teeth **316** of the lickerin **317** to define a passage **318** through which the pulpboard is moved during the individualizing operation. The pulpboard is individualized into short wood fibers by the teeth **316** of the lickerin **317** acting on the pulpboard directed into position to be contacted by the teeth by the nose bar **313**.

The feed roll **312** is journalled in a bracket **319** that is eccentrically mounted at **320** to permit adjustment of the feed roll relative to the pulp lickerin **317** and nose bar **313**. The bracket **319** and feed roll **312** are resiliently biased to direct the pulpboard toward the nose bar **313** by a spring **322** that is located between bracket **319** and head **324***a* of bolt **324** that extends through a hole in the bracket **319**, and is secured in place in plate **311**. The pivotal movement of the bracket **319** is limited by a set screw **328** that is threaded into and through bracket **319** and engages plate **311**. The spring **322** biases feed roll **312** into contact with pulpboard **310** to insure that the pulpboard is fed into position to be engaged by lickerin teeth **316**. This design accommodates varying thicknesses of material that can be used in this system.

The feed roll **312** is secured to a shaft **330** that is suitably supported for rotation by a variable drive means, a portion of which is shown schematically in FIG. **2**. The details of the drive means are not important to the present invention. The speed at which the feed roll is operated is determined by the rate at which pulp is to be fed into the system. A number of the mechanisms employed for supporting the rolls, lickerins, and so forth, are shown generally in FIG. **2** and they will be referred to when they will aid in understanding the present invention.

During the operation of the novel apparatus, the pulpboard **310** is fed into position to be engaged by the lickerin teeth **316** adjacent the nose bar **313**. The lickerin **317** is mounted on shaft **331**, which is driven at a very high speed by suitable drive means to individualize the pulpboard into short fibers. The drive means, together with shaft **331**, comprises means for rotating lickerin **317**. In an exemplary embodiment, the lickerin **317** is driven at a speed of 6,000 rpm. and produces a large throughput of pulp fibers without adversely affecting the fibers.

The lickerin teeth **316** fray the pulpboard until the fibers are loosened therefrom, after which the teeth comb the short fibers out of the board. The clothing on the lickerin is designed to act on the particular fiber and has the optimum tooth profile for the specific material it is processing. Each successive tooth has more opening action than the one before, which facilitates individualizing and when operated at an optimum speed greatly minimizes, if not totally prevents, clumps and salt from being extracted from the board.

The pitch and height of the teeth used on the lickerin for the pulpboard may vary, good results being obtained with a tooth pitch of about three thirty-seconds inch to about one-half inch and a tooth height of about three thirty-seconds inch to about one-half inch. The angle of the teeth of the lickerin for the pulpboard may also vary, generally within the limits of about −10° to about +10°. A positive angle for the teeth of the pulpboard lickerin which is standard in the industry, viz., +10°, may be used in accordance with the invention, but this is not preferred. In general, it is preferred that the angle of the teeth be positive and be below +10°.

After the wood fibers are individualized by the lickerin **317**, they are entrained in a turbulent air stream and directed through a duct **332** formed between the lickerin teeth **316** and a sidewall **333**, which duct **332** leads into a mixing zone **334**.

Referring now to the rayon fiberizing system which is illustrated on the right side of FIG. **1**, there are shown mechanisms that control the feeding of the rayon to the system. A number of the mechanisms used in processing the rayon are similar to those used on the pulp side of the system and where they are identical they are given the same numbers.

The rayon, which usually comes in the form of a carded batt **335**, has no integrity and must be positively directed to the clothing of the rayon lickerin **338** to insure that the rayon lickerin teeth **339** will pick the rayon up from a rayon source **335**. To this end, the nose bar **336** used with the rayon wire wound feed roll **337** differs from the pulp nose bar **313**. The nose bar **336** is curved at **336***a* to essentially conform to the adjacent circumference of the rayon feed roll **337**. The rayon fibers picked up from the rayon source are positively maintained in position relative to the feed roll **337** until the fibers are disposed immediately adjacent the teeth **339** of the rayon lickerin **338**, which teeth will then serve to comb the fibers from the rayon source. The rayon lickerin is mounted on shaft **341**, which is driven at a high speed by suitable drive means (not shown). The drive means, together with shaft **341**, comprises means for rotating lickerin **338**. A speed which can generally be used without seriously adversely affecting the fibers is 3,000 rpm.

The teeth of the rayon lickerin usually have a lower tooth height and pitch than the pulp lickerin. The pitch and height of the teeth used on the lickerin for the rayon may vary, good results being obtained with a tooth pitch of about one-eighth inch to about one-fourth inch and a tooth height of about one-eighth inch to about one-fourth inch. The angle of the teeth of the lickerin for the rayon may also vary, generally within the limits of about −10° to about +20°. The individualized rayon fibers are then air-conveyed into duct **340** located between sidewall **342** and lickerin **338**, which duct **340** leads into mixing zone **334**. The randomly oriented wood pulp and rayon fibers in the mixing zone **334** are then directed through duct **352** onto a condenser **350** where they form a web.

The movement of the air streams flowing through the system and its action on the fiber particles to effect the doffing, blending and condensing that takes place subsequent to the individualizing will be covered in detail hereinafter.

In the process of the present invention, the length of the fibers in the condensed nonwoven web may be varied as desired by varying one or more conditions in the process. These conditions include, (a) the method used to open the fibers, as by adjusting the height and angle of the teeth, (b) the rate at which the fibers are opened and entrained, and (c) the method and rate of feeding the fiber source to the fiber opening and entraining step.

While the lickerins, nose bars, and fiber receiving means have been shown in a fixed position, These mechanisms may also be made adjustable relative to the frame F if this is desired.

The doffing of the fibers from the lickerins **317, 338**, the air entrainment of the previously individualized fibers, the conveying of the fibers through the ducts **332, 340** into the mixing zone **334**, and the conveying of the intermixed fibers through duct **352** to condenser **350** are accomplished by high velocity, turbulent air that is introduced into the system by being pulled in through parallel passages **344, 346** by a suction fan (not shown).

The parallel flow paths **344, 346** lead to lickerins **317, 338**, respectively, to direct high velocity turbulent air in a uniform flow pattern against the lickerin teeth **316, 339**, respectively, to doff the fibers clinging thereto. The air with entrained particles therein then flows through ducts **332, 340**, respectively, into mixing zone **334** from where it flows through duct **352** and condenser **350**. The blended randomly oriented fiber particles entrained in the air stream are deposited on the condenser in the form of a web.

The condenser **350** on which the fibers are formed into a web consists of an endless movable mesh screen conveyor **381** that is directed over four pulleys **382, 384, 386**, and **388**. The position of pulley **388** can be adjusted to provide suitable tension on the screen. The conveyor is driven by suitable drive means (not shown). The conveyor **381** slides over the housing **348**, which contains an aperture **349**, through which the air is sucked into the housing and through conduit **389** that leads to the suction fan. The speed at which the condenser is moved will determine the thickness of the web being formed. For example, the thickness of the web will be increased by decreasing the web take-away speed, and vice versa.

The screen conveyor **381** leads to another conveyor belt **390** on which the web is carried to Another station for further processing. For example, the nonwoven webs obtained by the process of the present invention may be post-treated by any suitable conventional bonding technique, e.g., mechanical, or chemical, to bond the web and provide the required strength and coherency characteristics for a given product. The particular type of bonding technique chosen will depend on various factors well-known to those skilled in the art, e.g., the type of fibers, the particular use of the products, etc. To this end, typical of the conventional techniques are web saturation bonding, suction bonding, foam bonding, print bonding, fiber bonding, fiber interlocking, spray bonding, solvent bonding, scrim bonding, viscose bonding, mercerization, etc.

For further details of the various bonding techniques, including the binders that can be employed, reference may be made to the aforementioned Lovgren application.

In order to help seal off duct **352** and maximize the efficiency of the suction fan being used, a pair of vertically extending plate members **366, 368** are employed to define two outer wall portions of the duct **352** between the lickerins and the condenser. The lower portion of the duct **352** between the plates **366, 368** and the condenser **350** are essentially sealed off by rollers **369** that are rotatably mounted on pivotally mounted arms **370, 372** that are connected at their upper arms to a shaft **374**. The weight of the rollers and arms tends to maintain the rollers in a sealing condition to minimize the introduction of air between the rollers **369** and the plates **366, 368**, and condenser **350**.

Referring now to FIG. **4**, there is illustrated a sealing mechanism that acts to seal the flow duct **352** along the edges of the web being formed. On each side, there is provided a floating seal **376** that is biased into contact with the web by a spring **378**. The seal **376** is reciprocately mounted in a recess **379** defined in a side plate **380**. This mechanism is duplicated on the opposite side to prevent introduction of air into the suction fan other than down through the flow ducts **352**.

The condition and direction of the air flowing through the system has a very significant effect on the particular webs being formed. The air must have a uniform flow pattern through the system to aid in the formation of a uniform web. Also, the air should be in a turbulent condition and have a velocity greater than the peripheral speed of the lickerin which aids in doffing the fibers from the lickerin and prevents fiber clumping.

The ratio between the volume of air and volume of fibers passed through the system also has a significant bearing on the type of web that will be formed by the system. The air flow plays the important role that it does since it is in effect a pneumatic conveyor that deposits the fibers onto a condenser where they are formed into a web. The quantities of fibers to be conveyed determine the amounts of air to be directed against the particular lickerin used for fiberizing a given material. Thus, for example, when forming a web of 90 percent (by weight) of wood pulp fibers and 10 percent (by weight) of rayon, a substantially higher quantity of air is needed to convey the wood pulp fibers than is needed to convey the rayon fibers.

In order to control the relative quantities of air directed to the pulp and rayon lickerins while insuring that the air so introduced aids in doffing the fibers from the lickerins, the air passages **344, 346** are appropriately designed and located.

Air passage **344** is vertically disposed and the lower end is located immediately adjacent the teeth **316** of the pulp lickerin **317**. The webs being formed by this system have substantial width and thus it is important that the air flow across the axial length of the lickerin be uniform, so that the thickness of the web will be constant. Also, the air acts to more effectively doff the fibers from the lickerin if it is in a generally turbulent condition. To provide for turbulence while insuring that the air is uniformly distributed across the lickerin a wedge-shaped restrictor **354**, secured to plate **356** that forms a sidewall of passage **344**, is provided at the lower end of passage **344**. The restrictor **354** defines a throat **358** through which the air pulled through the passage **344** must pass. This throat portion **358** brings about a low pressure drop and raises the velocity of the air before it contacts the pulp lickerin teeth **316**. The high velocity turbulent air directed into duct **332** from passage **344** in conjunction with the centrifugal forces imposed on the fibers due to the high speed of rotation of the lickerin **317** doffs wood pulp fibers from the lickerin teeth. The air in duct **332** entrains the fibers therein and conveys them to a mixing chamber **334.** The duct **332** is directed downwardly at an approximately 45° angle and the high velocity air flowing therethrough will be directed into collision with the high velocity air flowing past the rayon lickerin, the path of which will be described below.

In a system where there is substantially less air needed to process the rayon fibers than to process the wood pulp fibers, it will be necessary to provide a substantial obstacle to the flow of air through the passage **346** to provide for the desired unbalanced air flow through the system.

In the passage **346,** there is a restrictor provided in the form of an adjustable block **360,** which has a substantial length and fills up a major part of passage **346.** Between the plate **311** and block **360** there is defined a narrow passage **362.** The block **360** results in setting up a turbulent condition for the air flowing into duct **340** and severely limits the quantity of air flowing thereto, as compared to the air flowing through the passage **344** and into duct **332.** The position of block **360** can be adjusted by mechanism **364.** The width of the passageways **344, 346** can also be adjusted by the insertion of blocks by varying widths therein.

The high velocity turbulent air in duct **340** is moving faster than the peripheral speed of lickerin **338** and acts to doff the fibers from the rayon lickerin teeth **339** and entrain the fibers therein. Duct **340** is directed downwardly at a 45° angle with the result that the high velocity turbulent air flowing therethrough comes into impelling relationship with the entrained wood pulp fibers in the air stream moving downward through duct **332** into the mixing chamber **334.** These air streams are moving at a very high rate of speed and the air is in a turbulent condition, with the result that when these two streams intermix, the fibers entrained therein will form a homogeneous blend of randomly oriented fibers. As the fibers are accelerated and entrained in the air streams flowing through ducts **332, 340,** they possess substantial kinetic energy because of their mass and velocity, and the inertia of the fiber tends to keep them moving along a path generally in the direction of their initial trajectory. The blended fibers then move down through the duct **352** onto the condenser **350,** where a job made up of a mixture of wood pulp and rayon fibers is randomly oriented more or less uniformly throughout the web, so that the web has substantially uniform strength characteristics lengthwise and crosswise thereof.

In practicing the present invention with the illustrated apparatus, a nonwoven web of homogeneously blended, randomly oriented fiber has been formed with a volume of air to volume of fiber ratio in the system being in the order of 5,000 to 1. Other types of webs can be formed with the illustrated apparatus by introducing a flow controlling member such as a baffle into the mixing zone, or by changing the volume of air to volume of fiber ratio.

The baffle **400,** when introduced into the mixing zone **334,** acts to at least partially block the intermixing of the separate air streams flowing through the ducts **332, 340.** With the baffle extended into the mixing zone, the entrained fibers in ducts **332, 340** are prevented from intermixing until they pass below the bottom of the baffle. This controls the mixing of the high velocity air streams being impelled towards each other down ducts **332, 340.** The webs that are formed with the baffle extending into the mixing zone will vary depending on the depth of penetration of the baffle into the mixing zone.

The baffle **400** is in the form of a plate that extends the full width of the machine and, as shown, intersects the space between the lickerins. The baffle **400** is positioned through the action of a pair of gears **402** that mesh with racks **406** secured to the baffle **400** (FIG. **2**). Leakage of air into the system past the baffle is prevented by sealing and guide members **408, 410.** The particular location of the baffle will determine how much blending will take place between the streams of fibers in ducts **332** and **340.** With the baffle located at an intermediate position in the mixing chamber and the volume of air to volume of fiber ratio in the order of 5,000 to 1, an isotropic web will be formed in which the bottom layer consists of substantially all wood pulp fibers, the upper layers consists of substantially all rayon fibers, and the intermediate layer is a homogeneous blend of the two fibers. As the baffle is moved further and further down toward the condenser, the intermediate layer of homogeneously blended fibers will become thinner and thinner and the outer sections of the web proportionately thicker. With the baffle all the way down, as shown in FIG. **7,** a two-layered web of short and long fibers will be formed with the separate layers of different fibers interlaced only at the region of their interface.

The apparatus of the present invention can also be used to form still different types of webs, depending on the ratio of the volume of air to the volume of fiber in the duct carrying the common air through the system and the position of the baffle. It has been found that the apparatus of this invention used with the baffle retracted out of blocking relationship with the ducts **332, 340** and the volume of air to volume of fiber ratio in the order of 12,000 to 1, or greater, the fibers cross each other in the mixing zone and a web is formed having a preponderance of one fiber on one face of the web and a preponderance of a second fiber on the other face, and a mixture of fibers in a transition zone between the faces wherein the fiber which predominates at one face diminishes progressively from that face toward the other face, and vice versa. When the baffle is introduced into the system in which the volume of air to volume of fiber ratio is in the order of 12,000 to 1, or greater, other types of nonwoven webs can be formed. For example, in the position shown in FIG. **5,** where the baffle is in line with a plane drawn through the axis of the lickerins, a homogeneous, randomly oriented web is formed. The process of utilizing such high volume of air to volume of fiber ratios and the novel products formed thereby are disclosed and claimed in the aforementioned commonly owned Ruffo and Goyal application.

FIGS. **8–10** schematically illustrate some of the various types of webs that can be formed with the illustrated apparatus. FIG. **8** is intended to be a graphic illustration of a fully homogeneous web W. FIG. **9** illustrates a cross section of a non-woven web **412** that is made up of three layers that are interlaced at their interface to form a web. The web **412** includes a layer

414 that contains essentially all staple fibers, a layer 416 of pulp fibers and a layer 418 which is a homogeneous blend of staple and pulp fibers. FIG. 10 illustrates a cross section of a web 434 made up of separate layers of staple fibers 436, and pulp fibers 438 which are interlaced at their interfaces. FIG. 11 illustrates a cross section of a web 440 in which the upper layer 442 has a predominance of pulp fibers and the bottom layer 444 has a predominance of staple fibers, and a transition zone therebetween in which the predominance of staple fibers decreases as it approaches the predominantly pulp layer 442 and the predominance of pulp fibers decreases as it approaches the predominantly rayon layer 444.

The following examples apply to the illustrated apparatus.

Example 1. A nonwoven web of a homogeneous blend of randomly oriented short pulp fibers and staple rayon fibers was formed in which, by weight, 90 percent of the fibers were pulp and 10 percent of the fibers were rayon.

The short fibers were extracted from pulpboard and the rayon fibers came from a rayon picker lap in which the average fiber length was 1-9/16 inches, with a denier of 1.5.

Lickerins 317 and 338 were approximately 9½ inches in diameter and were rotated at about 6,000 and 3,000 rpm., respectively, and the lickerins were spaced from one another by about 1½ inches. Lickerins 317 and 338 were spaced from duct walls 333 and 342, respectively, by about three-fourths inch. Lickerins 317 and 338 were about 18 inches long and a total of 700 pounds per hour of fibers were fed to the lickerins. Deflector plates 366 and 368 were spaced from one another by about 4½ inches. The average volume ratio of air to fiber was approximately 5,000 to 1 in the common air stream.

With the web take-away mechanism operated at a speed of 125 feet per minute, and with baffle 400 in the withdrawn position, a homogeneous web of randomly oriented fibers was produced having a weight of approximately 4,000 grains per square yard.

Example 2. The basic machine parameters of Example 1 were repeated, with the exception that the fiber feed was controlled to provide a feed rate of 180 pounds of fibers per hour 50:50 (by weight) mixture of wood pulp and rayon fibers, and the process employed a 70,000:1 volume ratio of total gas to total fiber in the combined stream as disclosed in the above mentioned Ruffo et al. application. Also, lickerin 317 was rotated at about 5,000 rpm. The resulting web weighed approximately 550 grains per square yard, and was removed from the condensation zone at approximately 150 feet per minute.

With the above volume of air to volume of fiber ratio, and the divider plate 400 withdrawn, the resulting web was found to consist of a predominance of rayon fibers at one face of the web and a predominance of wood pulp fibers at the opposing face of the web, with a decreasing amount of wood pulp and rayon fibers from the faces at which they predominate, respectively, to the opposed faces. This "transition" feature was found to be substantially uniform from face to face.

Example 3. The machine parameters of Example 3 were essentially the same as those in Example 2, except that an 80:20 (by weight) mixture of short wood pulp fibers and staple rayon fibers were fed to the respective lickerins. The wood pulp feed rate was approximately 1,000 pounds per hour and the rayon feed rate was approximately 150 pounds per hour. Also, the baffle 400, having a thickness of about one-fourth inch, was positioned with the lower end thereof essentially located at the level of the plane defined by the axes of the lickerins. The combined air stream had a total air to total fiber volume ratio of approximately 30,000 to 1, as disclosed in the above mentioned Ruffo et al. application. The take-away mechanism was adjusted to provide a take-away speed of approximately 550 feet per minute, and the resulting web had a weight of approximately 1,400 grains per square yard.

The resulting web was found to be a homogeneously blended nonwoven web of randomly oriented fibers. The cross-over product, such as that obtained in Example 2, was prevented because of the degree of interference of the baffle 400 with the separate gas streams.

I claim:

1. The method of forming a nonwoven web comprising the following steps:

1. providing at least two separate sources of fibers,
2. feeding each fiber source to the inlet of a confined separate fiber flow path, said paths converging toward one another and being in communication with a common fiber mixing zone and each fiber flow path having a fiber outlet leading to said common fiber mixing zone,
3. individualizing the fibers received from each separate source and introducing the individualized fibers from each separate source into one fiber flow path through the fiber inlet thereof,
4. providing a restricted opening upstream of the fiber outlet of each fiber flow path for directing a separate gaseous stream through each of said restricted openings with an impelling force to (a) entrain the individualized fibers in their respective streams while the fibers are in their respective flow paths, and (b) convey the entrained fibers with an impelling force along said converging flow paths and beyond said outlets and into said mixing zone to forcibly intermingle at least some of the fibers in one gaseous stream with at least some of the fibers in another gaseous stream,
5. applying centrifugal forces to the fibers from each source in each fiber flow path and in said mixing zone to aid in entraining the fibers in their respective gaseous stream and to aid in the intermingling of the fibers in the common mixing zone,
6. applying a driving force to said gaseous streams to (a) cause said gaseous streams to flow through said restricted openings, (b) accelerate the movement of the entrained fibers through their respective flow paths and impel the fibers into said mixing zone with at least some of the fibers from each flow path having a component of motion directed toward fibers from another flow path, and (c) accelerate the fibers through said mixing zone to a depositing zone, and
7. collecting the fibers in the depositing zone to form a web of nonwoven fibers.

2. The method of claim 1 wherein the separate gaseous streams are controlled so that each stream is in a turbulent condition when it is directed through its respective restricted opening.

3. The method of claim 1 wherein one source of fibers is textile length fibers, and the other source of fibers is short fibers.

4. The method of claim 1 including the further step of controlling the location of the fiber outlet of each separate fiber flow path relative to said depositing zone to control the configuration of the common fiber mixing zone and the degree of intermingling of said at least some fibers and to thus determine the type of web to be formed.

5. The method of forming a nonwoven web comprising the following steps:

1. providing at least two separate sources of fibers,
2. feeding each fiber source to the inlet of a confined separate fiber flow path, each path being in communication with a common fiber mixing zone and each fiber flow path having a fiber outlet leading to said common fiber mixing zone,
3. individualizing the fibers received from each separate source and introducing the individualized fibers from each separate source into a fiber flow path through the fiber inlet thereof,
4. introducing a separate high speed gaseous stream into each fiber flow path upstream of the fiber outlet thereof to (a) entrain the individualized fibers in their respective streams while the fibers are in their respective flow paths, and (b) convey the entrained fibers with an impelling force beyond said outlets, into said mixing zone, and to a depositing zone, with at least some of the fibers in one gaseous stream entering said mixing zone with a component of motion directed toward at least some of the fibers in another gaseous stream to forcibly intermingle said at least some fibers,
5. controlling the location of the fiber outlet of each separate fiber flow path relative to said depositing zone to control the configuration of the common fiber mixing zone and the degree of intermingling of said at least some fibers and to thus determine the type of web to be formed, and
6. collecting the fibers in the depositing zone to form a web of nonwoven fibers.

6. The method of claim 5 wherein said controlling step is performed by at least partially blocking the intermixing of said gaseous streams.

7. The method of claim 5 wherein the step of introducing said gaseous streams is performed by independently controlling individual gaseous streams for each source of fibers.

8. The method of claim 5 in which one fiber source is a source of textile length fibers and the other fiber source is a source of short fibers.

8. The method of claim 5 in which the collecting step is performed by applying a suction to a foraminous fiber receiving member at said depositing zone, whereby said fibers are retained at a relatively high velocity prior to depositing on the fiber receiving member.

10. Web forming apparatus comprising: frame means; means for feeding a fibrous material to a first fiberizing station at a first location on said frame means; means for feeding a fibrous material to a second fiberizing station at a second location on said frame means; means defining a mixing zone between said fiberizing stations, said mixing zone having a fiber inlet end and a fiber outlet end; a first lickerin located adjacent the inlet end of said mixing zone; a second lickerin located adjacent the inlet end of said mixing zone; means mounting said lickerins in spaced parallel relationship on said frame means; means rotating each lickerin at its respective fiberizing station in fiber-removing relationship with respect to its respective fibrous material to open said fibrous materials and produce supplies of individualized fibers through the inlet end of said mixing zone; means for providing air streams for doffing the fibers from the lickerins and for initially directing said supplies of doffed fibers toward one another and to said mixing zone; a flow controlling member; means mounting said flow controlling member for movement relative to said mixing zone to control the extent to which said gaseous streams intermix, including means for moving said flow controlling member along a path that bisects the space between said lickerins; and fiber collecting means adjacent the fiber outlet end of said mixing zone for accumulating fibers to form a web.

11. Apparatus for forming a non-woven web of nonwoven fibers from at least two sources of fibers: a pair of lickerins; means rotatably mounting said lickerins in spaced parallel relationship with one another, so that the adjacent facing surfaces of said lickerins define boundary walls of a fiber mixing zone; means for rotating said lickerins in opposite directions; means for feeding each source of fibers into contact with its respective lickerin whereby each lickerin individualizes fibers it receives from its respective source; means, including a portion of the periphery of each of said lickerins upstream of the facing surfaces of the lickerins that define the boundary walls of the mixing zone, defining separate duct means having a fiber inlet adjacent the position where the fibers are individualized and a fiber outlet opening into said fiber mixing zone; means providing a restricted opening adjacent each lickerin, each restricted opening communicating with one of said separate duct means upstream of the fiber outlet thereof; means for impelling separate gaseous streams through each of said restricted openings and for directing said gaseous streams into its respective duct means and against the associated lickerin to (a) doff at least some of the fibers from each lickerin, (b) entrain the doffed fibers within the said duct means, and (c) convey the entrained fibers beyond the fiber outlet of each duct means and into said fiber mixing zone to forcibly intermingle at least some of the fibers from one gaseous stream with at least some of the fibers in the other gaseous stream; and collecting means including a movable foraminous member communicating with said fiber mixing zone to collect said fibers and form a web of non-woven fibers.

12. Apparatus as set forth in claim 11 including passage means in communication with each of said restricted openings, and means in each of said passage means for controlling the flow therethrough to insure that the required quantity of gas in turbulent condition is uniformly provided to its respective lickerin.

13. Apparatus as set forth in claim 11 including generally parallel wall members located adjacent the source of fibers for its associated lickerin defining passage means in communication with each of said restricted opening, and flow restricting means in each of said passage means for controlling the flow of the gaseous stream to the lickerin to insure that the required quantity of gas in the prescribed condition is uniformly provided to its respective lickerin.

14. Apparatus as set forth in claim **13** including means for varying the position of at least one of said flow restricting means.

15. Apparatus as set forth in claim **11** including means for providing a flow control member at a preselected position between said lickerins to control the intermixing of said gaseous streams and the intermingling of fibers.

16. Apparatus for forming a now-woven web of fibers from at least two sources of fibers comprising: means rotatably mounting a lickerin for each source of fibers; means for rotating said lickerins; means for feeding each source of fibers into contact with its respective lickerin whereby each lickerin individualizes fibers from its respective source; means defining a mixing zone between said lickerins having a fiber inlet end and a fiber outlet end; fiber collecting means adjacent the fiber outlet end of said mixing zone; means for causing gas to flow against each lickerin, through said mixing zone and to said fiber collecting means to (a) doff the individualized fibers from each lickerin, (b) introduce the doffed fibers into the mixing zone through the inlet end thereof, and (c) to forcibly intermingle at least some of the fibers in the mixing zone prior to deposition on the fiber collecting means; a flow controlling member; and means mounting said flow controlling member at least for vertical movement relative to said mixing zone between said lickerins to control the degree of intermingling of said fibers.

17. Apparatus as set forth in claim **16** wherein the mounting means for said lickerins locates the lickerins with the axes thereof in a common plane, and wherein the flow controlling member is mounted for movement perpendicularly with respect to said common plane.

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