United States Patent

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[54] **METHOD OF MAKING NONWOVEN ARTICLES FROM CONTINUOUS FILAMENTS**
11 Claims, 9 Drawing Figs.

[52] **U.S. Cl.** **156/180,** 156/166, 156/181
[51] **Int. Cl.** **B32b 5/02,** B32b 5/04, D04h 3/03
[50] **Field of Search** 156/155, 166, 180, 181, 307, 381

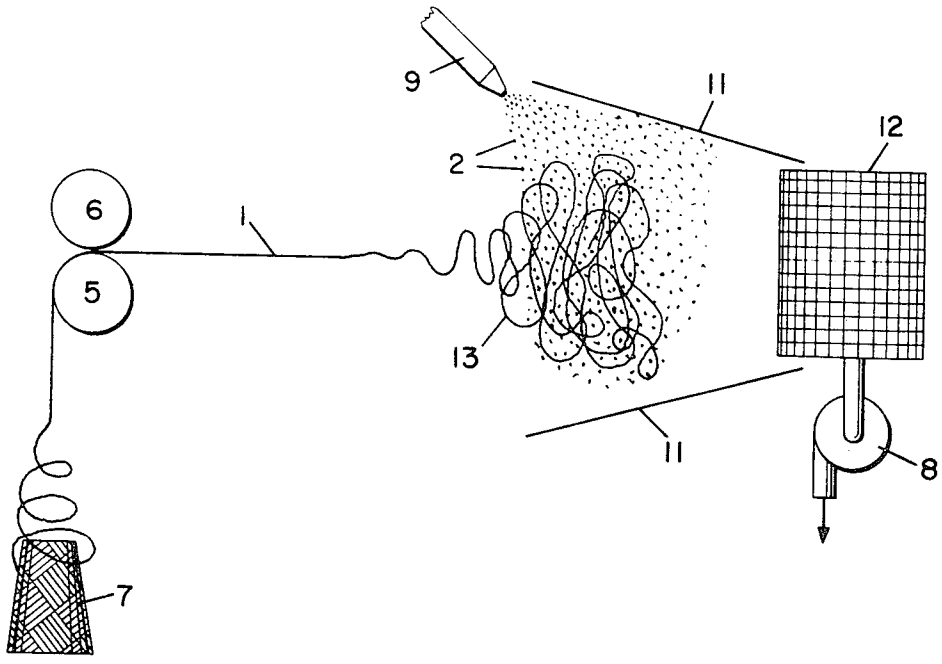
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Assistant Examiner—Roger S. Gaither
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ABSTRACT: This invention deals with nonwoven articles made from continuous filaments, including garments and porous sheet materials. In the past, nonwoven products have suffered the handicap of a stiff and "boardy" feel. We eject continuous yarn or filaments in an air space and contact them with binder droplets while still suspended in air, so that the droplets dry sufficiently to become nonmigrating before they are deposited on the screen or mold on which the fibers are brought into contact with each other and bonding takes place. This method is particularly suitable for making garments of elastomeric fibers, not easily handled in ordinary production machinery. Another generally applicable advantage is that the resultant products are exceptionally flexible and that the articles produced do not split into stratified binder-rich and -poor areas, but are uniformly bonded throughout.



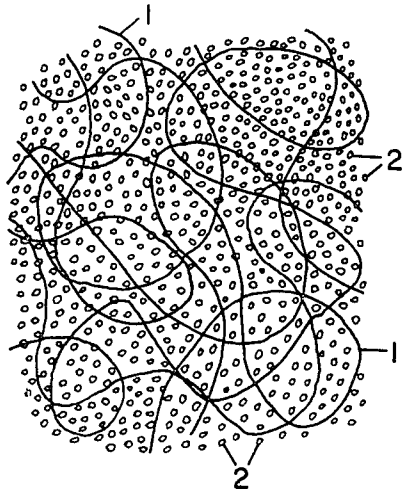


Fig. 1.

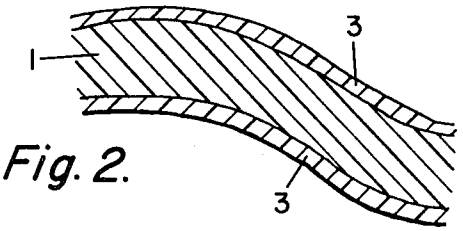


Fig. 2.

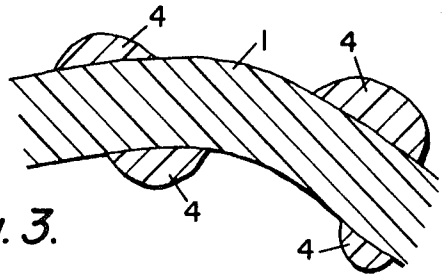


Fig. 3.

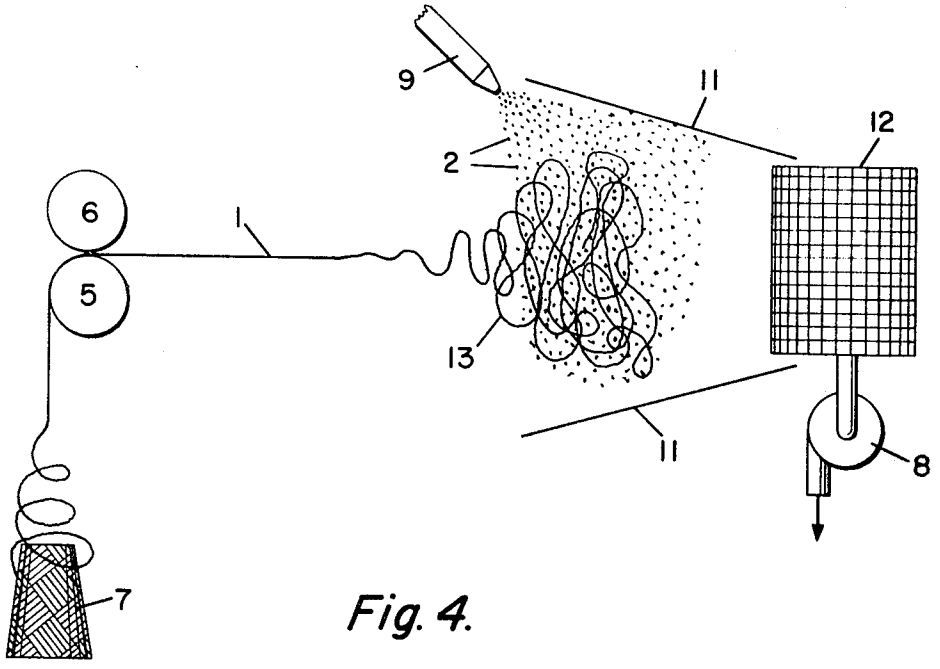


Fig. 4.

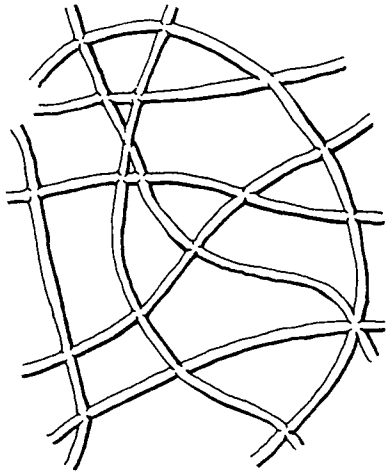


Fig. 5.

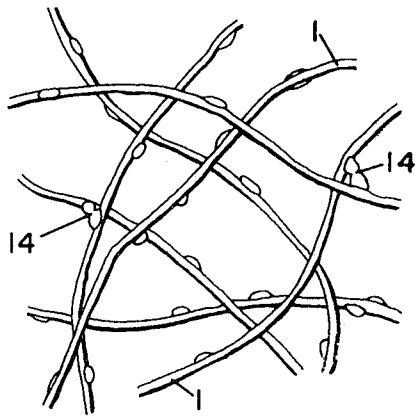


Fig. 6.

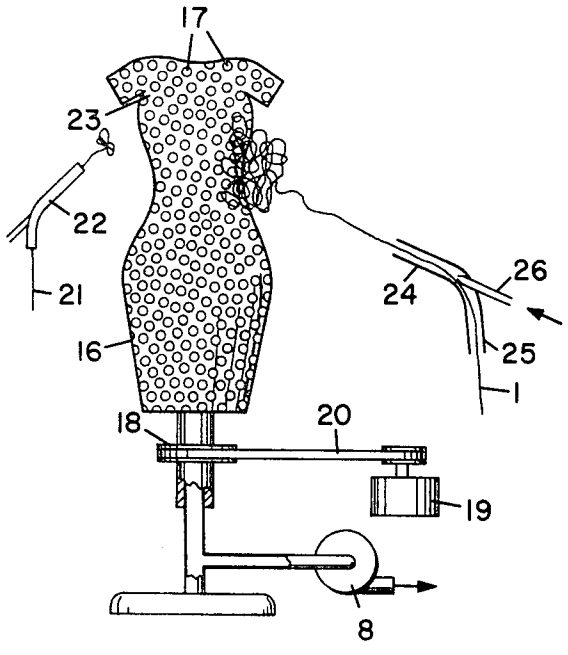


Fig. 7.

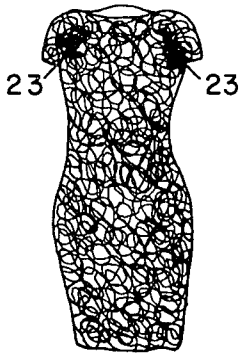


Fig. 8.



Fig. 9.

METHOD OF MAKING NONWOVEN ARTICLES FROM CONTINUOUS FILAMENTS

This invention relates to nonwoven fibrous products and to manufacture thereof, and has for principal objects a method to produce comfortable and attractive garments without the use of sewing techniques, and also the production of soft and nonboardy nonwoven fabrics.

Statement of Prior Art

Various methods have been used for producing preforms for subsequent impregnation with hardening resins to form automotive parts, boats and the like. These have included spraying glass roving onto perforated suction plates, and subsequent impregnation with resin, for example by means of suction, pressing and centrifugal casting. It is also known to make hats from felted fibers molded on forms, and set by resinous binders. Such methods have been used also with fibers to form nonwoven textiles.

The difficulty heretofore encountered in producing such textiles, is that the binder customarily applied in a solution and subsequently dried during the drying process will migrate to the periphery, where the evaporation is most rapid. As a result, the binder is enriched on the surface of the web, resulting in stiffness, while the center portion thereof is starved of resin and easily parts or delaminates. It has been attempted to remedy this by applying the binder in solid form, by dusting or mixing throughout the fiber mass, but this procedure is far less rapid and convenient, and a significant portion of the binder material is wasted because it is either not lodged at crossover points of fibers, which by capillary forces selectively attract liquid binders, or they provide an excess of binder, suitable for stiff products such as shoulder pads, but undesirable for garments generally.

Statement of Objectives

An object of this invention is a bulky fabric or mat in which the binder is uniformly distributed throughout the fabric.

Another object is a method for producing fabrics or mats in which the binder is uniformly distributed throughout the structure.

Another object is a process for making a soft and pliable nonwoven article, in which particles are deposited upon fibers uniformly from all sides, while such fibers are suspended in a gaseous medium, so as to form discrete particles thereon, said particles having a viscosity higher than 100 centipoise as deposited.

Another object is a process for making a uniform nonwoven article in which the binder is a solution in a volatile solvent, said binder being applied, and said solvent substantially removed, while said fibers are suspended in a gaseous medium in only minimal contact with each other.

Further objects will become apparent as the following detailed description proceeds.

SHORT STATEMENT OF THE INVENTION

In accordance with our invention, we suspend continuous filaments in a gaseous medium, we apply a binder comprising a volatile solvent and essentially remove said solvent while the filaments still remain suspended with the fibers essentially free from contact with each other. We are using the word "filament" in a broad sense to include any flexible textile strands, of essentially unlimited length, including also such strands or yarns as are made of a multiplicity of shorter fibers, such as for example staple yarns or cotton or woolen yarns. In this fashion, the stiffening of the binder prior to bringing the fibers into close contact with each other precludes further movement of the binder, particularly the migration which until now has greatly impaired the nonwoven fabrics.

When the binder is applied so that a coherent film is formed over the surface of the fiber, the evaporation of solvent while the fiber still is suspended in the gaseous medium will impede further enrichment or local impoverishment by migration. When the binder is applied so as to form tiny droplets on the fiber surfaces, migration is likewise impeded by evaporation while the fibers are still floating in the gaseous envelope, substantially unrestrained by contact with each other. An additional advantage is gained in that those parts of the fibers which are free from resin retain their original suppleness and flexibility, so that the resultant product does not have the "boardy hand" or stiffness which until now has generally characterized nonwoven fabrics.

THE DRAWINGS

The invention is further described with reference to the drawings, of which:

FIGS. 1, 5 and 6 are top views,

FIG. 4 is a schematic side view, and

FIGS. 2 and 3 detail sectional views,

FIG. 7 is a schematic side view,

FIGS. 8 and 9 are perspective views.

Referring now to FIG. 4, 7 is a fiber supply such as a pirn or roll of a continuous fiber, 5 and 6 are projection means, in this case a pair of rollers 5 and 6, which rotate so as to advance the fiber, of which there may be many, so as to impart to them a velocity in the range of 60 to 10,000 ft./min. and preferably 500 to 5,000 ft./min. The projected fiber 1 advances to a point where it has lost its velocity. Since new fiber is continually projected at high speed, but removed at a much lower rate, it will curl up in a three-dimensional pattern of loops and tortuosities 13.

This pattern is relatively slowly drawn onto a moving screen 12, through which some air is being drawn by a suction means 8, so as to deposit the said three dimensional pattern onto said screen and remove it from the space in which it was formed.

While this tortuous pattern 13 is relatively stationary or moving at a speed not greatly different from the speed of the air surrounding it, it is dwelling in a cloud of small droplets 2 of a binder composition, sprayed onto it by a nozzle 9. The space in which the fiber pattern 13 and the droplets of binder are present is confined by walls 11 so that spreading of the binder droplet beyond the confines of said space is limited, and the distribution of binder droplets within said space is substantially uniform.

FIG. 1 shows the fibrous loops 1 suspended in a gaseous ambient, together with suspended droplets of binder 2. Since both fibers and binder particles are moving, partly because of gravity, partly because of momentum and partly because of some gaseous turbulence or convention, the droplets are going to adhere to the fibers where these two components contact each other. If the droplet concentration is high, and the viscosity of the droplets low, and the wetting angle for the fibers low, then the binder may spread out along the fibers and form a substantially continuous layer 3 on it as shown in FIG. 2; if the droplet concentration is lower, or the viscosity high, or the wetting poor, the droplets will become attached to the fibers as discrete particles 4 shown in FIG. 3. In either event, the dwell in the gaseous ambient will be sufficiently long to evaporate enough of the solvent originally present to ensure that the binder will congeal into a kinetically stable state, whereby we mean a condition in which they will not respond to capillary spreading forces, but will stay put on the fiber, substantially without further migration or displacement from their positions on said fiber.

Thus, the binder becomes fixed onto the fibers in a state which resists further motion, before the fibers are brought in any extensive contact with each other.

When the placement and kinetic stabilization of the binder on the fiber has taken place, the fibers are carried by air currents or gravity or a combination of both onto a moving screen or belt, where the fibers contact each other, and are bound together at the point where binder contact is effected, for example when a binder droplet on one fiber contacts a binder droplet on another, or at least a receptive, adherable spot on the other, to which said binder droplet can become firmly attached. The resultant structure is shown in FIG. 5 which illustrates a web made by compacting fibers such as those in FIG. 2, while FIG. 6 shows the corresponding structure made of

fibers such as that shown in FIG. 3. 14 shows a point where bond between fibers has been accomplished by the union of two droplets. Since the major portion of the fibers is free from binder, these fibers retain their original softness and suppleness, and are free from the poor "hand" or boardy feel that usually is associated with nonwoven structures.

Referring to FIG. 7, 16 is a mold for a lady's garment. This mold is covered over its entire surface with perforations 17, into which air is sucked continually by means of air moving means 8 which exhaust the air from the hollow interior of mold 16, so as to create a continual suction through the perforations. A continuous fiber 1, in this case a woolen yarn, was projected toward the form by projection means which in this case are an air gun consisting of a tube 24, into which is fed at the distal end 25 the fiber to be projected onto the mold, and an air supply tube 26 into which air is fed to propel the fiber at high velocity. In the present case, the inner diameter of the said tube was 5/32 inch, of the air supply tube was 1/16 inch and the air pressure used was 40 p.s.i. The yarn was ejected at a rate of 1,500 ft./min. Simultaneously a binder having the following composition: 48–49 percent polyvinyl acetate copolymer in H_2O — particle size 0.15 microns, was sprayed at 100 p.s.i. thru a fogging nozzle into the area of tortuous suspended fiber so as to form rapidly drying discrete droplets of binder thereon, which when the fiber reached the mold, were already dried to the point of being fixed in their positions and nonmigrating. 18 is a pulley, attached to the base of the mold, which is made to revolve continually by means comprising for example said pulley, a belt 20 and a prime mover 19.

The air gun is moved by hand or by a programmable holder, so as to deposit the fiber at the desired rate. Often we prefer to spray a second reinforcing fiber 21, such as Nylon, "Dacron" or a high strength cellulose such as "Fortisan" onto the areas 23 where particular reinforcement is desired, that is, where the rate of wear is accentuated in use.

This reinforcing fiber may be sprayed by a separate air gun or projector 22 which resembles the air gun just described, except that the dimensions of the tubes are linearly ½ smaller, to compensate for the small diameter of the high-strength fibers. In this embodiment, we used 400 Denier woolen and 200 Denier Nylon.

The binder was caused to set by exposing the mold with fiber layer to a temperature of 320° F. while compressing it with a rubber roller by hand. We may also use inflatable balloons of a silicon rubber expanded within a small enclosure containing the mold to exert pressure to cause increased contact and bonding between fibers, or between different parts of the same fiber.

Upon completion, the finished garment was extended so as to slip over the protruding parts of the mold, and removed for use.

The completed garment is shown in FIG. 8.

EXAMPLES

The invention is further illustrated by the following specific examples:

Example 1

A thread of 480 Denier continuous filament Nylon was projected into an air space by means of the device shown in FIG. 4 and described above. The rate of projection was 3,000 ft./min. The rollers 5 and 6 were made of rubber molded over a metal insert and driven by a 1/15 hp. motor. The thread lost its initial velocity due to air resistance about 2 feet from the point of projection, and became nearly stationary in the air, slowly falling toward the screen 12. This was somewhat facilitated by a slow air current being sucked through this screen at a rate of 75 c.f.m.

Simultaneously we injected into the air space occupied by the fiber an atomized spray of a binder having the following composition: Piolon T-211 (Pioneer Chemical Works) diluted to 75 percent by volume with acetone. This binder was sprayed into said volume of air occupied by the fiber, by means of a spraying device in which the binder was supplied at a pressure of 1,500 p.s.i., and projected against a deflector, so as to break it up into droplets having an average diameter of 40 to 124 microns, and preferably 26 to 60 microns. These droplets filled the same space as the thread coils, and became attached to said thread, in a substantially uniform fashion. During this process, they lost solvent by evaporation, to such a degree that they became fixed and nonmigrating.

The fiber and binder combination was then pulled and/or gravitated to the screen 12, where the fibers became compacted by increasing the airflow to 10,000 c.f.m. and brought into intimate adhesive interaction with each other so as to form a coherent firmly bonded web. The density of this web could be increased by compression between rollers to which the binder in its state at that point was nonadherent, such as poly tetrafluoro ethane ("Teflon") coated rollers.

The resultant web was pliable and very strong. It showed no sign of stratification or binder migration.

Example 2

A 70 Denier Nylon yarn was sprayed by suitable means for projecting this yarn continuously, such as the device shown and described above in conjunction with FIG. 4, onto a receiving means consisting essentially of a flat 14 mesh screen thru which air was being sucked at a speed of about 300 c.f.m. A binder solution consisting of 2.5 percent of a polyamide such as DuPont Elvamide 8061 in methanol was simultaneously sprayed on, at a density of 2 gr./ft². Upon evaporation of the methanol, the binder caused the filaments to form adhesions at crossover points so as to form a coherent article. The resultant nonwoven fabric was pressed between sheets of 14 mesh screen at 25 p.s.i. and 320° F. for 2 minutes and cooled under the same pressure for 5 minutes. The average bending length of three samples was 10.5 cm. and the average breaking strength of three 1-inch wide samples was 34.8 lbs. Thus the breaking strength to bending lengths ratio was 3.32.

Extraction of the samples with boiling methanol indicated that the binder content was 30.1 percent.

A similar sample was prepared by putting an air laid batt of chopped 3 denier nylon staple fibers 2 inches in length, with a 5 percent solution of Elvamide 8061 in methanol, drying at 70° C., and pressed at 25 p.s.i. for 2 min. at 320° F. between pieces of 14 mesh screen and cooled for 5 minutes under the same pressure. The bending length of this sample was 9.8 cm. and the breaking strength 18.5 lbs. Thus the breaking strength to bending length ratio of this material was 1.89 or 57 percent of that prepared from the continuous yarn.

Example 3

A 70 Denier Nylon yarn was projected onto semihemispherically shaped 14 mesh evacuated screen while simultaneously spraying with a binder solution consisting of 2.5 percent "DuPont Elvamide 8061" in methanol. The molded article was removed from the screen and retained its shape as shown in FIG. 9.

The advantages of this invention are illustrated by the following comparative measurements of breaking strength:

When nonwoven fabrics are produced from batts of chopped fibers via the application of a binder such as Elvamide 8061, the breaking strength of the fabric drops off markedly when the binder content is reduced from a level of 31.7 to a level of 25.1 percent. With fabrics produced with the same binder via the use of a continuous yarn, there is no loss in strength even when the binder content is reduced from a level of 30.1 to a level of 17.1 percent.

Furthermore, at comparable levels of binder, i.e., 30.1 percent and 31.7 percent, the fabric produced from the continuous yarn had 1.9 times the strength of the fabric produced with chopped fibers.

The data substantiating these conclusions is shown in the following table.

Effect of Binder Concentration on the Breaking Strength of Nonwoven Fabrics Produced with Chopped Nylon Fibers and Continuous Yarns

Fiber Form	% Elvamide 8061	Breaking Strength of 1" Wide Sample (lbs.)
Chopped	31.7	18.5
Chopped	25.1	8.9
Continuous Yarn	30.1	34.8
Continuous Yarn	17.2	35.3

Example 4

An acrylic latex containing 50 percent solids in water and known as "Ucar 891" (Union Carbide) was diluted with an equal weight of acetone, and sprayed with an airless vibration sprayer known as "Jiffy Electric Sprayer," made by Astro Products Co., Branford, Conn. The following fibers were projected simultaneously with the above into the fog of acrylate droplets at the rate of 1,000 ft./min. in sequence, 200 Denier crimped Nylon; 30–20–RO2–56 duPont Dacron; a 50–10–S–280–Microphotographs taken of the resultant webs showed unmistakably the deposition on the fibers of discrete, separate beads of the resin, sometimes bridging and bonding fibers together, but always separated by stretches of fiber free from any visible coating.

In producing these webs, we varied the air suction in the range 3,000 to 10,000 cubic feet per minute, through a 20 inch × 40 inch screen. The thickness of the web produced in this example was from 0.01 inch to 1 inch. Cure was effected at 320° F., partly in a press at 25 p.s.i., partly without pressure in oven.

Example 5.

A perforated hollow mold was connected with the suction intake of a blower having a capacity of 45 ft.^{3}/min., and was thereupon sprayed with an air gun consisting of a ⅛ inch diameter, 12 inches long tube having an inclined air inlet entering at 20° angle with the axis of said tube, while the intake end thereof was connected with a fiber spool as supply of 210 Denier fiber of the elastic polyurethane known to the trade as "Lycra" and made by E. I. duPont de Nemours & Co. Simultaneously, we sprayed into the space in which the tortuous loops were formed, prior to reaching the mold, a binder of the following composition: Urethane Latex, Type X–1042, 50.2 percent solids in water.

The dwell time in the air of the tortuous loops was approximately two seconds. On striking the form, more than half of the solvent originally present had evaporated, and the residual material had a viscosity estimated at approximately 1,000 centipoise, which was sufficiently high to prevent any further migration of the binder on or along the fibers. On further drying for minutes at a temperature of 300° F., the fibers were permanently joined to an attractive dress, snugly fitting the form on which it was made, readily strippable therefrom because of the elasticity of the fibers used as well as because of the flexibility and extensibility of the random pattern.

Following the general procedure of example 2, we also made nonwoven fibers from 800 Denier crimped Nylon, projected onto a steel screen of 5/32 inch diameter holes on 3/16 inch staggered centers. The binder concurrently applied was "Flexbond 330" (Airco Chemicals & Plastics Co.) diluted with 75 percent of its volume by weight of methanol.

70 Denier ("Spandex" duPont "Lycra") was projected onto a window screen and simultaneously sprayed with "Urethane Latex X–1042"(Wyandotte Chemicals Corp.) diluted with 70 percent by volume of n-butyl acetate; 7–1–0–280–sd Nylon monofilament (duPont) was sprayed similarly onto 10 mesh window screen and simultaneously sprayed with "Polyco 2114" (Borden Chemical Co.) diluted 65 percent by volume with acetone. "70–34–RO–56"polyester yarn (duPont "-Dacron") was projected onto a 10 mesh screen while simultaneously spraying as a binder "Hycar 2671" (B.F. Goodrich Chemical Co.) diluted 70 percent by volume with acetone.

All of these procedures resulted in attractive fabrics or mats of much improved softness over corresponding products made according to prior art.

While the above examples illustrate some of the embodiments of the invention, it is evident that the scope is substantial. The fabrics of the invention have a thickness generally higher than 0.007 inches, as below this level the plasticizer migration due to flow of the binder during the drying step is not accentuated, and most strongly applies to fabrics having a thickness range from 0.010 inches to 0.600 inches.

The present invention is particularly valuable in the fabrication of garments from fibers so elastic that they cannot be handled at normal production speeds on a knitting machine or on weaving equipment. Thus, the invention is particularly applicable to fibers having a rubberlike character, the elasticity being generally characterized by a fully reversible elongation of more than 100 percent.

The resultant products are characterized by the absence of the previously prevalent migration of binder to the outer layers in the drying process. Thus, the central layers of the fabrics of the inventions are substantially indistinguishable from the outer layers on the basis of binder concentration, boardiness, stiffness and bonding strength, and the fabrics do not tend to part along planes of stratification when pulled apart by force applied perpendicularly to a flat surface.

The particles of the binder projected as a fog have a viscosity which at the time they become attached to the fibers, and these are allowed to aggregate, is sufficient to prevent capillary migration. This is generally a viscosity higher than 1,000 centipoise. To retain the ability to bind, there should be still some cohesive tendency. The upper limit of viscosity at the bonding step is generally about 10^5, however, this is more readily adjusted and can be reached for example by application of heat in the bonding process, so 5 – 15 effect adhesion when the adhesive at room temperature has hardened to a point where adhesiveness had all but vanished.

We prefer to employ binders in which the particles of the fog when sprayed comprise 10 percent to 50 percent of solid, 5–15 percent of a liquid solvent therefore which has a boiling range substantially between 75° and 120° C. and 55–75 percent having a boiling range substantially between 37° and 48° C.

We contemplate a structure of continuous filaments which have distributed substantially uniformly on their surface discrete, nonconnected droplets of adherent resinous or polymeric material. The droplets in question are in the finished article substantially dry to the touch, but have been made to form bridges or points of adhesion between the fibers where they touch two fibers, or droplets on another fiber usually at intersections of the fibers or filaments, or where these touch or almost touch each other. The bonding may have been effected at a stage of the process when the droplets were not yet quite dry to the touch, but yet dry enough to resist any capillary forces which might cause excessive spreading out or migration.

The fibers or yarns sprayed in this process are practically endless, so that they can be sprayed through the projection means as a continuous stream of connected matter. So long as this is possible, it does not matter greatly if a continuous yarn is made of continuous filament, or by spinning staple fiber, or natural fibers such as cotton, jute or wool.

The particularly preferred fibers are those which cannot otherwise be made into elastic knit structures, such as fibers or yarns of rubber, or of elastic polyacrylates, or elastomeric polyurethanes having elastic extensibility in excess of 100 percent, such as "Lycra." The invention is applicable to fibers of the synthetic thermoplastics, such as "Nylon," polyethylene glycol terephthalate, polyvinyl fluoride, split film fibers, for

example of polypropylene, polyolefin fibers generally, polyphenoxide fibers, polyoxymethylene, also to fibers extruded or drawn as thermoplastic but subsequently cross-linked, chemically or by exposure to ionizing radiation, and which may even decompose before melting, polyacrylate or methacrylate fibers, and the like, including also fibers not yet invented but of substantially equivalent mechanical properties to the above.

While the binder compositions are preferably solutions, when rapid spraying and drying is desired, we may also in some cases employ water latices. When these are sprayed, we prefer to maintain the mold at a temperature of about 180°–230° F., in order to enhance the rate of evaporation. Suitable latices are, for example:

"Ucar **891**"—Union Carbide, Inc.

"Urethane Latex, Type X-**1042**"—Wyandotte Chem. Corp.

"Flexbond **330**"—Airco Chemicals & Plastics, Inc.

The water latices are preferably used with slit film type of fibers having a width of at least 15 microns, or with fast drying synthetic monofilaments.

With "kinetic stability" we mean stability to capillary and other surface forces, so that a droplet or film deposited will stay put when the fiber is deposited on the mold or where its final bonding takes place, and will not then further spread or migrate so as to change the distribution of concentration thereof.

With "contact points" we mean those points on the fibers where they come in contact with another fiber, or another part of the same fiber so that bonding can be effected.

In accelerating the fiber to project it into the gaseous ambient in which it is contacted by the binder fog, it is necessary to give the continuous filament or yarn a velocity of at least 60 ft./min., and to decelerate it to at least half this velocity by contact with the air into which it is projected, so as to induce the formation of the tortuous or curvilinear patterns described. The preferred fiber velocity is from 300 ft./min. to 30,000 ft./min. The rate of air motion through the preform mold is in the order of 30 feet up to 100,000 ft./min., and preferably about 50–5,000 ft./min. The lower range is applied when the fibers are hovering in the air, the speed can be accelerated in cycle to effect pressure on the fibers to increase fiber contact in binding; however we generally prefer to use steady and continuous operating conditions.

Having thus disclosed our invention, we claim:

1. The process of producing a nonwoven structure which comprises the step of spraying into a gaseous ambient a solvent containing resinous binder medium so as to form a fog of substantially suspended droplets, projecting into said fog continuous filaments so as to form a semistatic randomly looped three-dimensional configuration within said fog, maintaining said configuration within said fog, maintaining said configuration within said fog for at least two seconds so as to cause the droplets of said fog to settle upon said configuration of filaments whereby the droplets stiffen to preclude their further movement relative to the configuration, allowing said configuration to settle upon a receiving means, and evaporating the residual solvent of the binder droplets on the filaments so as to cause the said filaments to adhere to each other at points of contact.

2. The process of claim **1**, in which the droplets of said fog have a viscosity in excess of 10^3 centipoise, and below 10^5 centipoise.

3. The process of claim **1** in which the droplets of said fog comprise 10–50 percent of solid, 5–15 percent of a liquid solvent therefore which has a boiling range substantially between 75° C. and 120° C., and 75–55 percent of a solvent having a boiling range substantially between 37° C. and 48° C.

4. The method of claim **1** wherein the step of projecting further comprises the step of suspending the filaments in the gaseous ambient.

5. The method of claim **1** wherein the gaseous ambient is a moving gaseous medium.

6. The method of claim **1** wherein the solvent of the binder droplets on said filaments is substantially removed by evaporation leaving a residue being highly resistant to capillary forces.

7. The method of claim **1** wherein the receiving means is a revolving hollow perforated mold having a reduced atmospheric pressure therein.

8. The method of producing an elastic article, which comprises the steps of projecting a continuous strand of a fiber having elastic recovery in excess of 100 percent onto a revolving hollow perforated mold, applying a binder to said fiber prior to the fiber contacting said mold, stiffening said binder while the fiber is suspended in air to preclude movement of the binder relative to the fiber at a point prior to the fiber contacting said mold, attracting said fiber to the surface of the revolving perforated mold by means of a reduced atmospheric pressure therein, causing the fiber to be bonded to itself at points of contact, and removing the resultant article from the mold.

9. The method of claim **8**, in which the said binder is spread over the said fibers as a uniform kinetically stable film.

10. The method of claim **8** in which the said binder is distributed over said filaments as discrete droplets.

11. The method of claim **8** in which the binder is distributed over said fiber as discrete droplets.

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