May 29, 1973 W. P. LIPSCOMB ET AL 3,736,211

TWO-PLANAR DEFLECTOR FOR DISPERSING AND DEPOSITING NONWOVEN FILAMENTARY STRUCTURES

Filed Sept. 28, 1971 2 Sheets-Sheet 1

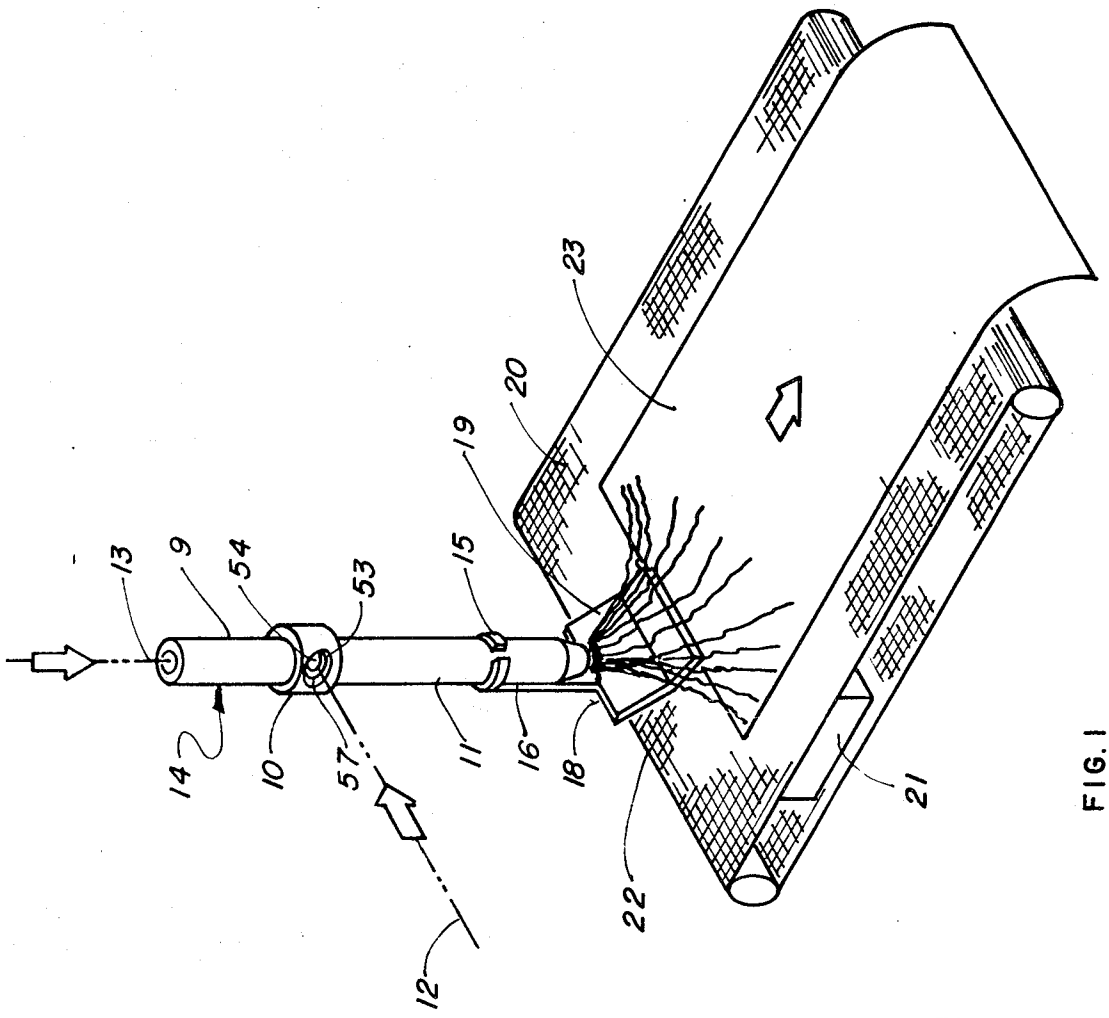


FIG. 1

INVENTOR.
Walter P. Lipscomb
Garland L. Turner

BY

ATTORNEY

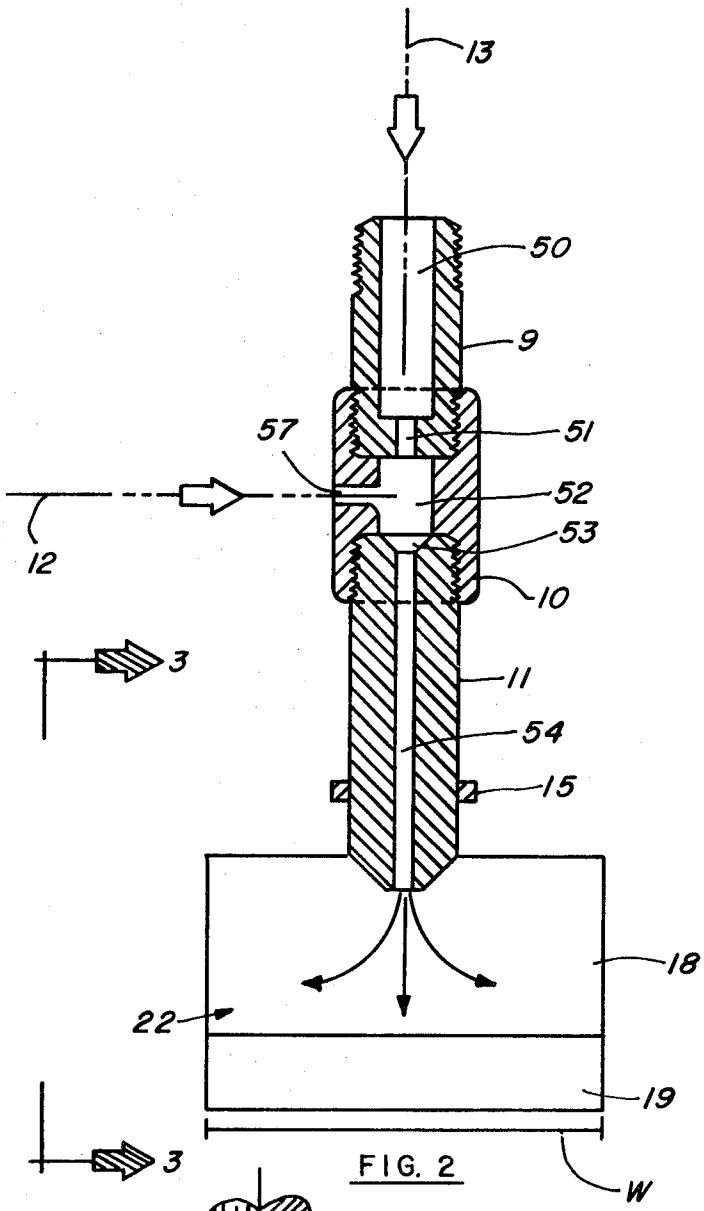


FIG. 2

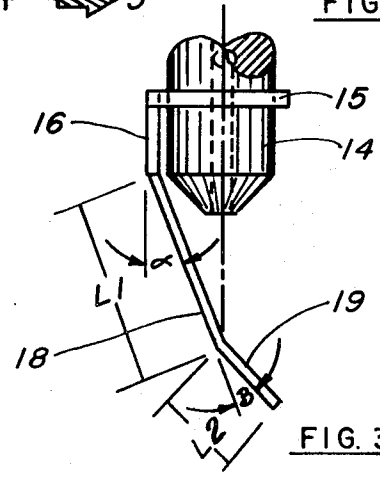


FIG. 3

INVENTORS
Walter P. Lipscomb
Garland L. Turner

United States Patent Office 3,736,211 Patented May 29, 1973

3,736,211

TWO-PLANAR DEFLECTOR FOR DISPERSING AND DEPOSITING NONWOVEN FILAMENTARY STRUCTURES

Walter Peter Lipscomb and Garland Linwood Turner, Chesterfield County, Va., assignors to Allied Chemical Corporation, New York, N.Y.

Filed Sept. 28, 1971, Ser. No. 184,420
Int. Cl. D04h 3/00
U.S. Cl. 156—441 7 Claims

ABSTRACT OF THE DISCLOSURE

An apparatus for augmenting dispersal and for improving deposition of a plurality of continuous filaments onto a continuously moving surface whereby random distribution of the filaments is provided for the production of uniformly distributed nonwoven webs. A nonmoving two-planar deflector is positioned near the exit of an aspirator so as to provide greater openness and greater random laydown of filaments.

CROSS-REFERENCE TO RELATED APPLICATIONS

The invention herein set forth is related to the inventions described in copending applications Ser. No. 184,422 entitled "Foraminal Apparatus for Splaying and Depositing Nonwoven Filamentary Structures," filed on Sept. 28, 1971 in the name of Walter P. Lipscomb and Garland L. Turner, and Ser. No. 184,421 entitled "Apparatus for Splaying and Depositing Nonwoven Filamentary Structures," filed on Sept. 28, 1971 in the name of Walter P. Lipscomb and Eli B. Shelburne, Sr., wherein different apparatus for improving the dispersal and deposition of a plurality of continuous filaments onto a continuously moving surface are disclosed.

BACKGROUND OF THE INVENTION

This invention relates to an improved apparatus for dispersing and depositing filaments. In particular, it relates to an apparatus for augmenting the dispersal of continuous filaments onto a receiving surface so as to form a nonwoven web of randomly disposed filaments.

Nonwoven webs formed from continuous filamentary materials which have been laid on a receiving surface in a random configuration are well known in the art. In the formation of such webs, great care is frequently taken to ensure that the filaments are maintained apart from each other and that interfilamentary entanglement and the formation of filament aggregates are avoided.

Nonwoven webs comprising multi-filaments are commonly formed by forwarding the filaments from a source of supply, such as a melt spinnerette, to and through an aspirator and then depositing the filaments at high velocity onto a moving surface. In the production of nonwoven products having a substantial width, there must be provided either a plurality of aspirators for depositing a plurality of filamentary bundles in a random manner upon the moving surface or there must be provided a means, normally unduly complicated and cumbersome, to move the aspirator over the width of the product to be produced.

When depositing filaments from a conventional aspirator onto a collecting surface, the filaments will spread out within the confines of the aspirator boundary. However, the filament distribution in the jet stream is not always uniform and random and is often restricted to a small laydown area; for example, a web width not exceeding eight inches when a fixed aspirator jet is situated at a distance of one to three feet from the receiving surface.

Some of these deficiences have been overcome by impinging the filaments against a single deflecting plane

before the filaments are massed in web form. The intermixing which is normally attendant with the deflection promotes a filament interaction which tends to integrate but also to aggregate the product. Also, there is normally an accompanying bulkiness or uneven filament distribution, a swirl pattern or roping, a tendency toward sagging or a loss of strength, each of which is undesirable for many end uses of the web material.

SUMMARY OF THE INVENTION

Accordingly, it is an object of this invention to provide an apparatus for augmenting dispersal of filaments which are deposited onto a receiving surface so as to form a web. It is a further object of this invention to provide a simple, reliable, inexpensive, and easily constructed apparatus for more expeditiously spreading filaments and thereby for producing superior nonwoven webs having high integrity. A further object of this invention is the provision of a filament dispersing and depositing means employing no moving parts that tend to generate repeating patterns of filament laydown which are detrimental to web strength. Further objects and advantages of the present invention will become apparent by reference to the following specification and drawings.

In attaining the foregoing objects, this invention features an apparatus for augmenting dispersal and for improving deposition of filaments onto a moving receiving surface in a randomly dispersed manner to form a nonwoven web. Such apparatus comprises, in combination, an aspirator to forward the filaments at a high velocity and a two-planar deflector to splay the filaments widely and randomly as such filaments pass from the aspirator to the moving receiving surface. The two-planar deflector consists of a first plane being rigidly affixed in one spatial position near or close to the aspirating means exit and a second plane being rigidly affixed in another, adjacent spatial position. The two-planar deflector is positioned near the exit of the aspirating means such that a majority of the filaments exiting from the aspirator impinge on the two-planar deflector. The first plane or its straight-line extension intersects the second plane, forming an angle greater than 90 degrees between the impinging surfaces of the two planes. The first plane makes an acute angle α of between 0 and 60 degrees with a line parallel to the center line of the aspirator exit passageway, the angle being measured in the general direction of forward motion of the moving receiving surface. The second plane makes an acute angle β of between 20 and 85 degrees with a straight-line extension of said first plane. The sum of α and β is always less than 90 degrees.

In a preferred embodiment of this invention, the two-planar deflector has an angle α of between 25 and 50 degrees and an angle β of between 35 and 60 degrees, the sum of α and β being between 45 degrees and 87 degrees.

Also preferably, the two-planar deflector is affixed near the aspirator exit in a manner such that there is a distance of approximately from 3 to 26 times, more preferably from 4 to 15 times, the diameter of the aspirator exit passageway between the aspirator exit and the area of initial substantial contact of the filaments on the two-planar deflector. More preferably, each plane of the two-planar deflector is substantially rectangular in shape. The first plane of such rectangular-planed deflector has a length measured in a direction proceeding from the aspirator exit passageway of approximately from 3.5 to 20 times, even more preferably from 4 to 10 times, the diameter of the aspirator exit passageway and a width approximately from 5 to 15 times, even more preferably 7 to 13 times, the diameter of such exit passageway. Also, the second plane of such rectangular-planed deflector has a corresponding length of approximately from 1.5 to 25 times, even more preferably from 2 to 4 times, the diameter of

the aspirator exit passageway and a corresponding width of approximately at least 5 times, even more preferably 7 to 20 times, the diameter of such exit passageway. Alternately, the second plane of the two-planar deflector may be a quadrilateral having the length and width ranges similar to those described above for the rectangular-planed deflector and also having substantially equal lengths; however, such quadrilateral second plane has widths such that the width farthest from the aspirator exit is substantially wider than the other parallel second plane width.

A feature of this invention is its quick and easy adaptability for use with many conventional aspirator jets in dispersing and depositing filamentary materials onto a moving receiving surface.

The method utilizing the apparatus for this invention comprises, in general, the utilization of the two-planar deflector in combination with an aspirator whereby filaments, preferably forwarded from a spinnerette of a spinning mechanism and thereafter from a drawing mechanism, are forwarded through a high velocity fluid jet of an aspirator. Subsequent thereto, the aspirator jet stream propels the filaments onto the two-planar deflector whereby the filaments are deflected onto a continuously moving, preferably foraminous, surface in the form of a uniform nonwoven web comprising randomly disposed, substantially uniformly distributed filaments. Deposition of the filaments may be aided by a suction chamber located underneath the moving surface.

The described apparatus can be readily used for dispersion of filaments or, alternately, strands, yarns, slivers or other similar forms of materials, or mixtures thereof. Such materials include any fiber-forming thermoplastic polymer from which filaments can be obtained. These materials include: polyamides, for example, poly(epsilon-caprolactam) (hereinafter nylon 6) and poly(hexamethylene adipamide) (hereinafter nylon 66); linear polyesters, for example, poly(ethylene terephthalate); acrylonitrile polymers and copolymers; olefinic polymers, for example, polyethylene, polypropylene, and polyvinyl chloride; and cellulose acetates. Preferred materials include nylon 6, nylon 66 and poly(ethylene terephthalate).

This invention will be more clearly understood and additional objects and advantages will become apparent upon reference to the discussion below and to the drawings which are given for illustrative purposes.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1 is a schematic perspective view depicting a preferred embodiment of the apparatus employed for carrying out the invention;

FIG. 2 is a fragmentary front elevation view of an apparatus as depicted in FIG. 1, showing an aspirator in section and a two-planar deflector attached to the exit end of the aspirating means;

FIG. 3 is a fragmentary side elevation of the apparatus as depicted in FIG. 2 showing parts of the aspirator removed and turned 90 degrees clockwise from the position of FIG. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawings and particularly to FIG. 1, a bundle of freshly formed filaments **12** enter inlet aperture **57** of an aspirator such as aspirating jet **14**. The filaments are formed from the spinnerette of a melt spinning apparatus (not shown). Subsequent to spinning, the filaments may also be attenuated and oriented on a drawing apparatus (also not shown). Filament bundles having a broad range of denier, i.e. 30 to 3400 total denier, may be used in the apparatus of this invention. Within the aspirating jet **14**, the filaments are acted upon by a high velocity fluid medium such as air, which is supplied through inlet conduit **13**. Aspirating jet **14** comprises an air nozzle **9**, a collar **10** and a diffuser **11**. The filament bundle **12** is forwarded via the high-velocity aspirating medium from the jet exit **17** to the two-planar deflector **22** wherein at least a majority of filaments of bundle **12** are deflected from such two-planar deflector **22** onto receiving surface **20**. Air stream deflection and its attendant turbulence spreads and opens the filament bundle **12** deflecting from two-planar deflector **22** in a wide and random manner, as shown in FIG. 1. The two-planar deflector **22** is clamped substantially rigidly near the exit end of jet **14** via any suitable means, such as extension **16** and clamp **15** at the exit end of aspirating jet **14**. On receiving surface **20**, preferably a foraminous continuously moving conveyor, with a suction chamber **21** provided beneath that portion of conveyor **20** on which the filaments are being laid down, the filaments are deposited in a random manner to form web **23**.

In FIG. 2, the aspirating jet comprises: a hollow air nozzle **9** which is externally threaded at each end and which has an air inlet conduit **13** attached to its upper end; a hollow collar **10** which is internally threaded at both ends so as to connect air nozzle **9** with diffuser **11** and which has an inlet aperture **57** for receiving filament bundle **12**; and a hollow diffuser **11** which is externally threaded at its upper end and through which the filaments and high velocity air are propelled onto two-planar deflector **22** and thereafter onto a receiving surface. The annular internal aperture **57** is arranged to direct the filaments entering therein downwards, i.e. in direction of air flow. The internal dimensions of collar **10** and of diffuser **11** are arranged so as to minimize twisting, knotting and entanglement of the filaments passing therein. By way of example only, the diameter of nozzle passageway **51** is most preferably from 20 percent to 33 percent of the nozzle passageway length. Also, cross-sectional area of nozzle passageway **51** is preferably from 25 percent to 35 percent of the cross-sectional area of diffuser passageway **54**. Further, the diameter of diffuser passageway **54** is preferably from 2 percent to 10 percent of the length thereof. Still further, the maximum diameter of diffuser entrance chamber **53**, which is conical in shape, is most preferably approximately two times the diameter of the diffuser passageway **54**. The cross-sectional area of diffuser passageway **54** is designed such that the cross-sectional area of filament bundle **12** passage therein ranges from 0.1 percent to 5 percent, preferably from 0.2 percent to 1.5 percent, of the diffuser passageway cross-sectional area. The respective lengths and diameters of air nozzle entrance chamber **50** and of collar chamber **52** are not critical. However, such lengths and diameters should be used as are practical; i.e. compatible with the overall operation of the present process.

The first plane **18** and the second plane **19** of the two-planar deflector **22** are each of a width W which is sufficient to deflect at least a majority of the filaments emanating from the aspirator exist passageway **17**. It is not essential that any width of plane **18** equal any width of plane **19**. The widths W of each plane may be varied to suit the particular situation. Each situation is dependent on such variables as air velocity at the jet exit, jet-deflector distances, type and properties of polymer from which the filaments are made, and desired filament laydown pattern. Preferably, a width of the first plane **18** ranges from approximately 5 to 15 times, and more preferably from 7 to 13 times, the diameter of the aspirator exit passageway **17** and a width of the second plane **19** ranges at least 5 times, more preferably from 7 to 20 times, the diameter of exit passageway **17**. These enumerated ranges for plane **18** width and plane **19** width are not limiting and are given in order to provide suitable widths for deflecting at least a majority of the filaments exiting from jet **14**. In an alternative preferred embodiment, the second plane width which is farthest from the jet exit **17** may be substantially wider than the other width of second

plane **19**, so as to increase the capacity of the two-planar deflector in deflecting a greater number of filaments when this is desired.

Although the two-planar deflector **22** works especially compatibly with the preferred aspirating jet **14** as described in FIG. 2 and as described in greater detail in patent application Ser. No. 184,542 entitled "Process and Apparatus for Production of a Nonwoven Web," filed on Sept. 28, 1971 in the name of Walter P. Lipscomb and Garland L. Turner, it has been designed to work compatibly with many conventional aspirators. In general, such conventional aspirators are especially suitable for use with the apparatus of this invention if these aspirators forward the filaments at high velocity, generate sufficient pull therein to maintain the filaments under minimum tension, open and separate the filament bundle during the exiting of the filaments from the aspirators, and prevent filaments from undergoing any substantial twisting, knotting, or entanglement therein.

Referring now to FIG. 3, the critical angular and dimensional relationship of the components of the two-planar deflector to the aspirator jet exit is shown. The first plane **18** is affixed rigidly to the exit of aspirating jet **14** by clamp **15** via a suitable extension **16**, which is compatible operatively with plane **18**. Plane **18** and plane **19** of the two-planar deflector, extension **16** and clamp **15** are designed to remain substantially rigid during normal operation of the apparatus. Planes **18** and **19** are positioned near the exit of the aspirator **14** such that a majority of said filaments impinge on the two-planar deflector after exiting from the aspirator. Plane **18** or its projection intersects plane **19**, forming an angle greater than 90 degrees between the impinging surface of plane **18** and the impinging surface of plane **19** in order to maintain control over the extent of filament deflection from the two-planar deflector. Plane **18** and plane **19** are constructed of a suitable material which is substantially rigid and does not degrade the filaments which contact it; e.g. shim brass or stainless steel. The angles which the two planes make with a line parallel to the center line of the aspirator are critical to the operability of this invention. For convenience, α is defined as the acute angle which the length of plane **18** makes with a line which is parallel to the center line of the exit passageway **17** of aspirating jet **14**, and β is defined as the acute angle which a straight-line extension of first plane **18** makes with the second plane **19**. We have found that a judicious choice of α and β assures a high degree of filament dispersal and separation. An exact determination of α and β is dependent on such variables as the type of polymer from which the filaments are made, the physical properties of the filaments which contact the two-planar deflector, the speed of filaments at the point of contact with the two-planar deflector, the desired properties of the resultant nonwoven web of filaments, and the desired filament laydown pattern. In order to obtain a suitable degree of filament spreading, α should range between 0 degree and 60 degrees, preferably between 25 degrees and 50 degrees. Similarly, β should range between 20 degrees and 85 degrees, preferably between 35 degrees and 60 degrees. The sum of α and β is less than 90 degrees and ranges preferably between 20 degrees and 89 degrees, more preferably between 45 degrees and 87 degrees. Use of the preferred values for α and β under the conditions of this invention, in comparison to a similar apparatus without the two-planar deflector, assures a surprisingly greater spreading of the filaments prior to deposition on the receiving surface and a surprisingly greater random distribution of uniformly distributed filaments within a wider web formed on the receiving surface. Experience has shown that a distance of approximately 3.5 to 26 times, more preferably from 4 to 15 times, the diameter of aspirator passageway exit **17** between the exit end of jet **14** and the area of initial substantial contact on the surface of two-planar deflector **22** has yielded satisfactory results. With values of such aspirator-deflector contact distance less than 3.5 times the jet exit diameter, filament deposition profiles are characterized by a detrimentally high degree of filament compacting and agglomeration. On the other hand, with values greater than 26 times the exit diameter, such profiles are characterized by inadequate dispersing as a result of reduced air velocities at such greater distances.

The length L1 of first plane **18** and the length L2 of second plane **19** are designed to be of a total dimension which is sufficient to deflect at least a majority of the filaments exiting from the aspirator passageway **54**. For similar reasons as discussed above for plane widths, the lengths of each plane may be varied to suit the particular situation. To accomplish a suitable degree of deflection when the two-planar deflector has quadrilateral planes, L1 as measured in a direction proceeding from the aspirator exit ranges preferably approximately from 3.5 to 20 times, even more preferably from 4 to 10 times, the diameter of the aspirator exit passageway **54**. Also L2 ranges preferably approximately from 1.5 to 25 times, more preferably from 2 to 4 times, the diameter of passageway **54**. With values of L1 less than 3.5 times and L2 less than 1.5 times the diameter of passageway **54**, no significant improvement in filament spreading was found when compared against apparatus using the jet without the two-planar deflector. With values of L1 greater than 20 times and L2 greater than 25 times the diameter of passageway **54**, the filament deposition profile was characterized by a relatively highly nonuniform distribution of filaments due to excessive randomness as a result of loss of control of filament laydown pattern.

The two-planar deflector is most preferably placed near the aspirator exit in a manner such that the widths of each plane are substantially perpendicular to the direction of forward motion of the moving receiving surface. Such placement assures symmetrical and uniform dispersal of the filaments on the receiving surface. Alternatively, the two-planar deflector may be placed such that the widths are at an angle which deviates from a direction perpendicular to the direction of motion of the receiving surface. However, such non-perpendicular placement is made at a sacrifice of uniform distribution of filaments across the laydown area during deposition; in some cases, depending on the intended usage of the nonwoven web product, this may be desirable.

We recognize that the planes of the two-planar deflector of this invention are not limited to quadrilateral forms. Planes of a greater number of sides than four may be used. However, as the number of sides is increased, expenses in production of the plane may increase without any substantial improvement in the degree of spreading occurring.

In operation, the aspirating medium, which may be a pressurized fluid such as air, is introduced from a supply source, not shown, into chamber **50**, at a pressure preferably ranging from 30 to 100 p.s.i.g. Such media enters and flows through nozzle passageway **51** and exits therefrom as a high velocity stream. The pressurized state of the aspirating media is contingent upon several conditions and thus may be varied to meet the specified circumstances. Some factors which influence operating pressures are the aspirating jet design, aspirating media, pressure consumed, type and nature of filament-forming polymer, degree of orientation to which filaments have been subjected, and the resulting properties of the nonwoven product. The high velocity fluid stream exiting nozzle passageway **51** engages filaments **12** entering the aperture **57** with sufficient energy to propel the filaments through collar chamber **52** into the diffuser **11**, which is characterized by an initially diverging chamber **53**. Subsequently, the propelled filaments are dispersed from diffuser passageway exit **17** in a wide and random manner via deflection from the two-planar deflector **22**. Then the filaments are deposited on a receiving surface which normally takes the form of a conveyor belt moving at a predetermined con-

stant speed and at a predetermined distance from the exposed width of the second plane **19** of the two-planar deflector **22**. The receiving surface should be placed below the two-planar deflector of this invention at a distance such that effectiveness and efficiency of random dispersal of filaments thereon in a uniform manner is achieved.

The following example is provided as further illustrative of the present invention. The enumeration of details therein, however, should not be considered as restrictive of the scope of this invention.

In an example, nylon 6 is melt spun into a 32-filament bundle **12** of 150 denier. The filament bundle **12** is subsequently introduced into aspirating jet **14** via aperture **57**. In collar chamber **52**, the filaments are subjected to air as the aspirating medium at a pressure of 30 p.s.i.g. The filaments **12** are forwarded to and through diffuser passageway **54** by the aspirating jet stream. Thereafter, the filaments **12** exit from jet **14** onto a two-planar deflector **22**. The two-planar deflector **22** has a ½-inch long, ¾-inch wide first plane **18**, and ¼-inch long, ¾-inch wide second plane **19**, an angle α of 40 degrees and an angle β of 45 degrees. The filaments exhibit an initial point of substantial contact on two-planar deflector **22** at a distance from jet exit passageway **54** of approximately ⅜ inch. Upon deflection from two-planar deflector **22**, filaments **12** open up considerably and are deposited on continuously moving, foraminous, horizontal conveyor **20** which is moving at a speed of 8 feet per minute and is at a distance of 8 inches from the closest portion of the two-planar deflector **22**. The nonwoven web produced is characterized by having a random filament distribution throughout. The appearance of the web is uniform and is essentially free of filament aggregates.

The nonwoven web or other useful construction processed from a coherent filament bundle which is prepared in accordance with this invention may serve a variety of useful purposes, particularly in the manufacture of nonwoven fabrics, such as carpet backing, wall covering, insulation, coating substrates, interfacing, filters, and the like.

Various modifications and other advantages will be apparent to one skilled in the art, and it is not intended that this invention be limited to details presented by way of illustration except as required by express limitations in the appended claims.

What is claimed is:

1. In an apparatus for depositing filaments onto a moving receiving surface in a randomly dispersed manner to form a nonwoven web of randomly disposed filaments substantially uniformly distributed throughout said web, said apparatus comprising an aspirating means for forwarding said filaments at high velocity to said moving receiving surface, the improvement comprising a two-planar deflector splaying means for augmenting spreading of, while advancing said filaments from said aspirating means to said moving receiving surface, said two-planar deflector consisting of a first plane rigidly affixed in one spatial position and a second plane being rigidly affixed in another spatial position, said two-plane deflector being positioned near the exist of said aspirating means such that a majority of said filaments exiting

from said aspirating means impinge on said two-planar deflector and such that said first plane or its straight-line extension intersects said second plane in a manner so as to form an angle greater than 90 degrees between the impinging surfaces of said planes, said first plane producing an acute angle α of approximately between 0 degree and 60 degrees with a line parallel to the center-line of the exit passageway of said aspirating means, α being measured in the general direction of forward motion of said moving receiving surface, and said second plane producing an acute angle β of approximately between 20 degrees and 85 degrees with the extension of said first plane in said direction, the sum of said angle α and said angle β being less than 90 degrees.

2. The apparatus of claim **1** wherein α is between 25 degrees and 50 degrees, β is between 35 degrees and 60 degrees, and the sum of α and β is between 45 degrees and 87 degrees.

3. The apparatus of claim **2** wherein said two-planar deflector is affixed in a manner such that there is a distance ranging approximately from 3 to 26 times the diameter of said aspirating means exit passageway between said aspirator exit means and the area of initial substantial contact of said filaments on said two-planar deflector.

4. The apparatus of claim **3** wherein said distance ranges from 4 to 15 times said aspirating means exit passageway diameter.

5. The apparatus of claim **3** wherein said two-planar deflector has substantially rectangular planes, said first plane having a length in a direction proceeding from said aspirating means exit ranging from 3.5 to 20 times said aspirating means exit passageway diameter and a width ranging from 5 to 15 times said exit passageway diameter, and said second plane having a length in a direction proceeding from said aspirating means exit ranging from 1.5 to 25 times said exit passageway diameter and a width of at least 5 times said passageway diameter.

6. The apparatus of claim **5** wherein said first plane length ranges from 4 to 10 times said aspirating means exit passageway diameter, said first plane width ranges from 7 to 13 times said exit passageway diameter, said second plane length ranges from 2 to 4 times said exit passageway diameter, and said second plane width ranges from 7 to 20 times said exit passageway diameter.

7. The apparatus of claim **5** wherein α is 40 degrees and β is 45 degrees.

References Cited

UNITED STATES PATENTS

3,692,618	9/1972	Dorschner et al.	156—181
3,655,862	4/1972	Dorschner et al.	264—290
3,341,394	9/1967	Kinney	156—167
3,423,266	1/1969	Davies et al.	156—167
2,736,676	2/1956	Frickert, Jr.	156—441

DANIEL J. FRITSCH, Primary Examiner

U.S. Cl. X.R.

156—167, 181, 433, 497; 425—83