

May 28, 1968

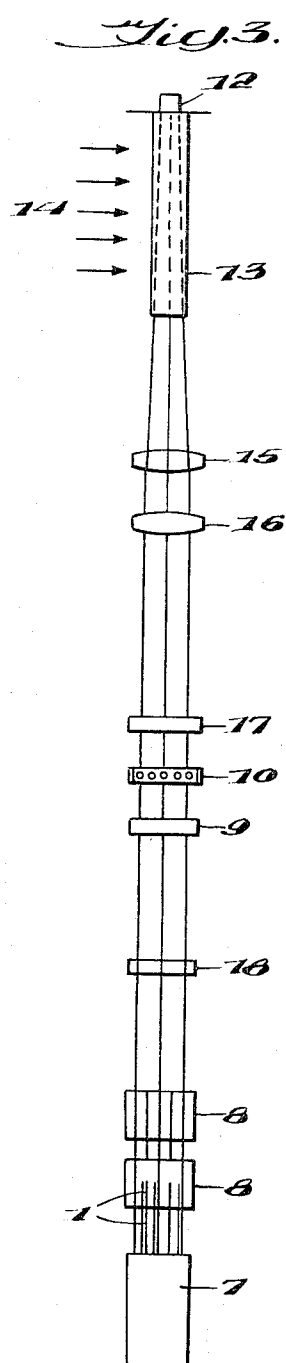
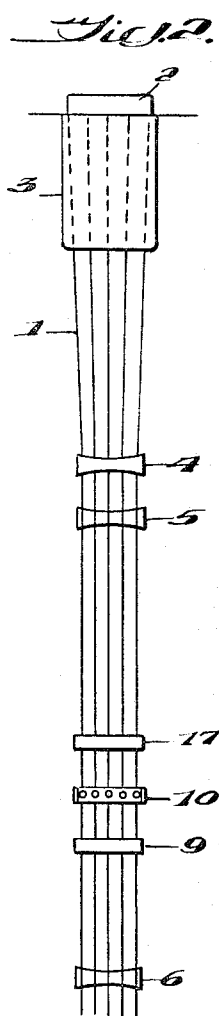
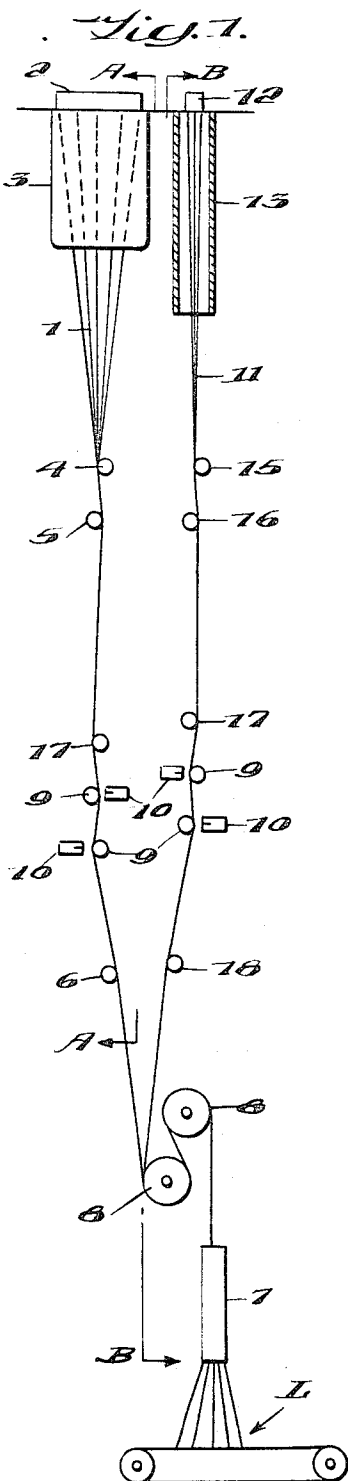
F. J. MEDEIROS ET AL

3,384,944

APPARATUS FOR EXTRUDING AND BLENDING

Filed Feb. 10, 1965

2 Sheets-Sheet 1



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APPARATUS FOR EXTRUDING AND BLENDING

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Fig. 4.

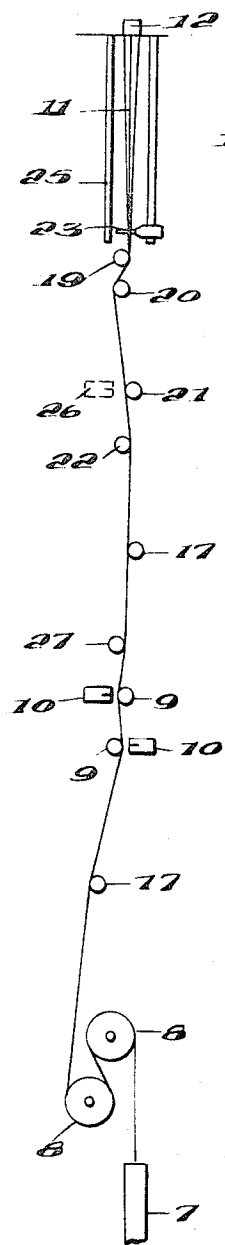


Fig. 5.

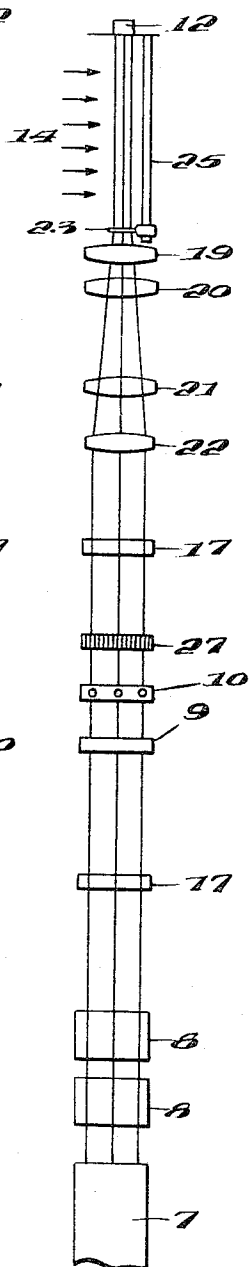


Fig. 6.

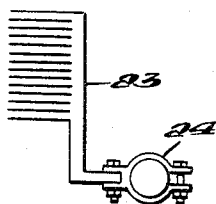
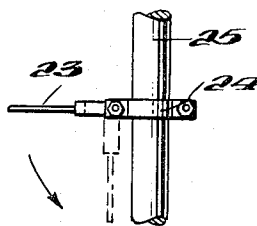


Fig. 7.



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3,384,944 APPARATUS FOR EXTRUDING AND BLENDING

Francis Joseph Medeiros, Hendersonville, and Larry M. Talbert, Madison, Tenn., assignors to E. I. du Pont de Nemours and Company, Wilmington, Del., a corporation of Delaware

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ABSTRACT OF THE DISCLOSURE

An apparatus for blending two moving ribbons of filaments of different widths by converging the wide ribbon, diverging the narrow ribbon and combining the two ribbons at the same width on a cylindrical combining member. An arrangement of concave and convex guides is used for equalizing ribbon widths.

This invention relates to an apparatus and process for handling filamentary materials.

In the preparation of nonwoven fabrics from continuous filaments by the recently-developed process described in British Patent 932,482, a multifilament strand of continuous filaments under tension is electrostatically charged by known techniques, for example, by triboelectric charging or by passing the filaments through a corona discharge zone; the charged filaments are then forwarded by means of a jet device toward a web-laydown zone; the tension on the filaments is released as they exit the jet device thereby permitting them to separate due to the repelling effect of the applied electrostatic charge; and the filaments while thus separated, are collected as a nonwoven web. A preferred method for effecting bonding of the web, thereby converting it to a strong nonwoven fabric, is by means of binder filaments distributed throughout the nonwoven web of matrix filaments. Since the binder and matrix filaments come from different sources it has been the practice in the aforementioned process to combine the strand of binder filaments with the strand of matrix filaments before entry into the jet device. The binder filaments have a lower softening temperature or melting point than the matrix filaments constituting essentially the remainder of the filaments of the web. Upon subsequent heating of the nonwoven web, the binder filaments adhere to the matrix filaments while retaining their filamentary character, or they may melt and flow to crossing points of the matrix filaments and form granule bonds upon cooling.

It is essential that the binder filaments be uniformly distributed in the nonwoven web in order to obtain sheet products of constant quality throughout the dimensions of the sheet. This does not normally present a difficult problem when the total number of filaments in each strand is small, for example, from about 20 to 100; however, for economical commercial operation large strands containing several hundred filaments, for example, 200 to 1000 are used. In this case, it has been found that the binder filaments tend to remain associated with each other, and the matrix filaments tend to remain associated with each other thereby leading to nonuniform distribution of the binder throughout the web.

Economical commercial production of nonwoven webs by the above-described web-laydown process requires the use of an integrated filament-spinning, attenuation and laydown operation. In order to obtain uniform filament properties from each of the large number of spinnerets required to prepare wide webs economically, mechanical attenuation of the filaments, for example, with draw

rolls, is used. This inherently results in the filament strands assuming a ribbon shape. The ribbon shape is also inherent from the contact of the filament strands with cylindrical bars in the step of application of an electrostatic charge to the filaments by triboelectric charging or by the corona-discharge technique described in Di Sabato & Owens, U.S. Patent 3,163,753. The problem of obtaining a uniform blending of the matrix and binder filaments within the web has, in accordance with the present invention, been found to be substantially reduced if the two ribbons of continuous filaments, i.e., the matrix and binder filaments traveling at high speeds, can be properly intermingled prior to entry into the jet device. This problem is complicated by the fact that the ribbons as first formed inherently have different widths because the spinnerets from which the matrix filaments and binder filaments are spun are of different sizes. It will be readily apparent that with a typical ratio of matrix filaments to binder filaments, for example, 500/50, a much larger spinneret is required for the matrix filaments than for the binder filaments, and accordingly, the ribbon of the matrix filaments is wider than the ribbon of binder filaments. In accordance with this invention, it has further been found that in order to obtain a uniform distribution of binder throughout the nonwoven web, it is necessary to spread and separate the filaments in the narrow ribbon and distribute them uniformly across the wider ribbon of matrix filaments.

It is the purpose of this invention to provide an apparatus and process for uniformly blending a ribbon of continuous filaments with a wider ribbon of continuous filaments, both traveling at high speeds.

Another purpose is to provide an apparatus and process for preparing nonwoven webs having a uniform distribution of filaments originating from strands of differing filament numbers.

A further purpose is to provide an apparatus and process for uniformly blending freshly-spun filaments obtained from two spinnerets having different sizes.

These and other purposes are attained in accordance with this invention by providing an apparatus having at least one guide having a symmetrical concave surface, at least one guide having a symmetrical convex surface and a combining member having a cylindrical surface. The guides are so positioned relative to each other that the center points of the curved surfaces of the guides lie in a single plane which is perpendicular to the planes which are tangent to the curved surfaces at the center points. The cylindrical surface of the combining member is perpendicular to the above-mentioned single plane. The wider ribbon of continuous filaments passes over the guide with the concave surface, the other ribbon of filaments passes over the guide with the convex surface, and the two ribbons are then brought together on the combining member. More than one convex guide and one concave guide can be used, if required. The number used is dependent on (1) the effectiveness of the guides for converging and diverging the ribbons and (2) the amount the narrow ribbon must be diverged and the wide ribbon converged so that they will be of substantially the same width when they are brought together on the combining member. In addition to controlling the width of the ribbons of filaments, the guides must also stabilize the ribbons and bring them into exact register at the point of combining.

The web-forming apparatus comprises means for providing at least two continuous multifilament strands, such as a plurality of spinnerets, charging means for the application of an electrostatic charge to the filaments, rolls for attenuating or drawing the filaments, a jet device for forwarding and directing the filaments and a receiver for collecting the filaments as a random nonwoven web. The

aforementioned guide arrangement fits into the over-all web-forming apparatus and is located between the multi-filament strand-providing means and the jet device. The first of the rolls for attenuating or drawing the filaments may also serve as the combining member of the guide apparatus.

The invention will be further understood by reference to the drawings in which

FIGURE 1 is a schematic representation of an apparatus for spinning filaments from two spinnerets and uniformly blending the filaments prior to web laydown;

FIGURE 2 is a view along line A—A of FIGURE 1;

FIGURE 3 is a view along line B—B of FIGURE 1;

FIGURE 4 is a front view of an alternative embodiment of guide members for spreading a narrow ribbon of continuous filaments;

FIGURE 5 is a side view of the embodiment of FIGURE 4;

FIGURE 6 is a top view of a comb guide which can be used in the alternative embodiment of FIGURE 4; and

FIGURE 7 is a side view of the comb guide of FIGURE 6.

Referring to FIGURES 1, 2, and 3, matrix filaments 1 are spun from spinneret 2 and quenched by radial quench diffuser 3. The filaments are brought together in ribbon form on concave guide 4, which, in combination with concave guides 5 and 6, converges the ribbon of filaments to the width required for passage through jet device 7. Draw rolls 8 provide the tension to attenuate the filaments in the region between the spinneret and concave guide 4. This process of spin-drawing is taught by Hebel in U.S. Patent 2,604,689 and is an especially useful technique when a nonwoven web with matrix filaments of poly (ethylene terephthalate) is being prepared. Alternatively, a typical roll-drawing operation can be used for attenuation of the filaments. In this method the filaments pass over heated feed rolls and then over draw rolls which are running at a more rapid surface speed than the feed rolls.

The filaments are electrostatically charged by means of corona-discharge devices comprising target bars 9 and charging heads 10. The ribbon of filaments is passed into light contact with slowly-rotating target bars 9 which are positioned adjacent charging heads 10 which have needle electrodes. A corona discharge is generated by applying a high electric potential to the electrodes and grounding the target bars.

Binder filaments 11 (generally fewer in number than the matrix filaments) are spun from spinneret 12 and quenched by cross-flow air using chimney 13. The direction of flow of the air is indicated by arrows 14 in FIGURE 3. The filaments are brought together on convex guide 15, which, in combination with convex guide 16, diverges the ribbon of filaments to the same width as the ribbon of matrix filaments leaving concave guide 6. The two ribbons are brought together and uniformly blended on the first draw roll 8. Binder filaments of an 80/20 copolymer of poly(ethylene terephthalate)/poly(ethylene isophthalate) are suitable for use with poly(ethylene terephthalate) matrix filaments. A binder content within the range of 2 to 25 percent of the web weight may be used.

As in the case of the matrix filaments 1, the tension required to attenuate the binder filaments, and to move them over the guides and target bars of the corona-discharge devices is provided by the draw rolls 8. Jet device 7 provides the tension needed to strip the composite filament ribbon from the last draw roll and to forward the filaments toward the web-laydown zone L of a foraminous belt receiver. One or more cylindrical snub guides, as indicated at 17 and 18, may be used if desired to provide further control and stabilization of the rapidly-moving ribbons of filaments.

In order to minimize formation of deposits on the solid surfaces which the filaments contact, it is preferred that

the guides and target bars rotate; however, the guides may be stationary, if desired. In this case, they may take the form of curved rods or tubes and the filaments contact either the convex or concave surface as required to obtain the desired effect on the ribbon of filaments. Similarly, the combining member may be a stationary bar or other flat surface which the two ribbons contact before reaching the draw rolls. In referring to the combining member as having a cylindrical surface, the broadest meaning of cylindrical is intended, that is, the surface can be one generated by any straight line moving parallel to a fixed straight line.

In order for the two ribbons of filaments to have the exact register required for uniform blending, it is essential (1) that both the convex and concave surfaces be symmetrical, (2) that the center points of all these surfaces that the two ribbons contact lie in a single plane which is perpendicular to the planes which are tangent to the curved surfaces at the center points and (3) that the cylindrical surface of the combining member be perpendicular to the above-mentioned single plane; that is, the moving straight line which generates the cylindrical surface of the combining member is perpendicular to the single plane. In the case where the guide and combining member rotate, it is essential, in order to have the required register between the ribbons of filaments, for the axes of the guides and the combining member to be parallel and for the midpoints of the axes of the convex and concave guides, corresponding to the midpoints of the symmetrical curved surfaces of these guides, to lie in a single plane.

In a typical operation with an apparatus as shown in FIGURES 1 to 3, except that the guide 18 has a concave surface, 250 matrix filaments (3 d.p.f.; 0.3 tex.) are spun from a spinneret having a 5.625 in. (14.28 cm.) maximum aperture-circle diameter and 50 binder filaments (3 d.p.f.; 0.3 tex.) are spun from a spinneret having a 2.125 in. (5.40 cm.) maximum aperture-circle diameter. By using a combination of convex and concave guides with dimensions as indicated in Table I below, the filaments from each of the two spinnerets are formed into ribbons 4.5 in. (11.4 cm.) wide, which is a suitable width for use with a 5-in. (12.7-cm.) slot jet device 7.

TABLE I

Guide Member ¹	Type	Radius of Curvature		Diameter ²	
		In.	Cm.	In.	Cm.
4	Concave	18	46	1.50	3.81
5	do	11	28	1.50	3.81
6	do	11	28	1.50	3.81
9	Cylindrical			1.50	3.81
15	Convex	45	114	1.25	3.17
16	do	45	114	1.25	3.17
17	Cylindrical			1.50	3.81
18	Concave	45	114	1.50	3.81

¹ Numbers refer to guide members in Figures 1-3.

² Measured at center of guide member.

With this specific arrangement of filament guides, the binder filaments are converted to a 5-in. (12.7-cm.) wide ribbon by taking a slight S-wrap around guides 15 and 16 (about 30° wrap around each guide), and the ribbon is then converged to 4.5-in. (11.4-cm.) width by a slight wrap around concave guide 18.

Ribbons of filaments containing 400 matrix filaments and 70 binder filaments, or 525 matrix filaments and 150 binder filaments, can also be uniformly blended into a single 4.5-in. (11.4-cm.) wide composite ribbon by means of the above guidance apparatus.

With both concave and convex guides the final ribbon width attained is a function of the radius of curvature of the guide and the angle of wrap which the filaments take around the guide. Concave guides which have radii of curvature of 4 to 45 in. (10 to 114 cm.) are suitable for handling filament ribbons up to 6-in. (15-cm.) wide. With concave guides it is possible to decrease the width of the ribbon of filaments either by increasing the angle

of wrap or by decreasing the radius of curvature. The latter method is favored from a continuity standpoint. With convex guides it is possible to increase the width of the ribbon of filament either by increasing the angle of wrap or by decreasing the radius of curvature. There are, however, lower and upper limits on the radius of curvature for convex guides. Convex guides with radii of curvature below 35 in. (89 cm.) tend to split the filament ribbon in half. Guides with radii of curvature above 60 in. (152 cm.) are ineffective in spreading the ribbon of filaments.

The convex and concave guides used in the apparatus of this invention can be made from any hard, corrosion- and wear-resistant material, for example, carbon steel or brass with a chromium-plated surface having a smoothness corresponding to 25 to 45 microin. RMS (0.0006 to 0.0010 mm.).

The alternative embodiment of guide members for handling the narrow ribbon of binder filaments shown in FIGURES 4 and 5 uses convex guides 19, 20, 21, 22 to diverge the ribbon to the desired extent. Comb guide 23, shown in greater detail in FIGURES 6 and 7 is adapted to be inserted into the filaments as they leave the spinneret and to hold them in a fixed position relative to the guide rolls, which position is unaffected by variable room-air currents or quench air. The comb guide is mounted on mechanism 24 which is slidably mounted on rod 25. The comb is pivotally attached to mechanism 24 so that it can be rotated from a horizontal to vertical position as shown in FIGURE 7. With the comb in the vertical position, the guide is moved vertically to within about 1 in. (2.5 cm.) of spinneret 12. The comb is rotated to a horizontal position into the filaments and the guide is then moved down and fixed in position above guide 19. The comb holds the filaments in the same geometry as spun from the spinneret and on machine center line.

The comb can be made from any hard corrosion- and wear-resistant material, for example, carbon steel with a chromium-plated surface and given a satin finish (70 to 100 microin. RMS) (0.0018 to 0.0025 mm.). Suitable dimensions for the comb are as follows:

	Inches
Comb length (15 cm.)	6
Dent length (7.5 cm.)	3
Dent width (0.32 cm.)	0.125
Spacing between dents (0.076 cm.)	0.030

FIGURE 4 also shows the optional use of an additional corona charging head 26 in association with guide 21. In this case, guide 21 preferably is a typical target bar with a cylindrical surface as indicated at 9. It has been found that the electrostatic charge applied to the binder filaments aids in spreading the ribbon of binder filaments and in maintaining the filaments separate from each other. This is particularly true when the filaments travel unsupported for long distances. Accordingly, the application of an electrostatic charge to the filaments soon after they are spun is often desirable. Instead of using an additional charging device as indicated in FIGURE 4, one of the charging devices indicated at 9 and 10 may be located closer to the spinneret.

Grooved guide 27 is used in the embodiment in FIGURE 4 to provide additional guidance for holding the filaments evenly spaced over a specific width on the machine center line. A typical guide for this purpose has a cylindrical, chromium-plated carbon steel body with 0.010 in. (0.025 cm.) wide grooves, 0.008 in. (0.020 cm.) deep, and spaced on 0.040-in. (0.102-cm.) centers.

The best results as regards binder filament separation and uniform binder distribution throughout the nonwoven web are obtained with the filament-guidance apparatus of this invention when the spinnerets used to spin both the matrix and binder filaments have aperture arrangements such that the projections of the apertures onto center lines parallel to the ribbons of filaments are

uniformly spaced. With nonuniform spacing such as is obtained with spinnerets having the apertures equally spaced on concentric circles, the filaments tend to bunch at the extremities of the circle diameters when projected on the guide surfaces. A spinneret design which has been found to be especially valuable for use with the apparatus of this invention has the apertures arranged on ellipses having a common major axis which is parallel to the axes of the rotatable filament guides below the spinneret. The apertures are spaced on the ellipses in such a manner that the horizontal distance (parallel to the major axis) between adjacent apertures on a given ellipse is constant and the horizontal distance between adjacent projections of all the apertures onto the major axis is constant.

It will be understood that although the present invention has been described with respect to the filament strands being fed to a single jet device forwarding means, the preparation of webs of significant width requires the simultaneous employment of several such jet devices.

The filament-guidance apparatus of this invention has been described with particular reference to the combination of ribbons of matrix and binder filaments prior to the formation of a continuous-filament nonwoven web. The utility of this apparatus is not so limited and it will be recognized that this invention is applicable whenever it is desired to uniformly blend the filaments into moving ribbons having different widths.

What is claimed is:

1. In an apparatus for preparing a nonwoven web from a plurality of running multifilament strands at least one having relatively few filaments and at least one other having substantially more filaments comprising spinneret means for providing the strands, means for forming them into ribbons, charging means for the application of an electrostatic charge to the filaments, means for combining the ribbons of filaments, a jet device for forwarding and directing the filaments and a receiver for collecting the filaments as a random nonwoven web, the improvement comprising a guide arrangement located between the strand providing means and the jet device, said arrangement comprising at least one guide having a symmetrical convex surface for diverging the strand of few filaments and at least one guide having a symmetrical concave surface for converging the strand of more filaments and a combining member having a cylindrical surface, the guides so positioned relative to each other that the center points of the curved surfaces of the guides lie in a single plane which is perpendicular to the planes which are tangent to the curved surfaces at the center points and the cylindrical surface of the combining member is perpendicular to the single plane.

2. The apparatus of claim 1 wherein the radius of curvature of the convex guides is between about 35 and 60 inches.

3. The apparatus of claim 2 wherein a comb guide is positioned immediately below the spinneret means to hold the extruded filaments in a fixed position relative to the guide rolls.

4. The apparatus of claim 2 wherein a grooved guide is employed to assist in holding the filaments evenly spaced.

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LOUIS K. RIMRODT, *Primary Examiner*.

ROY B. MOTTS, *Examiner*.

R. B. MOFFITT, *Assistant Examiner*.