United States Patent

[11] 3,607,588

[72] Inventor John W. Soehngen
Berkeley Heights, N.J.
[21] Appl. No. 580,994
[22] Filed Sept. 21, 1966
[45] Patented Sept. 21, 1971
[73] Assignee Celanese Corporation
New York, N.Y.

[54] **NONWOVEN FIBROUS PRODUCTS AND METHODS AND APPARATUS FOR PRODUCING SUCH PRODUCTS**
13 Claims, 7 Drawing Figs.

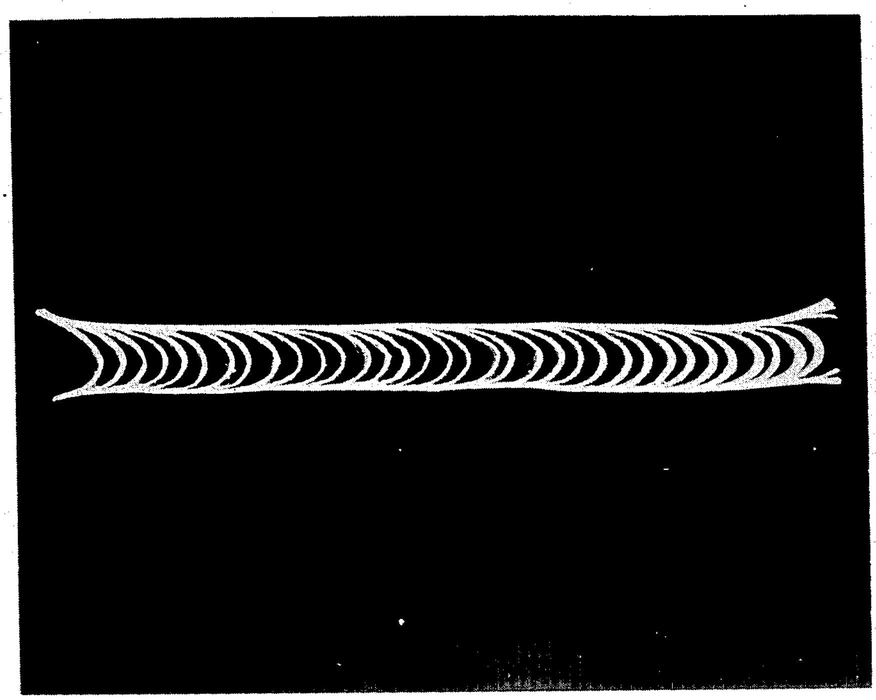
[52] **U.S. Cl.** **161/53,** 161/67, 161/69
[51] **Int. Cl.** **D03d 27/00,** B32b 3/12
[50] **Field of Search** 161/49, 53, 67, 69; 156/179, 435, 437

[56] **References Cited**
UNITED STATES PATENTS

3,012,923	12/1961	Slayter	161/53
3,287,196	11/1966	Koller	161/67
3,309,252	3/1967	Adler	161/67
3,348,993	10/1967	Sissons	161/67

Primary Examiner—Douglas J. Drummond
Attorneys—D. J. De Witt, R. J. Blanke and S. D. Murphy

CLAIM: 1. A nonwoven fibrous product comprising a series of similar fibrous subassemblies each made up of randomly arranged fiber components bonded together in the form of a thin sheet, each of said subassemblies including top and bottom zones extending generally parallel to the surfaces of the product and an intermediate zone extending angularly with respect to the surfaces of the product, the top and bottom zones of a plurality of adjacent ones of said subassemblies being disposed in overlapping and contacting relation to each other to provide the product with surface strata of substantial density, and major portions of the intermediate zones of adjacent subassemblies being spaced apart from each other.



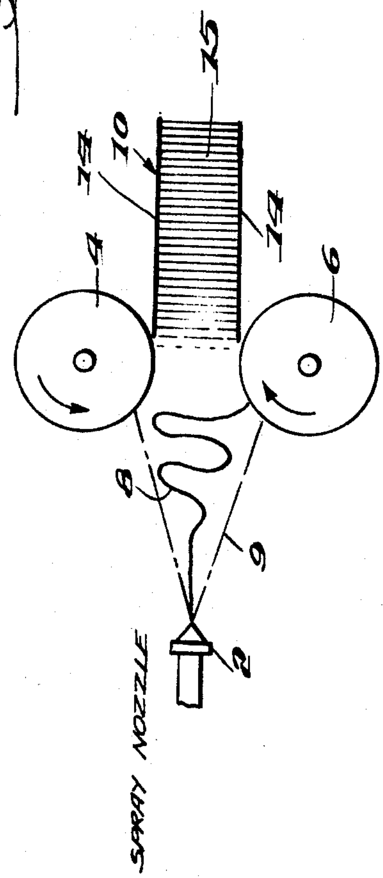

SPRAY NOZZLE
2
4
6
8
9
10
14
14
15

Fig. 1.

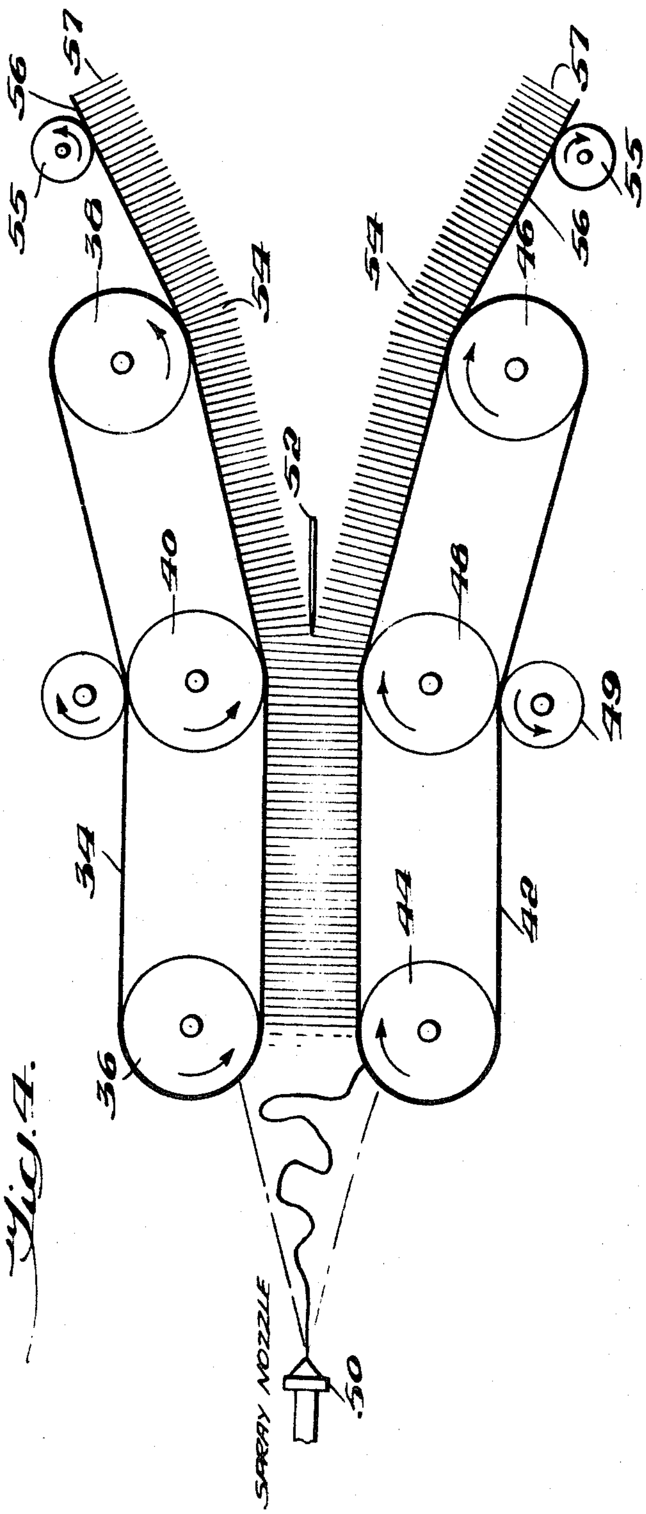

SPRAY NOZZLE
30
34
36
38
40
42
44
46
48
49
52
54
54
55
55
56
56
57
57

Fig. 4.

Fig. 2.

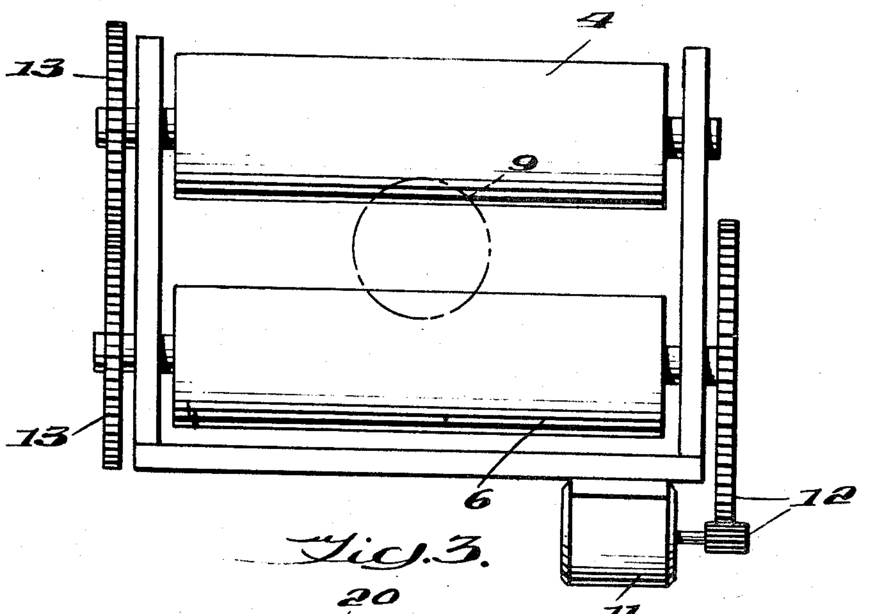


Fig. 3.

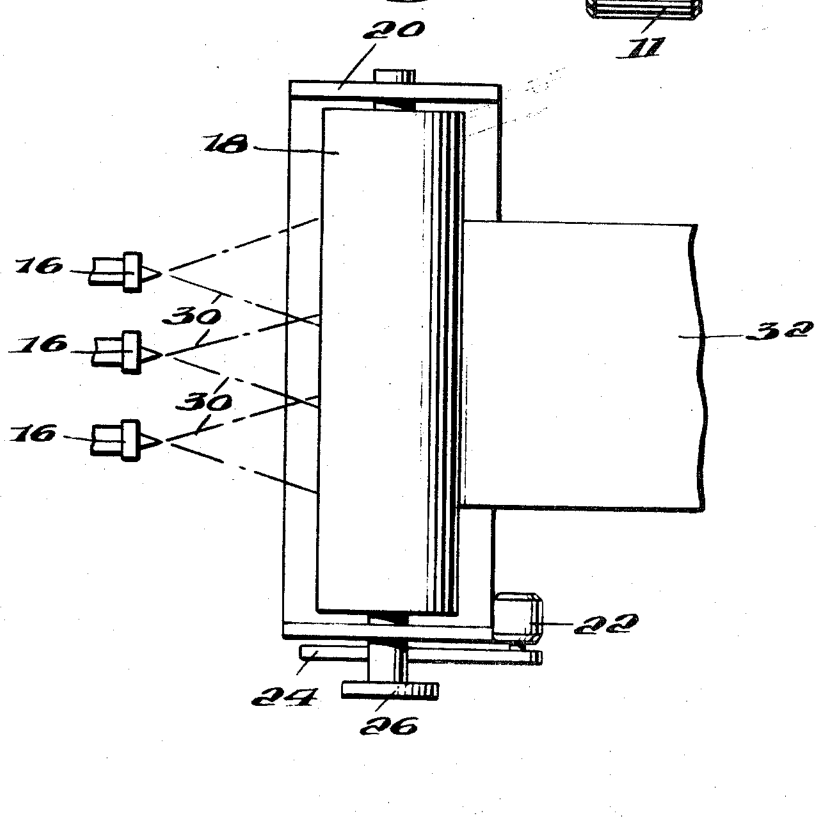


Fig. 7.

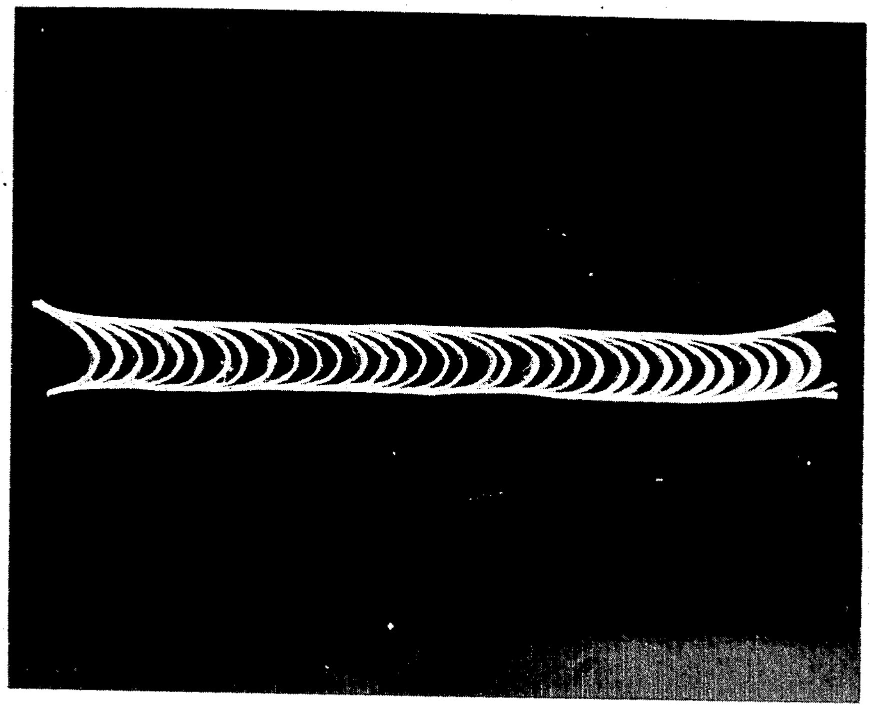


Fig. 5.

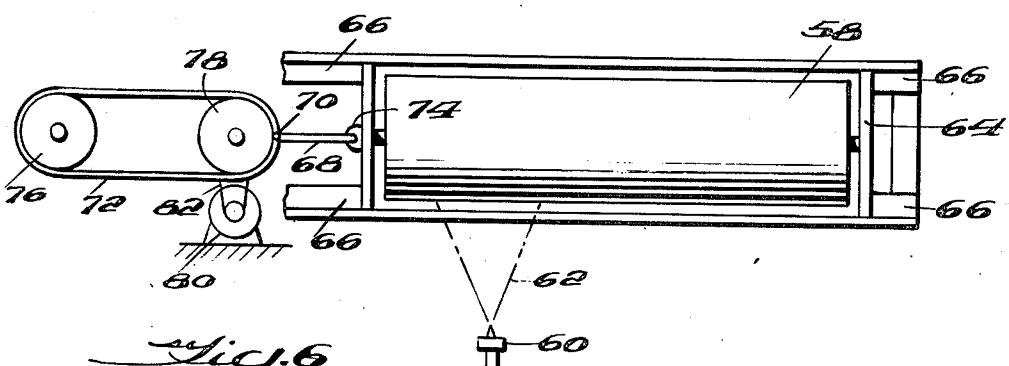
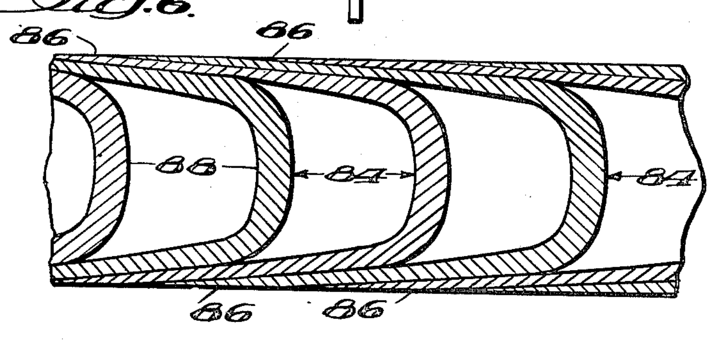


Fig. 6.



NONWOVEN FIBROUS PRODUCTS AND METHODS AND APPARATUS FOR PRODUCING SUCH PRODUCTS

This invention relates to nonwoven fibrous products and to processes and apparatus for producing such products. The invention is concerned particularly with the provision of nonwoven fibrous products of substantial bulk.

Various proposals have been advanced heretofore for the formation of such fibrous products as mats and the like directly from molten fiber-forming material. In general, the fiber-forming material is extruded through orifices to form fiber and the fiber is collected on moving belts or the like in mat form. Examples of such proposals are disclosed in U.S. Pat. Nos. 2,206,058; 2,382,290; and 2,810,426. The density of the fibrous bodies collected by these techniques, and the orientation patterns of the fiber therein, do not vary much from zone to zone across the thickness direction of the mat.

More recently improved spray-spinning processes and apparatus have been developed which permit the formation of substantially continuous filaments at high-production rates and without the concurrent formation of quantities of shot and such other undesirable physical forms as very short fiber elements. In this connection reference is made to the patent application of Wagner et al. Ser. No. 581,075 filed Sept. 21, 1966, now abandoned, which is being filed concurrently herewith under the title "Method and Apparatus for Producing Fibrous Structures" and which is owned by applicant's assignee.

The present invention also is concerned with the collection of spray-spun filamentary material in the form of fibrous bodies. However, the invention envisions the formation of a single collection station of nonwoven fabrics in which different arrangements of the filamentary material exist at different zones across the thickness direction to give the fabrics distinctive properties.

More particularly, it is an object of this invention to provide novel nonwoven fibrous structures having spaced-apart surface layers of substantial density and having an integrally formed core made up of fibrous components bridging the space between the surface layers.

Another object of the invention is to provide nonwoven pilelike fabrics characterized by the presence of a backing layer and integrally formed fibrous components protruding upwardly from the backing layer.

Other objects of the invention include the provision of novel processes and apparatus for producing these fabrics economically and reliably.

The invention may be used in connection with the production of products from any of the various materials that may be melted and extruded through an orifice to form a filament. Examples of suitable types of fiber-forming materials are polyolefins, polyamides, polyesters, cellulose acetate, polyvinyl acetate, poly(methyl methacrylate), styrene copolymers, and glass.

In accordance with a preferred embodiment of the invention, a substantially continuous filament of thermoplastic polymeric material formed by the spray spinning techniques disclosed in the aforesaid patent application of Wagner et al. and collected by means of opposed spaced-apart, contra rotating rolls disposed in the path of the material issuing from the extrusion orifice. The gap between the two rolls in substantial, and only portions of the spray-spun filamentary material are deposited directly upon the roll surfaces. The remainder of the filamentary material crosses back and forth randomly between the layers of material deposited on the roll surfaces to form a bridging structure connecting the layers together.

Some bonding together of the filament sections ordinarily is desirable. For example, the rolls may be located close enough to the spray-spinning nozzle of receive the filamentary material while surface portions of the filament sections are sufficiently tacky to permit a degree of self-bonding at crossover points.

As the rolls rotate, the collected filamentary material is removed from the collection zone in the form of a nonwoven fabric having surface layers in which the fiber components are generally parallel to the fabric surfaces and having an interior core in which the fiber components extend at angles to the surfaces. The relative thicknesses of the different fabric zones may be regulated by suitable adjustment of such factors as a gap between the rolls, the spacing of the rolls from the spray-spinning nozzle and the speed of rotation of the rolls. In producing the high bulk products of this invention, it ordinarily is desirable that the individual surface layers have a thickness no greater than one-third of thickness of the product. More preferably, each of the surface layers should have a thickness less than one-sixth of the total fabric thickness, leaving over one-half of the fabric thickness to be taken up by the bridging structure constituting the interior core.

In accordance with another aspect of the invention, fibrous subassemblies contributing significantly to the overall fabric properties may be formed during the collection of the spray-spun filamentary material. In one embodiment for example, the collector rolls are traversed laterally back and forth in front of the spinning nozzle in such a manner as to produce during each traverse a generally U-shaped sheet and the ends of which are adjacent the roll surfaces and the central portion of which bridges the gap between the rolls. As the traversing continues, the successively collected U-shaped sheetlike units are combined into a nonwoven fabric in which overlapping and contacting end portions of a number of the U-shaped sheets are consolidated as surface layers or skins and in which the central bridging portions of adjacent sheets are spaced apart from each other to provide a resilient core formed integrally with the surface layers.

In another embodiment, a plurality of spray-spinning nozzles are arranged to project filamentary material toward the gap between the opposed collection surfaces of a single collector unit. The spray patterns from adjacent nozzles overlap in the collection zone so that a unitary product will be formed even though the filamentary material issues from different sources. Setups of this type are particularly desirable in producing fabrics having zones of different characteristics across the width thereof and in producing wide fabrics without the sheetlike subassemblies which sometimes are formed when a traverse motion is employed.

The invention also contemplates the production of pilelike nonwoven fabrics. The fibrous body removed from the collection zone through the gap between the opposed collector surfaces may be severed or slit lengthwise at a level between the surface layers deposited on the collector surfaces to provide two fabrics in each of which the surface layer serves as a backing and the attached portion of the bridging structure projects upwardly form the backing. The nature of the upstanding material or "pile" will depend of course upon the conditions maintained during collection of the spray-spun fiber, and a variety of effects can be achieved. For example, the upstanding material on the surface of the fabric may be thin sheetlike subassemblies forming transversely extending leaves. This particular effect is achieved by slitting an assembly collected on a setup having a traverse motion and operating as described above to produce a series of thin, generally U-shaped sheetlike subassemblies as the spray pattern moves laterally back and forth across the collector surfaces. A more complete understanding of these and other features of the invention will be gained from a consideration of the following description of certain embodiments illustrated in the accompanying drawings, in which:

FIG. 1 is a schematic elevational view depicting one form of apparatus setup that may be used in practicing the invention;

FIG. 2 is a face view of the collector roll assembly shown in FIG. 1;

FIG. 3 is a top view of an apparatus setup similar to that illustrated in FIG. 1 but having a plurality of spray-spinning nozzles associated with a single collector unit;

FIG. 4 is an elevational view depicting another form of collector structure and also illustrating the formation of pilelike nonwoven fabrics in accordance with the invention;

FIG. 5 is a schematic top view of another embodiment of the invention in which the collector unit is traversed bodily back and forth in front of the spray-spinning means;

FIG. 6 is a diagrammatic view of the fibrous subassemblies produced during traverse motions of the collector unit of the apparatus of FIG. 5; and

FIG. 7 is a photograph showing in longitudinal cross section the nonwoven fabric produced through the use in accordance with the invention of the apparatus of FIG. 5.

Spray-spinning nozzle means are indicated schematically at 2 in FIG. 1. Preferred nozzle structures are disclosed in the aforesaid patent application of Wagner et al., and for detailed information on these structures reference should be made to such application. It will be sufficient to point out here that the preferred spray-spinning nozzle is provided with an orifice through which the molten fiber-forming material is extruded and is also provided with a plurality of gas passages disposed about the axis of the extrusion orifice. The gas passages are inclined to direct heated gas, such as steam, along paths the axes of which converge toward but do not intersect the projected axis of the extrusion orifice. The high-velocity gas streams issuing from the gas passages attenuate the filament extruded through the extrusion orifice and project the filament away from the nozzle in a random swirling pattern.

The collector unit depicted in FIG. 1 includes a pair of opposed, spaced-apart rolls 4 and 6 mounted for rotation in a suitable frame and having smooth surfaces. The rolls 4 and 6 are spaced a predetermined distance from the nozzle 2, and the gap between the rolls is in substantial alignment with the central axis of the nozzle 2.

The filament 8 is projected in a generally longitudinal direction from the nozzle 2, but increments thereof deviate randomly from the extrusion orifice axis due to the high-filament velocity and the effects of the gas issuing from the nozzle. The overall result in a spray pattern that is generally conical in outline as indicated schematically at 9 in FIGS. 1 and 2.

In establishing the proper spacial relationship between the nozzle 2 and the collector unit, consideration should be given to he shape and size of the spray pattern 9 in the collection zone. As indicated in FIG. 2, the diameter of the spray pattern 9 should be greater than the gap between the surfaces of the collection rolls 4 and 6. When this relationship exists, portions of the projected filamentary material will be deposited directly upon the surface of the rolls 4 and 6 and other portions will be swirled about randomly to bridge the gap between the rolls.

The extent to which the freshly spun filamentary material hardens prior to collection also is affected by the spacing between the nozzle 2 and the collection unit. Ordinarily, it is desirable that collection take place while the surfaces of the filamentary material are still sufficiently tacky to effect self-bonding as between filament sections at crossover points. If other factors be held constant, the degree of self-bonding may be varied by changing the distance from the nozzle 2 to the collection rolls 4 and 6. Control over the degree of self-bonding achieved may also be exercised by regulation of the extrusion temperature at the nozzle 2 and/or by heating or cooling the surfaces of the collection rolls 4 and 6.

In instances where supplemental fiber-to-fiber bonding may be desired, suitable binders and/or plasticizers may be employed. For example, compositions compatible with the fiber-forming material may be added to the melt supplied to the extrusion orifice, or spraying techniques may be used to apply suitable compositions to the filamentary material either in the zone of collection thereof or at a subsequent stage of the process.

As the collection rolls 4 and 6 are rotated in the directions indicated by the arrows in FIG. 1, the collected filamentary material is removed from the collection zone through the gap between the rolls in the form of a nonwoven fabric product 10. Any suitable drive means may be employed for rotating the rolls 4 and 6. In FIG. 2 the drive means have been shown as including a motor 11, gear means 12 coupling the motor 11 to the shaft of roll 6, and gears 13 coupling together the rolls 4 and 6 for rotation at the same speed but in opposite directions.

The nonwoven fabric 10 has a distinctive structure. This structure includes upper and lower surface layers 14 spaced apart by an integrally formed core 15. The surface layers 14 are made up of the fiber deposited upon the smooth surfaces of the collector rolls 4 and 6, and in these layers the predominant orientation of the filamentary material is parallel to the surface of the product 10. However, a significantly different orientation exists in the core 15. The fiber components here are those that were collected as bridging units extending across the gap between the collector rolls 4 and 6, and their predominant orientation is at an angle to the faces of the product 10.

The density characteristics of the zones 14 and 15 also are different. In the surface layers 14 the filamentary components are packed closely together. The bridging portion 15, however, is in the form of a network having substantial open spaces between fibrous components.

The thickness of the fabric 10 is determined by the spacing between the collector rolls 4 and 6. Normally it will be found desirable to mount the rolls so as to permit adjustment of their relative positions, so that fabrics of different thicknesses may be produced. The gap between the opposed surfaces of the rolls 4 and 6 should be in the range of from about ⅛ inch to about 4 inches in thickness, and more preferably within the range from about ½ inch to about 2 inches.

Although a single spray-spinning nozzle is indicated in FIG. 1, the use of a plurality of such nozzles is preferable in some instances. Such an embodiment of the invention is illustrated in FIG. 3. This embodiment includes a plurality of spray nozzles 16 disposed in alignment with the gap between a single pair of opposed collector rolls 18. The rolls are mounted in a frame 20. A motor 22 on the frame drives a belt 24, which passes over a pulley on the end of the shaft for the lower roll 18, and the shaft for the upper roll 18 is connected with the lower roll by a crossed belt 26. Thus, the rolls 18 rotate in opposite directions when the motor 22 is operating.

The positional relationships between the several nozzles 16 are such that the spray patterns 30 from adjacent nozzles overlap in the collection zone. With this arrangement, a wide nonwoven fabric 32 is produced during operation of the equipment. This fabric 32 is similar to the fabric 10 described above in connection with FIG. 1 in the sense that it is made up of surface layers connected together by bridging fiber components. In the widthwise direction the fabric 32 may be substantially uniform from zone to zone across the fabric or it may be characterized by zones that are different from one another.

Transverse uniformity is achieved when the overlap between the spray patterns from adjacent ones of the nozzles 16 is sufficient to assure delivery of substantially the same amount of filamentary material to all portions of the collector zone. On the other hand, where density variations in the transverse direction are desired, the overlap between adjacent spray patterns from the nozzles 16 may be such as to cause the delivery of filamentary material to one portion of the collector to be greater than the delivery of filamentary material to another portion thereof.

Still other effects may be achieved in the embodiment of FIG. 3 by supplying fiber-forming materials having different characteristics to various ones of the several nozzles 16, and/or by using nozzles having extrusion orifices of different sizes or different rates of delivery. The spray patterns of several nozzles 16 may overlap to the extent of intermingling filaments during formation of the mat or fabric. Different materials may be sprayed simultaneously from the nozzles to produce a fabric having a uniform dispersion of filaments of different materials. The nozzles may be arranged along an axis perpendicular to the width dimension of the gap between the collector rolls, or any other suitable arrangement of nozzles may be used. By arranging a plurality of nozzles side-by-side along an axis parallel to the width of the gap, a nonwoven fabric 32 may be produced that is characterized by the presence of longitudinally extending portions or stripes having different visual or structural properties. For example, in some applications for the high-bulk nonwoven fabrics of this invention it is desirable that the fabrics be provided with a defined flex-zone susceptible of being bent more readily than other portions of the fabric. Such a zone can be formed by spray-spinning from one of the nozzles **16** filamentary material of significantly smaller average denier than the filamentary material issuing from the other nozzles **16**.

Although the collector units in the embodiment described above have been shown as including opposed rolls having smooth surfaces, it will be understood that the invention is not limited to this particular form. Suitable collector surfaces may be provided by endless belts, webs or the like, and the collector surfaces may be rough or provided with protruding portions or embossed patterns. Also, laminated products may be formed by collecting the filamentary material directly upon sheets or webs passed over one or both of the collector rolls and causing the filamentary material to adhere to such sheets or webs, as by heating or bonding treatments.

In the embodiment illustrated in FIG. **4**, an endless belt **34** is mounted over rolls **36** and **38** and over an idler roll **40** which supports the intermediate portion of the belt **34**. An opposing belt **42** is mounted between the rolls **44** and **46** and passes over an idler roll **48**. Presser rolls **49** are mounted adjacent the idler rolls **40** and **48** in position to bear against and guide the exterior surfaces of the belts **34** and **42**.

A spray spinning nozzle **50** corresponding to the nozzle **2** in FIG. **1** is positioned opposite the gap between the belts **34** and **42** in the zone of the rolls **36** and **44**. Collection of the filamentary material issuing from the nozzle **50** takes place in much the same manner as in FIG. **1**. Portions of the filamentary material are deposited directly upon the surfaces of the belts **34** and **42** and other portions bridge back and forth across the gap. As the rolls rotate in the directions indicated by the arrows, the collected material is removed from the collection zone in the form of a nonwoven fabric structure.

In the area between the front rolls **36** and **44** and the idler rolls **40** and **48**, the fiber contacting flights of the belts **34** and **42** are substantially parallel. These surfaces maintain the newly formed nonwoven fabric to the dimension of the gap and serve to minimize the mechanical loads imposed on the material.

The nonwoven fabric product delivered by the belts **34** and **42** in the zone of the idler rolls **40** and **48** is similar to the product **10** produced as described in connection with FIG. **1**, and this product may be used as such if desired. However, FIG. **4** illustrates an additional operation that may be carried out in forming other novel products in accordance with the invention. Severing means **52** is disposed between the belts **34** and **42** just beyond the idler rolls **40** and **48**. This severing means **52** may be in the form of a stationary cutter blade, a reciprocating saw or blade, a band saw, or other suitable fiber-severing device.

The level of the severing means **52** is such that it contacts the fiber components bridging the vertical space between the surface layers of the fibrous body being advanced by the belts **34** and **42**. The severance of these bridging components across the entire width of the body yields two separate fabrics **54**. These move with the diverging flights of the belts **34** and **42** in the zone between the idler rolls **40** and **48** and the back rolls **38** and **46**, and they are individually guided away by suitable means **55** for separate collection.

Each of the nonwoven fabrics **54** is pilelike in character. The surface layer of the filamentary material deposited on one of the belts of the collector constitutes a firm backing structure **56**, and the severed portion **57** of the bridging fiber components extends from the backing in flexible pilelike configurations. These nonwoven pilelike fabrics may be produced economically and they are suitable for use in many of the environments where conventional pile fabrics have been employed heretofore.

In producing these pilelike fabrics it is not essential that a belt-type collector unit be employed. Apparatus having roll-type collector units as shown in FIGS. **1–3** can be used for the production of pile fabrics by disposing suitable severing means downstream of the gap between the rolls. Generally, however, it will be found preferable to utilize a belt-type collector, because belts such as those shown at **34** and **42** in FIG. **4** provide relatively large surface areas for frictionally advancing the fibrous assembly against the severing means **52**.

Still other aspects of the invention are illustrated in connection with FIGS. **5–7** of the drawings. FIG. **5** illustrates schematically an apparatus setup in which relative lateral movement is effected as between spray-spinning nozzle means and a collector unit.

A pair of opposed collector rolls **58** are disposed in front of spray-spinning means **60**, with the spray pattern **62** from the nozzle **60** intersecting the gap between the rolls **58**. The rolls **58** are mounted for rotation in a frame **64**, and the frame **64** is carried by rails **66**. The rolls **58** are relatively long, as compared with the diameter of the spray pattern **62** at the collection zone. However, the frame **64** is shifted back and forth along the rails **66** to position different portions of the roll surfaces in the path of the filamentary material issuing from the nozzle means **60**.

The traversing motion of the rolls **58** may be accomplished through the use of any suitable drive means. In FIG. **5** the drive means has been illustrated as including a link **68** pivotally connected at one of its ends to a pin **70** projecting from a belt **72** and at its other end to a bracket **74** on the frame **64**. The belt **72** is disposed beneath the level of the frame **64** and is trained about rolls **76** and **78**. The roll **78** is driven from a motor **80** through suitable coupling means such as a belt **82**. Upon operation of the motor **80**, the roll **78** is rotated to move the belt **72** through an endless path. As the pin **70** moves along the belt path, the frame **64** traverses back and forth along the rails **66** in front of the nozzle **60**.

In this embodiment, it is preferred that a substantial degree of bonding at crossover points between contacting filament sections be achieved in the collection zone. This normally presents no difficulty because it usually is feasible to regulate the extrusion temperature and/or the spacing between the nozzle **60** and the collector rolls **58** so that the filamentary material reaches the collection zone while surface portions thereof are still sufficiently tacky to permit self-bonding at crossover points. However, a suitable binder or plasticizer composition may be sprayed into the collection zone along with the filamentary material if desired.

As the zone of intersection between the spray pattern **62** from the nozzle **60** and the collection rolls **58** shifts back and forth across the width of the collection unit, a series of thin sheetlike fibrous subassemblies **84** are formed. Each of the subassemblies is generally U-shaped in configuration, as suggested in FIG. **6**, and within each sheet the filament is randomly arrayed in the sense that, if the U-shaped subassembly were flattened into a plane, incremental portions of the filament would be found extending in substantially all directions within that plane.

Of course, the U-shaped subassemblies **84** formed on successive traverse of the collector units are not entirely separate from each other. At the end of one traversing motion and the beginning of the next traversing motion, only a single body of filamentary material is collected, so that successive ones of the subassemblies **84** actually are united at the lateral margins of the fabric. This effect ordinarily is a desirable one, but in those instances where a high degree of widthwise product uniformity is required, the lateral margins of the fabric may be trimmed off.

The upper and lower end portions **86** of adjacent U-shaped subassemblies overlap substantially. These are interentangled somewhat and are packed together to form the surface layers at the top and bottom of the product collected. Portions of at least three and preferably five or more of the subassemblies **84** should be present at any given vertical cross section through one of the surface layers. In these surface layers, the fiber components are generally parallel to the faces of the fabric.

The midportions **88** of adjacent ones of the U-shaped subassemblies **84** are spaced apart from each other. This effect is indicated in FIG. **6** and in the photograph designated FIG. **7**. The amount of the spacing is subject to variation, depending upon the characteristics desired in the products produced. Control over the spacing between the midportions **88** of successive U-shaped subassemblies **84** may be effected by suitable regulation of the surface speeds of the collector rolls **58** in relation to the rate of traverse of the rolls along the rails **66**.

The midportions **88** of the subassemblies extend at angles to the faces of the nonwoven fabrics. Thus, although the fiber components are randomly arrayed within the individual subassemblies **84**, the nonwoven fabric as a whole exhibits different fiber orientations in different zones across the thickness of the fabric. That is to say, the predominant orientation of the fiber components in the surface layers is parallel to the faces of the fabric, while the predominant fiber orientation in the middle of the fabric is at an angle to the fabric faces. This angle varies, of course, from 90° on down as one follows a U-shaped subassembly from its midpoint toward a surface layer of the fabric.

Fabrics of the type illustrated in FIG. **7** may be used as such or they may be subjected to further treatments. Particularly interesting results may be obtained, for example, by slitting a fabric of this type through the midportions **88** of the U-shaped subassemblies. This slitting action may be carried out as described above in connection with FIG. **4**.

Each of the two fabrics resulting from the slitting operation is characterized by a base or backing structure having a plurality of leaflike assemblies of fiber components protruding therefrom. The leaflike bodies may be flexed independently of each other in a manner somewhat analogous to that of the pile of pile fabrics of a more conventional nature. However, the transverse continuity of the leaves gives these fabrics structural properties not heretofore attainable.

An example will serve to further illustrate the invention. This example outlines conditions used in the production of a nonwoven fabric adapted to be employed as a pad under a carpet.

EXAMPLE

Polypropylene pellets (Hercules Pro-fax 6423) were fed to a MOdern Plastics Machinery extruder (1×24 inches) having three zones maintained at 205°, 275° and 335° C., respectively, and extruded through a nozzle having a circular orifice of 0.028-inch diameter at a material temperature of about 332° C. The nozzle included three 0.082-inch ports disposed annularly about the orifice, directing streams of stream along paths the axes of which converged toward but did not intersect the extended axis of the extrusion orifice, the closest point to convergence lying about 1 inch from the orifice. The stream had a line pressure of 16 p.s.i.g. and a temperature of 410° C.

The ports were spaced about 120° apart the axes were arranged to provide an opening of about one-sixteenth inch in diameter therebetween at the point of closest convergence, through which the extrudate passed. The extrudate was thereupon attenuated and whipped about with little or no breakage, and taken up while still at least tacky and capable of self-bonding at a point 8-½ **inches from the die orifice on a pair of rolls of** 4-inch diameter, counterrotating at about 0.11 r.p.m. and providing a ½-inch nip therebetween through which the material passed in a band of about 3 inches width.

About 1 lb./hr. of material was extruded and taken up as about a 25 oz./yd.^{2} batting containing principally endless continuous filament ranging in diameter from about 15 to about 55 microns with the changes in diameter having a relatively long period on the order of several inches. The average diameter was about 24 microns, indicating some preponderance of the lower diameters.

The resulting fabric had the firmness, deformability and resilience qualities required of carpet underlayments.

Of course, in normal production operations it is desirable to produce carpet-padding material in wide strips. A suitable carpet underlay may be provided as 4×8 foot sheets or as a continuous matting of e.g., 9-foot width rolled about 4 to 6 inches cores, by utilizing a multiplicity of spray nozzles or traversing the takeup surface. The underlayment may also be sprayed directly onto a carpet backing with a suitable binder or may even constitute the secondary backing itself. Such an embodiment is particularly desirable where the carpet backing comprises a similar synthetic polymer such as polypropylene as in the woven form described in U.S. Pat. No. 3,110,905.

The products of this invention are suitable for many other uses. Since the bulky structures are produced directly from an extrusion operation, they are relatively inexpensive. Furthermore, the structures produced in accordance with this invention do no necessarily contain any adhesive and therefore may be more resistant to solvent action than conventional nonwoven fabrics. The unsevered fabric may be used for insulation, ceiling tile, air filters and other articles. The pilelike structures produced from the severed fabric may be used for low-cost floor covering, in clothing apparel, and other articles. While this invention has been illustrated and described in several embodiments, it is recognized that variations and changes may be made therein without departing from the invention as set forth in the claims.

What is claimed is:

1. A nonwoven fibrous product comprising a series of similar fibrous subassemblies each made up of randomly arranged fiber components bonded together in the form of a thin sheet, each of said subassemblies including top and bottom zones extending generally parallel to the surfaces of the product and an intermediate zone extending angularly with respect to the surfaces of the product, the top and bottom zones of a plurality of adjacent ones of said subassemblies being disposed in overlapping and contacting relation to each other to provide the product with surface strata of substantial density, and major portions of the intermediate zones of adjacent subassemblies being spaced apart from each other.

2. A nonwoven fibrous product according to claim **1** wherein adjacent ones of said subassemblies have a common lateral margin in which the fiber components of said subassemblies are united with each other.

3. A nonwoven fabric according to claim **1** wherein said subassemblies each comprises a thin generally U-shaped sheet of randomly disposed, intertangled fibers, the end portions of adjacent sheets being in overlapping relationship and being adhered together to form generally parallel upper and lower surface strata, the remaining portions of the sheets being in spaced relationship with adjacent sheets to form a resilient core between the upper and the lower surface strata.

4. A nonwoven fabric according to claim **3** wherein the end portions of at least three of said sheets are disposed in overlapping relationship at any given section of said surface strata.

5. A nonwoven fibrous product according to claim **1** wherein said nonwoven product is embossed.

6. A nonwoven fabric having a face zone and an adjacent zone integral with said face zone and an additional face zone integral with said adjacent zone and spaced from the first-mentioned face zone, all of said zones being formed from the same fiber but with the fiber components so arranged as to give said zones different characteristics, the predominant orientation of the fiber components in substantially any given small portion of said face zones being substantially parallel to the surface of said small portion, and the predominant orientation of the fiber components in said adjacent zone being at an angle to said surface.

7. A fibrous product according to claim **6** including flexible preformed sheet material and a fibrous body formed on said material and adhering thereto, said fibrous body including said face zones and said intermediate zone, said face zones each having a thickness no greater than one-third the thickness of the fibrous body and being made up of fiber components randomly arranged in generally planar assemblies, said sheet material being disposed on the side of at least one of said face zones opposite said intermediate zone.

8. A nonwoven fabric according to claim **6** wherein said fabric is an integral fibrous body, said face zones being of greater density than said intermediate zone between said face zones, said face zones each having a thickness no greater than one-third the thickness of the fibrous body and being made up of fiber components randomly arranged in generally planar assemblies, said intermediate zone being made up of fiber components bridging the space between said face zones and connected to said face zones.

9. An integral fibrous body according to claim **6** wherein said fiber components are portions of a substantially continuous synthetic filament.

10. A nonwoven fabric according to claim **6** in which said fiber is in the form of a plurality of substantially continuous filaments and in which each filament occupies a widthwise portion of the fabric less than the entire width of the fabric, the widthwise portion of the fabric occupied by an adjacent filament being in overlapping relation with the widthwise portion of the fabric occupied by an adjacent filament, and adjacent filaments being entangled and bonded together in those portions of the fabric where they overlap.

11. A nonwoven fabric according to claim **6** in which said fiber is in the form of a substantially continuous filament occupying the entire width of the fabric with portions of said filament being bonded to each other to form sheetlike subassemblies of generally U-shaped configuration, in which said face zones are formed by overlapping and contacting end portions of said subassemblies, and in which the remaining portions of said subassemblies form said adjacent zone and are spaced apart from each other to provide a resilient core between said face zones.

12. A nonwoven fabric according to claim **6** in which the fiber components in said face zone are bonded together to provide a backing layer and in which the fiber components in said adjacent zone form a pilelike layer extending upwardly from said backing layer.

13. A nonwoven fabric according to claim **12** in which fiber components of said pilelike layer are bonded together to form a plurality of thin, longitudinally spaced-apart, sheets protruding upwardly from said backing layer and extending laterally of the fabric.