APPARATUS FOR SPREADING TOWS OF CONTINUOUS FILAMENTS INTO SHEETS

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Notice: The portion of the term of this patent subsequent to April 9, 1982, has been disclaimed.

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ABSTRACT
Apparatus for spreading a plurality of tows of continuous filaments into sheet form comprising a container for a liquid in which there are placed a series of pairs of nip rolls submerged in a liquid. Between each successive pair of nip rolls there are positioned in the liquid means for applying both longitudinal and transverse forces to the plurality of tows as they pass through the successive pairs of nip rolls. There is feed means at one end of the container and means for removing the tow in sheet form at the other end of the container. The removing means is preferably an inclined plane over which liquid from the container is flowing to apply diverging forces to the plurality of tows to further open them into sheet form.

2 Claims, 6 Drawing Figures
APPARATUS FOR SPREADING TOWS OF CONTINUOUS FILAMENTS INTO SHEETS

This application is a divisional application of my co-pending application Ser. No. 472,504, filed July 16, 1965 and now U.S. Pat. No. 3,376,609, granted Apr. 9, 1968.

The present invention relates to apparatus for manufacturing unitary webs. More particularly, the invention relates to apparatus for manufacturing fibrous webs of continuous synthetic textile filaments. These textile filaments are known man-made materials, being artificial or synthetic in nature as hereinbefore indicated, as distinct from natural fibers, such as cotton, wool, etc. For convenience herein they will hereafter be referred to as "synthetic filaments" and/or "synthetic textile filaments."

As used herein, the term "web" means a thin, flimsy fibrous sheet of indefinite length as distinguished from ribbons or batts which have considerable thickness.

Hereinafter, fibrous webs have been made from staple length fibers and/or short papermaking fibers, that is, fibers less than about 2 inches in length. Such webs are made by a card engine or by papermaking or air laying machines. These machines produce a thin sheet or web of overlapping, intersecting randomly arranged fibers; the web is held together by the frictional entanglement of the fibers and is quite weak.

Nonwoven fabrics are produced from these prior art webs by plying a number of webs together and applying an adhesive to the laminate to bond the same into a unitary structure.

The present invention contemplates apparatus for making a nonwoven unitary web from synthetic textile filaments. The filaments in the web may have an irregular sinuosity throughout their length and have looped fiber portions which overlap and frictionally engage looped fiber portions of adjacent filaments of the web. The filaments are substantially the same length and the resulting web is of substantially uniform construction throughout its entire area. The web will have a substantially uniform density and uniform covering properties, that is, free of holes or thick areas.

Substantially all of the filaments lie in the same general direction and the nonwoven unitary webs made in accordance with the invention have considerable strength in the direction in which the filaments lie. Strong nonwoven fabrics may be produced by plying a number of these webs together, usually at angles to each other, and adding a small amount of adhesive to hold the plies together.

In accordance with the present invention a tow of continuous synthetic filaments is spread into web form by submerging the tow in a liquid media. While the tow is in the liquid media, it is stressed in the longitudinal and transverse directions intermittently. Between the application of the forces which give the stresses, the tow is allowed to relax and float free in the liquid. If desired, after these forces have been applied to the tow while submerged, the opened tow may then be passed down an inclined plane and a liquid media also passed down this inclined plane to apply diverging hydraulic forces to the open tow to further spread it into web form. The liquid is removed and the web of continuous filaments is dried. The resulting web is of substantially uniform construction throughout its entire area. It is free of voids, thin areas, and thick areas and the filaments relatively uniformly cover the entire surface. If desired, the filaments may have a sinusoidal path and present looped portions which overlap and entangle looped portions of adjacent filaments. The web may be laminated to other fibrous webs or other filament webs, either in an aligned direction or at angles to each other, or it may be laminated with paper or various other materials to produce various fabrics having a variety of different properties.

Apparatus of the present invention comprises a container, preferably rectangular in shape to hold the liquid media. Positioned in this container beneath the surface of the liquid are a series of pairs of nip rolls. The tow to be spread is fed from creels into the container and guided to the first pair of nip rolls and subsequently to each successive pair of nip rolls. Between successive pairs of nip rolls means for applying longitudinal stresses to said tow are supplied. Suitable means would be a beater or oscillating bars or wiping bars which intermittently apply longitudinal and transverse forces to the tow between the nip rolls while submerged in the liquid media. The application of these forces applies tension to the tow between nip rolls, the tension is relaxed and the tow allowed to float in the liquid, tension is again applied and released and so on as the tow passes through the liquid to open the tow into a web of continuous filaments. On removing the web of filaments from the container, if desired, the web may be passed down an inclined plane, and liquid allowed to overflow the container also down this inclined plane whereby the liquid presents diverging forces to the web to further open and spread the filaments. The web is then placed on a permeable conveyor to allow the liquid to be removed from the web. If desired, suction may be applied beneath this conveyor to further aid in the removal of the liquid. The web is dried by any suitable means. If desired, the conveyor on which the web is collected may be driven at a speed less than the linear speed at which the tow is fed to the liquid container to impart a sinuosity to the individual filaments or it may be driven at approximately the same speed as the tow is fed to allow the filaments to remain substantially parallel or aligned with little sinuosity.

The invention will be further described in conjunction with the accompanying drawings wherein:

FIG. 1 is a side elevation view of suitable apparatus for carrying out the method of the present invention.

FIG. 2 is a plan view of the apparatus shown in FIG. 1.

FIG. 3 is a cross-sectional view taken along line 3—3 of FIG. 1.

FIG. 4 is a cross-sectional view taken along line 4—4 of FIG. 1.

FIG. 5 is a plan view of nonwoven unitary web made by the method of the present invention, and

FIG. 6 is an enlarged cross-sectional view taken along line 6—6 of FIG. 5.

Referencing to the drawings in FIGS. 1 and 2 there is shown apparatus for carrying out the method of the present invention. A number of packages 20 of tow of continuous filaments 21 are supported on spindles 22 which are rotatable in the frame bars 23 mounted from the frame 24. Positioned in front of these packages is the container 25 which is substantially rectangular in shape and which contains the liquid media 26.
Mounted from frame pieces 27 extending from the inlet end of the container is a stationery roll 29. Mounted immediately adjacent and after the stationery roll is a guide bar 30 having a series of pins 28 on its upper surface. Mounted also at the inlet end from the frame and adjacent the guide bar is a second stationery roll 31. The tow from the packages is fed under the first stationery roll and through the pins on the guide bar and over the second stationery roll. The tow are uniformly spaced along the guide bar aiding in the uniform distribution of the tow. After passing over the second stationery roll the tow passes into the liquid media.

The liquid container is spaced above the floor. It has lips or flanges 35 and 36 extending along both sides at the top and preferably a platform 37 extending the entire length of the container beneath the container. Positioned at the inlet end of the container is a pair of nip rolls 38 and 39. These nip rolls, more clearly shown in FIG. 4, are mounted for rotation in bearings mounted in frame pieces 40 suspended from the flanges of the sides of the container. The bottom nip roll is driven by means of a pulley 41 and a belt 42 which passes about a second pulley 43 mounted on a shaft 44 mounted for rotation in a bearing mounted on the side flange of the container. On the opposite end of the shaft 44 is a sprocket 45 about which a chain drive 46 passes which leads down to a motor and drive mechanism 47 mounted on the platform beneath the container. The nip rolls rotate to feed the material in the direction shown and the upper nip roll may be moved away from the lower nip roll or pressed against the lower nip roll at various pressures as desired by means of air pressure. Similar sets of nip rolls are mounted successively along the container as shown by the similar numerals with an, a, b, c, d after successive stations. Positioned between each pair of nip rolls is a means for applying forces to the tow as it passes between the nip rolls, more clearly shown in FIG. 3. This means comprises a curved bar 60 mounted in a stationery manner from two vertical shafts 61 and 62. On each vertical shaft is a turn buckle 63 to control the depth the bar extends into the liquid and thus control the amount of force applied to the tow. The vertical shafts are loosely mounted on a horizontal shaft 64 so that as the horizontal shaft turns, the vertical shafts slip and do not turn. Mounted at each end of the horizontal shaft is a plate 65 and mounted on the opposite side of the plate in a slot in an eccentric manner is a second horizontal shaft 66 and 67. These shafts may be adjustedly mounted in the slot of the plate to control the off-set or eccentricity of the common horizontal shaft. It is preferred that the outer shafts be positioned in the same concentric setting. Mounted on each of these concentric shafts 66 and 67 is a sprocket 68 and 69 and the shafts themselves are mounted in bearings 70 and 71 mounted from the side flanges of the container. Mounted adjacent these horizontal shafts and parallel thereto is a jack shaft 72 which is mounted for rotation in bearings mounted from the side flanges of the container. On this jack shaft are a pair of sprockets 73 and 74, one each in line with the sprockets on the concentric shafts and these sprockets have a chain drive 75 and 76 thereabout to uniformly drive the concentric shafts. Mounted on one end of this jack shaft is a sprocket 77 about which a chain 78 passes and which is connected to a drive and motor 79 mounted from the platform below. The eccentric mechanism, etc., is more clearly shown in FIG. 3. Similar bow bars 60a, b, and c are mounted between each set of nip rolls. Depending on the setting of the concentric shafts to the horizontal eccentric shaft and the speed at which the shafts are driven, these bow bars are given an oscillating or reciprocating motion, that is, an up and down motion of varying amplitude and frequency.

A pair of nip rolls 38d and 39d are placed at the outlet end of the container. Positioned at this outlet end just below the liquid level and extending away from and down from the outlet end is an inclined flume 92. The outlet end of the container acts as a weir and allows the liquid in the container to overflow the outlet end and flow down the inclined flume. This flume has an angle of between 25 and 30 degrees with the end of the container, though other angles may also be used. The flume is smooth so as not to disturb the filaments. Positioned beneath the inclined flume is a permeable conveyor 93. Beneath this conveyor is a collecting means (not shown) for the liquid. Suction 97 is also preferably used to aid in the removal of liquid from the spread tow as the tow hits the conveyor. The conveyor moves in the direction shown and may move at a slower surface linear speed than the tow so that the filaments of the tow take a sinusuous path as they are laid on the conveyor. The tow is then dried and may be laminated with various materials to produce the desired end products.

With regard to the nip rolls it is preferred that the bottom nip roll be fluted and the top roll be rubber covered to provide a good grip on the filaments as they pass through this nip roll and maintain them under tension as the forces are being applied.

Though a bow bar has been shown, other means of applying forces may be substituted therefor, such as ultrasonic forces, other types of beating bars, oscillating rolls, etc. In operation the tow to be spread is fed from the creels down under the first guide bar and through the guide pins. The tow passes through the guide pins in a uniform manner and is uniformly distributed across the guide pins. The uniformly distributed tow passes over the second guide bar down into the liquid to the first pair of nip rolls. The first pair of nip rolls actually is pulling the tow from the creels. The tow is then passed to the second pair of nip rolls which are rotating at the same linear surface speed or if desired slightly faster. Between the two sets of nip rolls the intermittent stresses are applied to the tow, and the tow is slightly spread open. The tow is then passed to the third set of nip rolls which are rotating at the same speed as the second set or slightly faster. Between the second and third set again longitudinal and transverse stresses are again applied to the tow, and the tow opened more. The tow then passes to the fourth set of nip rolls moving at the same speed or slightly faster than the third set of nip rolls and more stresses applied to further open the tow. From the last set of nip rolls the tow is passed upwardly out the outlet end of the container and down the inclined flume. Water in the liquid container overflows the flume and presents diverging hydraulic forces to the tow which spreads it even further. The tow is then collected on the conveyor, the water removed and the tow dried.
In operation, as the longitudinal and transverse stresses are applied to the tow there is some slippage of the tow from the nip of the nip rolls depending on the speed of the rolls, the bite of the rolls and the amplitude and frequency with which the stresses are applied.

Although it appears that the longitudinal stresses applied are most important in opening the tow, the bow in the bar along with the manner the bar moves, i.e., up and down or back and forth also applies transverse forces to the tow which aid in opening the tow.

It is desired that the bow in the bars be reduced at each station as the tow is spread further, that is, the radius of curvature be such that the bar straightens out as it gets closer to the outlet end of the container. The amplitude and the frequency of the oscillatory force or of any other force may be varied as desired depending upon the type of tow used and the number of stations.

The liquid used is relatively unimportant in the spreading of the tow provided the liquid has no adverse effects on the filaments. Economics and safety and ease of handling, etc., make the use of water one of the better liquids for the spreading of tow in accordance with the invention. Very often, especially when the non-wettable type filaments, such as polyester filaments are used, it is desired that a surfactant be placed in the water to make the filaments more wettable and improve the application of the forces to these filaments, or the water be warmed to improve the spreading action. Once the tow is spread into web form, it is presented to the slower moving conveyor or condensing surface. The differential in speed between the tow and this conveyor may be varied over wide ranges to impart various irregular sinusous paths to the filaments. The speed differential also governs the amplitude of the sinusous path of individual filaments in the web. Differentials in the speed of the tow and the speed of the conveyor in the range of from about 0.05 : 1 to 2 : 1 and even higher have given satisfactory results.

By the method of the invention tows ranging in diameter from one thirty-second of an inch up to about 1 inch or more and containing from about 5,000 to 60,000 filaments or more may be spread to thin flimsy webs having weights ranging from about 25 grains per square yard up to about 200 grains per square yard or more.

In FIG. 5 there is shown a unitary web 100. The web comprises individual filaments 101, each of which lies in a sinusous path running in the direction of the length of the web. Looped or kinky portions of filaments overlap and entangle looped or kinky portions of adjacent filaments. Each individual filament in the web is at least as long as the length of the web formed. The web is very thin with the filaments relatively uniformly distributed throughout the width of the web as indicated in FIG. 6.

The webs produced by the method and apparatus of the invention may be produced from any of the known filaments including artificial filaments. Suitable examples are viscose rayon; cuprammonium rayon; ethylcellulose; cellulose acetate; polyamides, i.e., nylon; polyesters, i.e., “Dacron,” acrylics, i.e., Orlon, Acrilan, and Dynel; polyolefins, i.e., polyethylene, polypropylene, polyvinylidene chloride, i.e., saran; polyvinyl chloride; polystyrene; etc. These synthetic filaments may be used alone or in combination with one another.

The weights of the webs range from about 25 grains per square yard to 200 grains per square yard, and preferably from about 35 grains per square yard to 100 grains per square yard.

The denier of the filaments used to produce the web is in the range of from about 1 denier or somewhat less to 10 denier. It is preferred that the filaments have a denier in the range of from about 1/2 to 6. For example, viscose rayon filaments from about 1/2 to 3 denier have produced excellent results in the production of fabrics according to the invention.

Filaments having a denier above the indicated broad range are stiff and rigid and will not lie in irregular sinusous paths uniformly throughout the webs. The fabrics produced from webs of such high denier filaments are not drapeable textile fabrics as contemplated herein but are rigid and harsh and are unsuitable for use in surgical dressings, sanitary napkins, and the like.

The invention will be further illustrated in greater detail by the following specific examples. The percentages indicated are by weight unless specifically stated otherwise.

**EXAMPLE 1**

A tank 5 feet long and 27 inches wide is filled to a depth of about 8 inches with water. Three pairs of nip rolls are spaced along the tank and completely submerged in the water. The bottom roll of each pair is fluted and the top roll of each pair has a rubber surface. Spaced between the first and second sets of nip rolls is a bow bar having a radius of curvature of 52 inches. This bow bar is adjusted to oscillate in an arc of about 90 degrees with the low point of this arc in a perpendicular plane and about 2 inches below the plane between the nips of the pairs of nip rolls. The bar sweeps about 40 times each minute. A similar bar is placed between the second and third sets of nip rolls; however, this bar is given an oscillatory motion, that is, a straight up and down motion so that it passes from about 2 inches below the plane between nip rolls and about to the plane between nip rolls. It oscillates at 40 oscillations per minute.

A viscose rayon tow approximately three-sixteenths of an inch in diameter, 12,000 denier and containing 6,000 individual continuous filaments of about 2 denier per filament is led from a creel through a pin guide mounted on the inlet side of the liquid container at a rate of 17 yards per minute. The tow is fed underneath the water into the nip formed by the first pair of nip rolls and subsequently passed to the second and third pair of nip rolls. These nip rolls rotate at the same speed so that the tow is continually kept under slight tension while passing from the first to the third set of nip rolls. Intermediate the first and second sets of nip rolls, forces are applied to the tow by the sweeping motion of the bow bar to spread the tow. Between the second and third pairs of nip rolls, the oscillating bow bar applies forces to the tow to further spread the tow and open it. Upon leaving the nip of the last set of nip rolls the tow is spread to approximately 11 inches in width. The tow is then brought to the surface of the water at the outlet end of the liquid container. Extending from the outlet end of the container is an inclined flume. This flume is approximately three-sixteenths of an inch below the water surface in the container and...
extends outwardly and downwardly from the outlet end of the container at an angle of about 30 degrees. The water in the container is allowed to overflow and pass down the flume. The spread tow brought to the surface of the water also passes down this flume and by the diverging hydraulic forces of the flowing water is further opened to approximately 13 inches in width. The tow is put on a permeable conveyor positioned beneath the inclined flume. The water passes through the permeable conveyor and is removed. The tow is dried to form a unitary web of continuous synthetic filaments approximately 13 inches wide and weighing about 50 grains per square yard.

EXAMPLE II

In this example similar apparatus to that described in Example I is used, with the exception that all of the bow bars are allowed to oscillate similarly to the second bow bar of Example I. The water in the container is warmed to about 125°F by steam heat. A polyester tow of 2,000 denier, 1,000 filaments, 2 denier per filament is fed from a creel through a pin guide to the first set of nip rolls submerged in the water and passed through two successive sets of nip rolls while forces are applied between each set of rolls. Upon leaving the last set of nip rolls the tow is opened to approximately 11 inches. The tow is brought to the surface and allowed to pass down the flume as described in Example I, and the tow further opened to about 13 inches. The tow is placed on a permeable conveyor, the water removed and the tow dried. The resultant web produced is approximately 13 inches wide and weighs about 50 grains per square yard.

Although several specific examples of the inventive concept have been described for purposes of illustration, the invention should not be construed as limited thereby nor to the specific features mentioned herein except as the same may be included in the claims appended hereto. It is understood that changes, modifications and variations may be made and the method and apparatus herein described without departing from the spirit and scope of the claimed invention.

What is claimed is:

1. Apparatus for spreading a tow of continuous filaments into sheet-like form comprising: a liquid container, a first pair of nip rolls submerged in liquid in said container and positioned at the inlet end of said container, feed means at said inlet end for feeding tow to said first pair of nip rolls, a second pair of nip rolls submerged in said liquid and positioned downstream from said first pair of nip rolls, means having a transverse arcuate configuration for intermittently applying longitudinal and transverse stresses to alternately relax and apply tension to said tow while said tow passes between said first and second pair of nip rolls in an unsupported state to open and spread the tow into sheet-like form, an inclined plane positioned at the outlet end of said liquid container, a weir positioned at said outlet end for controlling the flow of liquid from said liquid container down said inclined plane whereby liquid passing down said plane presents diverging hydraulic forces to said tow passing down said inclined plane to further open said tow into sheet-like form and means for removing said liquid from said opened tow.

2. Apparatus according to claim 1 wherein the means for intermittently applying longitudinal and transverse stresses is a sweeping bowed bar.

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