United States Patent [19]

Marshall

[11] **3,862,867**

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[54] **PROCESS FOR PRODUCING REINFORCED NONWOVEN FABRICS**

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[22] Filed: **June 27, 1973**

[21] Appl. No.: **374,003**

Related U.S. Application Data

[62] Division of Ser. No. 256,711, May 25, 1972, Pat. No. 3,816,231.

[52] **U.S. Cl.** **156/62.2,** 19/156.3, 156/74, 156/181, 264/121

[51] **Int. Cl.** **D01g 25/00**

[58] **Field of Search** 156/62.2, 62.4, 62.6, 74, 156/62.8; 264/121; 425/80, 81, 82, 83; 19/145, 155, 156–156.4

[56] **References Cited**

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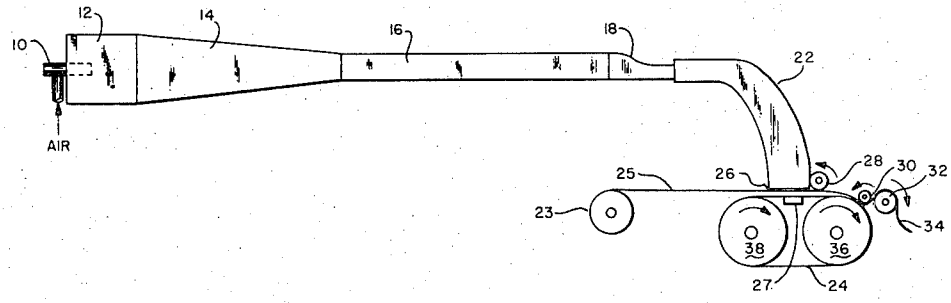
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Primary Examiner—Daniel J. Fritsch

[57] **ABSTRACT**

Textile-length fibers are subjected to a centrifugal force which orients them in a lateral direction, in which orientation they are deposited upon and mechanically engaged with a set of spaced-apart warp strands to form novel nonwoven fabrics.

4 Claims, 6 Drawing Figures



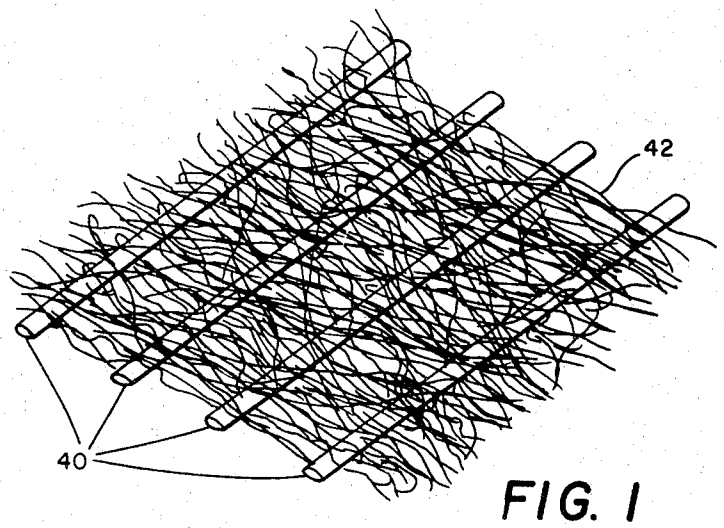


FIG. 1

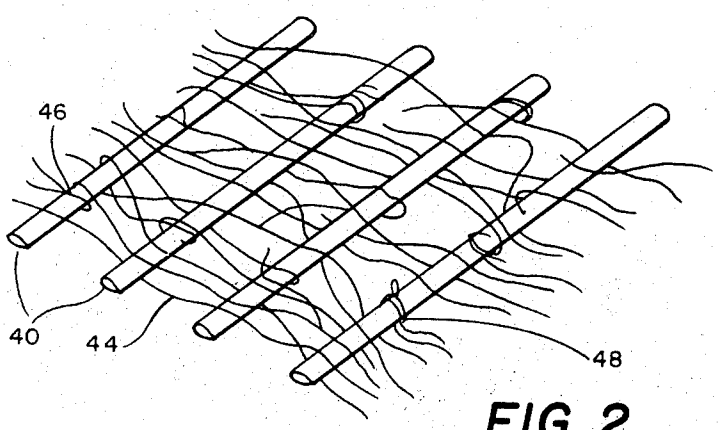


FIG. 2

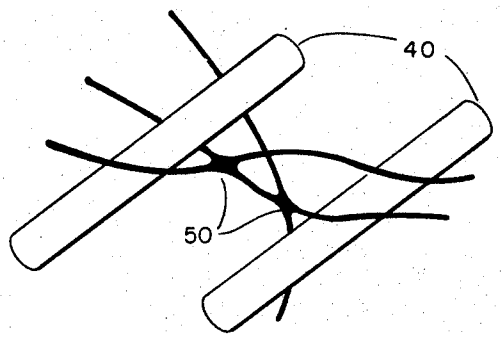


FIG. 3

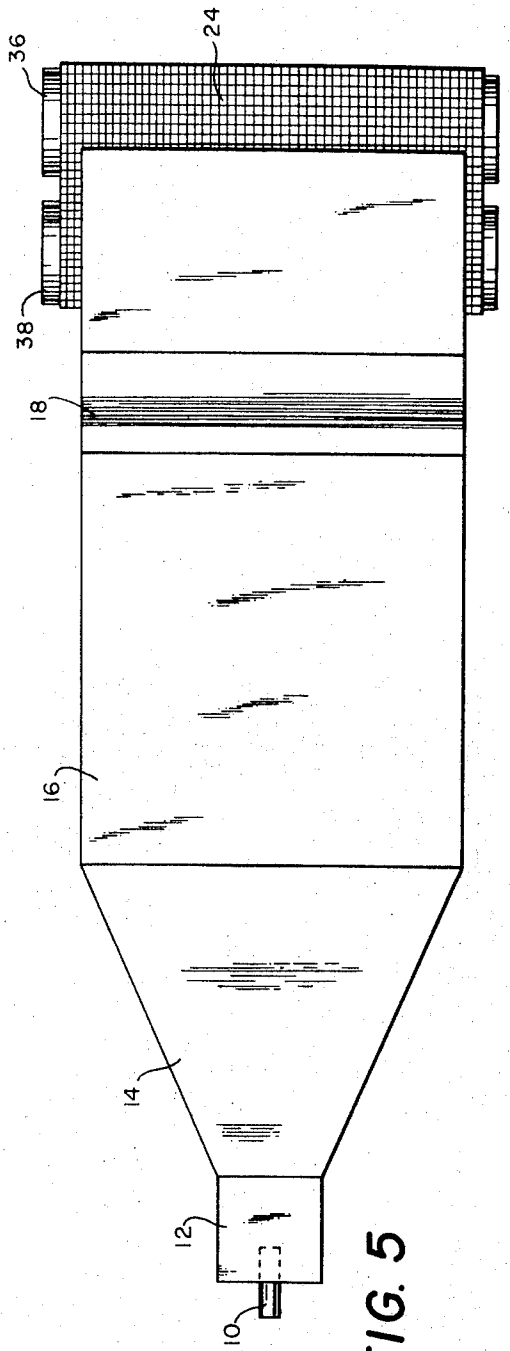

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FIG. 5

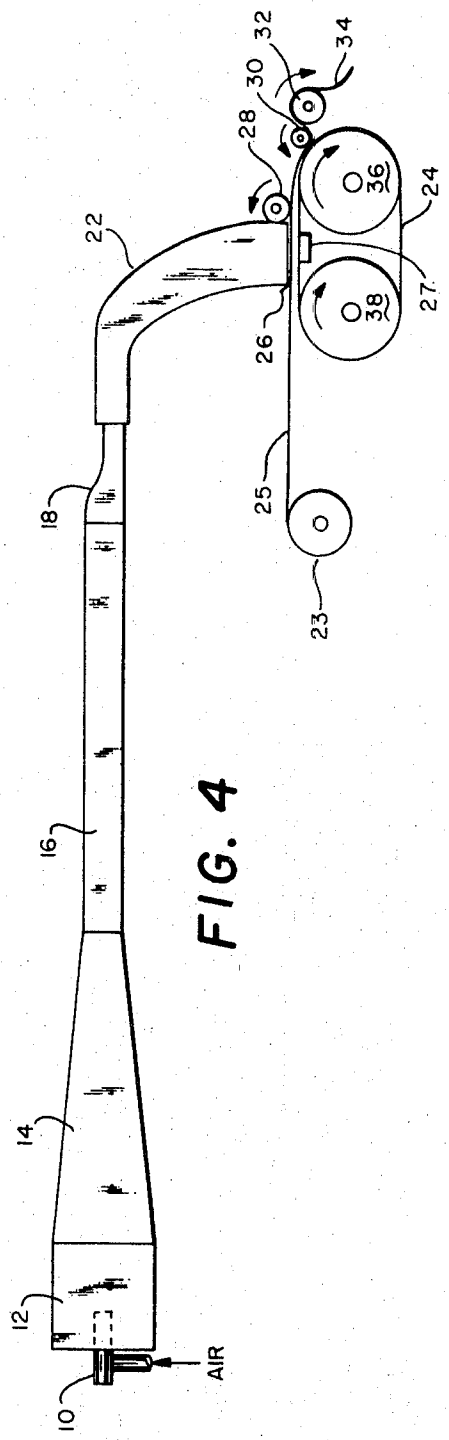

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AIR
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FIG. 4

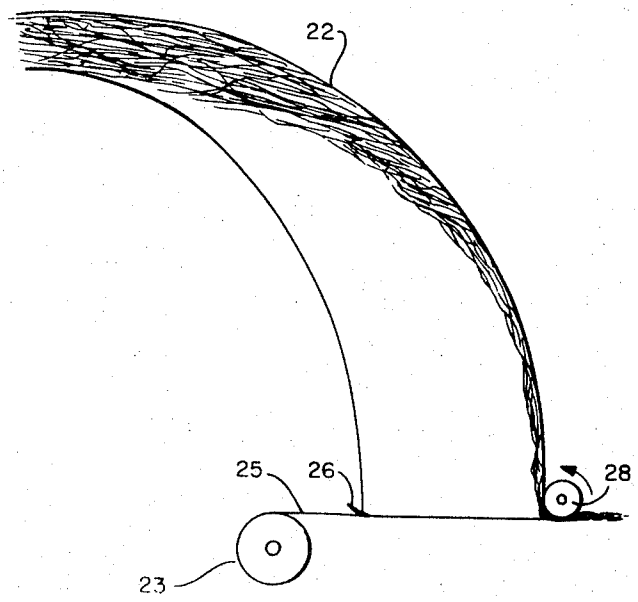


FIG. 6

PROCESS FOR PRODUCING REINFORCED NONWOVEN FABRICS

This application is a division of Ser. No. 256,711, filed May 25, 1972, now U.S. Pat. No. 3,816,231.

This invention relates to novel nonwoven fabrics, and to a process therefor. More particularly it relates to nonwoven fabrics comprising a spaced-apart set of warp strands running along the length of the fabric, with a web of textile-length fibers disposed substantially normal to said warp strands, a substantial number of said textile-length fibers being interlaced or otherwise mechanically engaged with said warp strands.

DISCUSSION OF PRIOR ART

In the preparation of nonwoven fabrics wherein a substantial degree of tensile strength, toughness, and opacity are desired, as for use in disposable garments, hospital drapes, and the like, it is common practice to laminate together nonwoven fabrics composed of textile-length fibers with other sheet material such as cellulose tissue, plastic films, paper, or other continuous sheet material. Such laminates, however, are usually deficient in tensile strength unless semi-rigid binder materials are employed in the lamination, in which case the laminate is liable to be unpleasantly stiff and papery, lacking in drape and esthetic appeal. In such cases, in order to combine adequate tensile strength with soft polymeric binder material in a product with suitable drape and conformability, recourse is frequently had to the use of an internal reinforcing layer or layers of textile yarns, spun or continuous filament.

Such a reinforcing layer may be in the form of woven gauze or scrim, but due to the relative expense of woven fabrics, a more frequent reinforcement expedient is the use of a layer of warp strands crossed physically by, but not interwoven with, a layer or layers of filling strands which may be normally disposed to the warp strands, or disposed at an angle or angles thereto. In order to impart stability to such an array, the multiple sets of yarns are commonly bonded to each other at at least a portion of their crossover points.

Prior art yarn-reinforcing devices of this nature, however, are intricate, expensive, difficult to maintain, and are rarely capable of operating at the speed at which it is desired to produce nonwoven fabrics in order to make them economically feasible for use in disposable garments.

BACKGROUND OF THE INVENTION

One obvious way to facilitate the processing of nonwoven fabrics and laminates with strand reinforcement would be to omit the time-consuming need for cross-strand reinforcement, using only a set of spaced-apart warp strands. However, unless the warp strands are spaced very closely together, there is no support for that portion of an overlay, such as a tissue, lying between the warp strands. Spacing the warp strands closely together is economically inexpedient: furthermore, no cross-direction (C.D.) strength is provided.

It is an object of this invention to provide a primarily two-dimensional nonwoven fabric comprising a set of spaced-apart warp strands, reinforced in the cross direction by a planar web of textile-length fibers, the textile length fibers being predominantly oriented normal to the warp strands and a portion of said fibers being mechanically engaged with said warp strands.

Further objects of the invention will be apparent from the following description and drawings, in which:

FIG. 1 is a perspective view of a product of this invention.

FIG. 2 is a similar view of the product of FIG. 1 showing in detail the nature of the mechanical engagement of fibers and warp strands.

FIG. 3 is an enlarged view of another embodiment of the invention.

FIG. 4 is a side elevation of an apparatus suitable for carrying out the process of the invention.

FIG. 5 is a top elevation of the apparatus of FIG. 4.

FIG. 6 is a side elevation of the centrifugal or horn section of FIG. 4.

Basically, the process comprises the formation of a high-velocity fluid stream of textile-length fibers, diffusion and deceleration of the fibrous stream in a chamber that is of substantial width in comparison with its thickness, to form a relatively wide but shallow fibrous stream, and then deflecting the fluid stream of fibers along a transversely extended smoothly curved surface curved in the direction of the stream, the curved surface forming what will herein be termed a horn.

In this manner, centrifugal force is exerted on the fibers, causing them to align in a transverse direction along the curved surface and to concentrate in a narrow transversely extended band along the forward edge of the curved surface.

The above process, with a description of the apparatus and the operating parameters, is set forth in detail in copending U.S. Patent Application Ser. No. 248,106, filed Apr. 27, 1972 now U.S. Pat. No. 3,812,553, of common assignee, and incorporated herein by reference, said application being a continuation-in-part of U.S. Ser. No. 196,709, filed Nov. 8, 1971.

The essence of the present invention is the interposition of a set of spaced-apart warp strands which traverse the lower edge of the centrifuge or horn, in a direction substantially normal to the flow of the narrow band of transversely-aligned fibers. The spacing of the strands and the length of the fibers are so chosen that at least a portion of the fibers, traveling at high velocity as they reach the forward exit edge of the horn, become mechanically engaged with the warp strands and with each other. Thus a set of parallel warp strands, having no crosswise tensile strength per se, is converted into a nonwoven fabric, with a strand warp and a fibrous filling substantially normal thereto. The nature of the mechanical engagement will be more fully explained below.

TECHNICAL DISCLOSURE

By warp strands is meant herein a spaced-apart non-interconnected set of supportive and reinforcing strands, of substantial tensile strength, running in the machine (M.D.) or longitudinal direction of the fabric. Exemplary but not restrictive illustrations are spun yarns, continuous filament yarns, narrow ribbons of film, fine wires, and bands of spread-apart tow comprising continuous synthetic filaments.

By textile-length fibers is meant fibers between 1 ½ and about 6 inches in length, capable of being formed into a fluid stream of substantially individualized fibers under the influence of an air jet.

Referring to FIG. 4 there is shown a fluid-powered jet or aspirator, **10**, capable of converting a top or sliver

of staplelength fibers into a high-velocity fluid stream of substantially individualized fibers. Such jets, their parameters, and their function are described in detail in my copending applications Ser. Nos. 159,229, filed July 2, 1971, now U.S. Pat. No. 3,793,679 and 164,255, filed July 20, 1971, now U.S. Pat. No. 3,727,270, and there are also commercially available aspirators capable of performing a similar function.

The high-velocity fluid stream of fibers is directed into the entry chamber **12**, and thence is diffused into a guiding chamber **14**, which, as seen by comparing FIGS. **4** and **5**, reforms the fibrous stream into a stream which is wider and shallower than the diffuse stream emerging from the aspirator. The wide and shallow fibrous stream flows then then through the chamber **16** and preferably to a constricting region **18**, which acts as a Venturi. While not absolutely mandatory, this constriction **18** serves to iron out or minimize local disruptive pressure differences or vortices, thus evening out the flow of fibers.

From the Venturi section **18** the fibrous stream passes into the curved centrifuge section **22**, where the actual reorientation takes place. The majority of the fibers are thrown against the leading or forward contour of the centrifuge **22**, causing them to become reoriented from their previous orientation parallel to the fluid stream, or long axis of the apparatus, to a position in which they lie predominantly across or normal to the direction of fluid flow.

Immediately adjacent to and preferably in contact with the exit section of the horn, a warp of spaced-apart strands **25**, from supply roll **23**, is caused to traverse the exit section in a direction normal to the fiber flow. As seen more clearly in FIG. **6**, the reoriented fibers are flowing in a narrow band traversing downwardly along the forward section of the horn. This band is customarily so narrow as to be less in width than the length of an individual fiber.

In preferred operation, the operating air pressures and apparatus configuration are such that the air velocity in the Venturi section **18** is about 88 to 176 feet per second, and at the forward edge of the exit section of the horn, where the fibers are grouped in a narrow transverse band, the air velocity is from about 44 to 88 feet per second. In this manner the fibers are strongly impelled onto the warp strands, and become mechanically engaged therewith as explained more fully below.

It should be appreciated that when the fibrous web is described as being oriented substantially normal to the warp strands, this does not mean that the fibers are laid down absolutely straight and parallel, like a row of matchsticks, since the length of the fibers being dealt with herein is so much greater than their diameter, and the fibers are so flexible, that practically without exception every fiber will lie in a twisted and cursive path, with curves and direction reversals along its path. The mean orientation of the fibers, therefore, is measured by the ratio of M.D. to C.D. strength of the fibrous web per se. By the statement herein that the fibers are predominantly oriented normal to the warp strands is meant that the ratio of C.D. to M.D. strength in the fibrous web alone is at least 4 or 5 to 1.

As desirable auxiliary equipment, means may be supplied to prevent excessive downward deflection of the warp strands as they traverse the exit section of the horn. This preferably is in the form of an air-permeable conveyor, such as a screen, **24**, driven by drive rolls **36** and **38**. In order to bleed off excess air, and to allow high air volumes and velocities to be employed in the horn, a conventional suction box **27** may be mounted immediately below the screen, as shown in FIG. **4**.

Also, in order to prevent leakage of air into the exit section of the horn, as shown in FIGS. **4** and **6**, a sealing roll **28** may rotate across the leading edge of the exit section of the horn, contacting the warp strands, and a curved plastic strip may make similar contact with the warp strands along the rear edge of the exit section.

The warp strand-textile length fiber combination may conveniently be doffed by means of take-off rolls **32** and **34**, whence it is wound up by conventional means, not shown.

The size of the apparatus will naturally vary with the width of fabric to be produced, the volume of fiber to be processed, and with other factors. A typical set of dimensions might involve an entry chamber **12** in the form of a 10 inch cube. The guiding chamber **14** may taper down to a 4.5 inch depth, while widening out to 40 inches for the purpose of producing a 40 inch-wide web. The chamber **16** may be 40 inches square and 4.5 inches deep, with a capacity of 180 cubic inches.

The outlet slot of the Venturi section **18** may taper down to a depth of about 1.2 inches, ejecting a fibrous stream into the 2 inch deep opening of the centrifugal section **22**. The guiding surfaces of this centrifugal section **22** are curved in a 15 inch radius through a 90° turn, terminating in an outlet section 6 inches wide, thus giving a 240 square inch screen deposition area.

The above dimensional parameters are illustrative only, and not restrictive. Engineering details for modifications of the apparatus may be made, bearing in mind that the centrifugal force developed is proportional to the square of the velocity of the air stream, and inversely proportional to the radius of curvature.

NATURE OF THE PRODUCT

The products of this invention are in general planar nonwoven fabrics of substantial length and breadth in comparison with their thickness. As shown in FIG. **1**, they comprise a set of warp streands, strands, and a superimposed web or fleece of textile-length fibers **42**, lying principally on and normal to the warp strands.

As mentioned previously herein, a portion of the fibers are mcehanically engaged with the warp strands. This is shown more clearly in FIG. **2**, wherein it may be assumed that that portion of the fibers of FIG. **1** which are not engaged with the warp strands, but are merely lying across the strands, has been removed for clarity. The nature of the mechanical engagement with the warp strands is of three principal types. First, there is a plain interlacing, as shown at **44**, where a textile-length fiber passes above certain warp strands and below certain other warp strands. Second, there is a wrapping action of one end of a fiber around a strand, as shown at **46**. Third, as shown at **48**, certain portions of the length of a fiber may be formed into a loop or series of loops, which loops are then at least in part wrapped around one or more wrap strands.

Additionally, there is a certain degree of entanglement and wrapping of some fibers, which are not in mechanical engagement with the warp strands as described above, with and around certain other fibers which are so engaged. It will be appreciated that the greatest degree of mechanical engagement of fibers with warp strands occurs with the fibers initially depos-

ited on the strands, and that as more and more textile fibers are deposited, they tend to lie upon the initially deposited portion of the fleece. Light weight nonwoven fabrics of this invention, therefore, will generally show greater tensile strength per unit of fabric weight than fabrics with a heavier deposit of fibers.

In general, in the practice of this invention, a set of warp strands of, for example, spun cotton yarns, will be spaced from 0.5 to 1.5 inches apart, and will have applied thereto a fleece or web of textile-length fibers of from 1.5 to 6.0 inches in length, weighting from 5 or 6 to 60 or 70 grams per square yard. The invention will be illustrated by the following examples.

EXAMPLE 1

The apparatus employed was that shown in FIG. 4, wherein the warp strands were 40's 2 ply cotton yarns spaced approximately 0.75 inches apart.

The chamber 12 of FIGS. 4 and 5 was fed by 4 aspirator jets of the type described as Type C in copending application Ser. No. 164,255, referred to above. The throat diameter of each jet was 0.562 inches in-diameter, the taper was 2.7°, and the exit section diameter was 0.600 inches. Each jet was powered by air at 75 P.S.I.G., which, as set forth in Ser. No. 164,255, develops a maximum vacuum in the tube, of approximately 24 inches of mercury.

Each jet was fed by a 60 grain rayon sliver, 1.5 denier per filament, 1 9/16 inches long. The total denier of the four ends of sliver was 153,060, and the feed rate was 4 feet per minute.

The 40 inch wide beam of cotton warp strands traversed the exit section of the horn at a speed of 8 feet per minute, in the manner shown in FIG. 4.

The product resembled that shown in FIG. 1, with a portion of the cross-deposited fibers mechanically engaged with the warp strands, as shown in FIG. 2. The yarn-fiber product weighed 8.7 grams per square yard, of which 2.9 grams was cotton yarn and 5.8 grams was rayon fiber. When a 1-inch wide strip was cut across the 40 inch width of the fabric and suspended by one end, the strip remained integral and self-sustaining in the absence of binder, indicating internal cohesion due to fiber-yarn interengagement.

If it is desired to produce stronger products, or to provide a potential adhesive property to fabrics of this invention, auxiliary binding material may be deposited within the product by the same air-deposition process. Such binding material may be in the form of thermoplastic fibers, or thermoplastic powders, or both, and the fiber-warp strand composite may be further unified by developing the adhesive properties of the auxiliary binding material, or the composite may be laminated to another planar sheet material, as shown in the following example.

EXAMPLE 2

The same apparatus, jets, rayon sliver, and cotton warp strands were used as in Example 1. In addition, two auxiliary aspirators were set up to feed into chamber 12 of FIGS. 4 and 5. These were a commercially available type, CP 200, from Clevepak Pollution Control Systems. These aspirators consist of a straight pipe approximately 9 inches long and 2.75 inches I.D., with an air supply delivered through four holes 0.089 inches in diameter distributed around the periphery of the central air chamber and inclined at about 30° to the axis of the pipe. Aspirators of this type are designed to operate at from 5 to 150 P.S.I.G., depending on the degree of vacuum it is desired to establish.

One CP 200 aspirator was fed with a supply of 3 denier 0.25 inch long Vinyon fibers (Union Carbide trademark for a copolymer of vinyl chloride-vinyl acetate in fiber form), at 75 P.S.I.G., delivering 6 grams of short thermoplastic fiber to each square yard of product. The other CP 200 aspirator, operating at 20 P.S.I.G., delivered to each square yard of product approximately 5 grams of a thermoplastic powder, 35 mesh, a copolymer of polyethylene-polyethylacrylate.

The composite product, after leaving the take-off roll 32 of FIG. 4, was plied with a layer of cellulose tissue weighing 20 grams per square yard, and was passed through a 3-roll calender. The bottom steel roll was heated to about 420°F: the center silicone covered roll equilibrated at about 360°F., and the top steel roll at about 120°F. The tissue side made contact with the heated steel roll, and the pressure was about 70 pounds per inch of nip.

The final compodite product weighed 59 grams per square yard, of which 25 grams was rayon fiber, 20 grams tissue, 3 grams cotton yarn, 6 grams fused thermoplastic fiber, and 5 grams fused thermoplastic powder. It has a tensile strength of 6.4 pounds per inch-wide strip cut to include one cotton warp strand, and a filling strength of 1.45 pounds.

Under the conditions of hot calendering, the thermoplastic fibers and thermoplastic powder granules were found, under microscopic examination, to have fused to binder globules unifying the rayon fibers, principally at their points of intersection, as shown at 50 in FIG. 30. Both thermoplastic components also served to bond the sheet of tissue to the assembly.

It will be apparent to those skilled in the art that any desired sheet material, such as film, foil, paper, or other nonwoven fabric, may be thus laminated to the basic fiber-warp strand-binder composite.

Having thus described my invention, I claim:

1. The process of making a nonwoven fabric which comprises passing a fluid-borne stream of textile-length fibers through a passageway having a transversely-extended smoothly curved surface curved in the direction of said stream,
thereby changing the direction of said fluid-borne stream along said surface and causing centrifugal force on said fibers to align said fibers in a transverse direction along said surface and concentrating said fibers thereat in a narrow, transversely-extended band,
collecting said fibers of said band on a set of parallel, spaced-apart warp strands,
said warp strands extending continuously in the longitudinal direction of said fabric,
and causing a portion of said fibers to entangle with said warp strands in mechanical engagement by passing over certain of said warp strands and under other of said warp strands,
and causing an additional portion of said fibers to entangle with said warp strands by having a portion of their length wrapped around at least a portion of the perimeters of certain of said strands.

2. The process according to claim 1 wherein a thermoplastic binder material is diffused into said fluid-borne stream of fibers.

3. The process according to claim 2 wherein the thermoplastic binder material is a powder.

4. The process according to claim 2 wherein the thermoplastic binder material is thermoplastic fibers.

* * * * *