

April 5, 1955

I. S. NESS ET AL

2,705,686

LATERALLY EXTENSIBLE NON-WOVEN FABRIC

Filed May 7, 1952

3 Sheets-Sheet 1

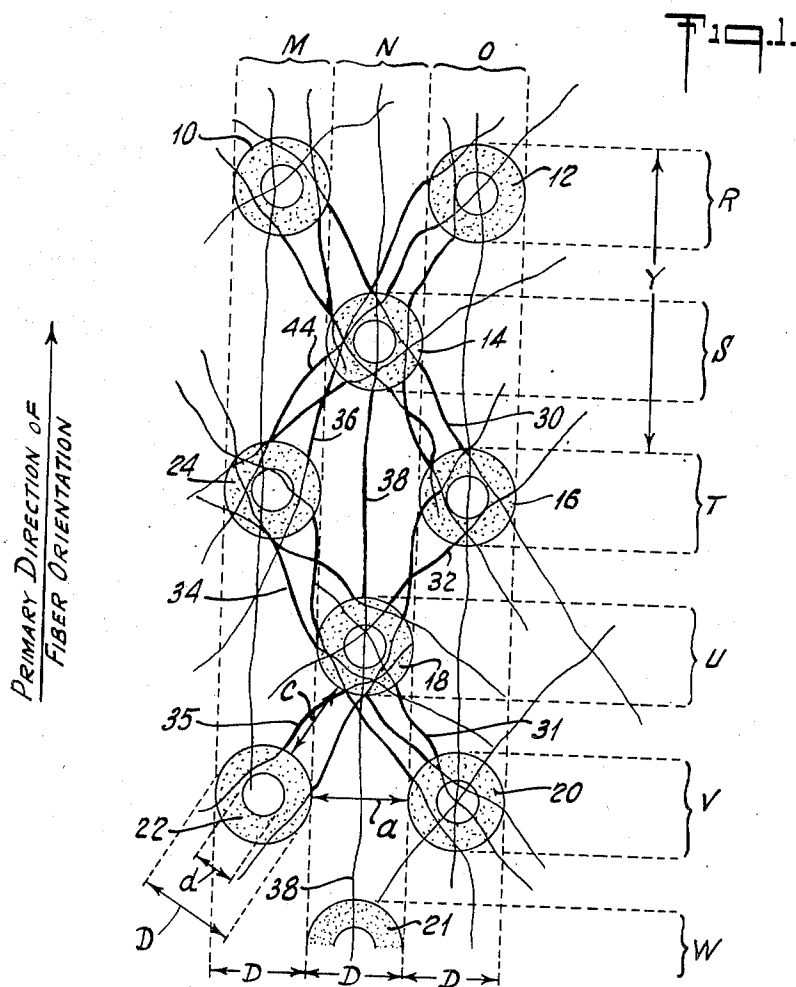
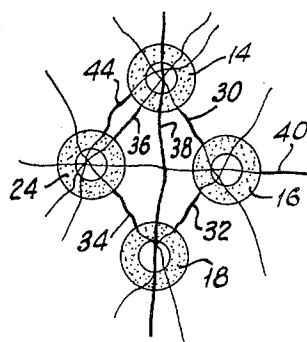


Fig. 1a.



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3 Sheets-Sheet 2

Fig. 2.

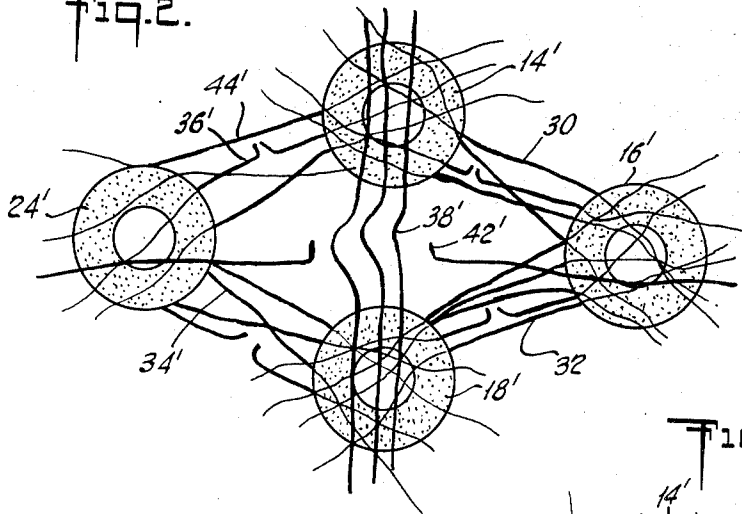


Fig. 2a.

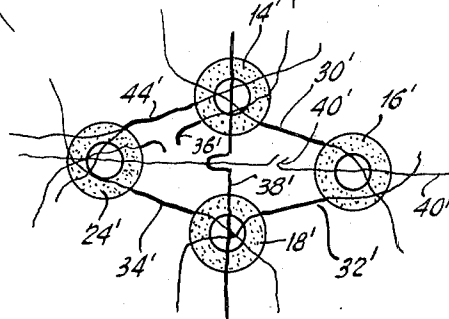


Fig. 3.

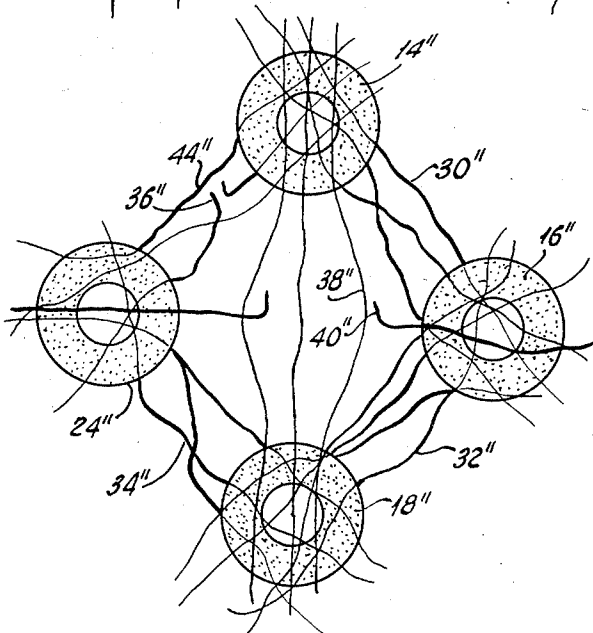
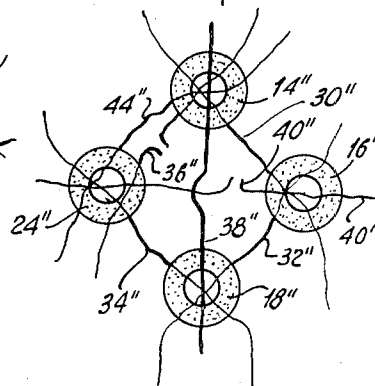


Fig. 3a.



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3 Sheets-Sheet 3

Fig. 4.

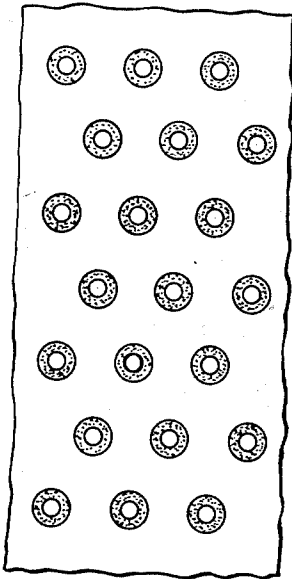


Fig. 5.

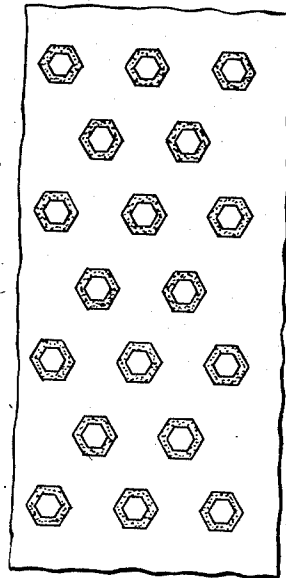
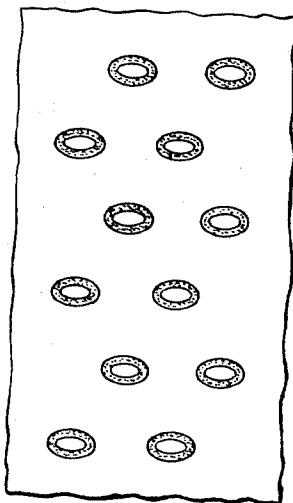


Fig. 6.



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1

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LATERALLY EXTENSIBLE NON-WOVEN FABRIC

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Application May 7, 1952, Serial No. 286,482

2 Claims. (Cl. 117—38)

The present invention relates to textile fabrics and their manufacture. More particularly, it is concerned with so-called "nonwoven" fabrics, i. e., fabrics produced from textile fibers without the use of conventional weaving or knitting operations. Although not necessarily limited thereto, the invention is of primary importance in connection with "oriented" nonwoven fabrics composed of unspun textile fibers, the major proportion of which are substantially "parallelized" or oriented predominantly in one direction.

Nonwoven fabrics of various types have become increasingly important in the textile field during the past decade, primarily because of their low cost of manufacture compared to fabrics formed by weaving or knitting spun fibers. Nonwoven fabrics are particularly suitable for applications where launderability is not a prerequisite, or low cost is an important consideration, especially in the case of finished products that are used once and then discarded, as for example in the manufacture of sanitary napkins; surgical dressings; casket liners; or disposable table napkins, hand towels, diapers, drapery fabrics, and the like.

Nonwoven fabrics are conventionally manufactured at the present time by producing a more or less tenuous web of loosely associated textile fibers disposed in sheet form (using any one of a variety of well-known procedures) and then subjecting the web or sheet to a bonding operation to anchor or bond the individual fibers together. The conventional base material for nonwoven fabrics is a web comprising any of the common textile-length fibers, or mixtures thereof, the fibers varying from approximately one-half inch to two inches in staple length. These fibers are customarily processed through any suitable machinery (e. g., the conventional cotton card) to form a web or sheet of loosely associated fibers, weighing from 100 to 4000 grains per square yard. This essentially two-dimensional web or sheet of fibers is produced continuously with the fibers substantially parallelized or oriented in the "machine direction," i. e., the direction in which the product moves continuously from the sheet-forming machine. In such a web the degree of fiber orientation may range from about 70% to about 90%; in other words, from about 10% to about 30% of the fibers will be "non-oriented" or more or less randomly disposed while the remainder will be substantially parallelized in the machine direction.

The bonding operation by which such a web is converted into a fabric is accomplished in several different ways. One method is to impregnate the web over its entire width with various well-known bonding agents such as natural or synthetic resins. Such over-all impregnation produces a product of good longitudinal and cross strength. However, the product tends to be stiff and boardlike, possessing more of the properties of paper or board than of a woven textile fabric; for these reasons, over-all impregnated webs are unsatisfactory for many applications as textile fabrics.

It has also been known to print nonwoven webs with continuous straight or wavy lines of binder extending transversely across the web. The resulting nonwoven fabric, as exemplified by the product disclosed in the Joshua Goldman Patent 2,039,312 and sold by the present assignee under the trade-mark "Masslinn," is far more satisfactory as a textile fabric in that the softness, drape and hand of the material more nearly approach those of a woven textile fabric. However, the Joshua Goldman type of product in the cross direction is characterized by

2

relatively low elongation properties, low degree of elasticity, and a low energy absorption to break. For these reasons, the product upon stressing in a direction transverse to the direction of fiber orientation, tends to rip, tear or develop irregular holes due to irregular rupture of the continuous binder lines.

More recently discontinuous or "spot bonding" has been proposed. This type of bonding involves the use of tightly spaced, symmetrical solid dots or spots arranged in staggered relationship and covering more than half of the total surface of the web, as exemplified by the product disclosed in the Esther Goldman Patent 2,545,952. Such "spot bonded" products are flexible when the fabric is folded upon itself. However, flexibility has been attained at the sacrifice of other desirable properties. Thus, the Esther Goldman type of product, although excellent in respect to cross strength, has little if any "give" or elasticity in the cross direction; practically no cross elongation characteristics; low energy absorption to break in the cross direction; and lacks the desired degree of textile properties of hand, loft and softness.

Generally speaking, the object of the present invention is to provide a nonwoven fabric that obviates the foregoing disadvantages. Expressed affirmatively, one of the objects of the invention is the provision of a nonwoven fabric characterized by the desirable properties of "spot bonded" fabrics but substantially free of the undesirable properties thereof.

A more specific object is the provision of a nonwoven fabric characterized by the following combination of properties:

1. High cross-elongation;
2. Good cross-strength;
3. Relatively high energy absorption to break in the cross-direction; and
4. Excellent textile-like properties such as softness or "hand," flexibility or "drape," and the three-dimensional appearance or "loft" characteristic of woven fabrics.

A further object is a nonwoven fabric that is additionally characterized by an inherent capacity to develop a more pronounced loft, softness and drape when stretched in the crosswise direction.

Another object is the provision of an oriented nonwoven fabric having a high capacity for fiber reorientation when stressed in the cross direction, with further improvement of its textile-like properties due to the development of a uniform puckering of some of the fibers coupled with a substantially uniform rupturing or pulling out of other fibers from the binder areas and the formation of a uniformly napped or downy-like surface.

Still another object is a nonwoven fabric characterized by a pronounced loft, drape and hand; a uniformly open, net- or lace-like reticular pattern, and a uniform downy-like surface.

Still another object is the provision of a novel binder pattern or design that is capable of imparting the foregoing properties to an unbonded oriented textile web.

An additional object is to provide a simple, commercially feasible, and economical method of manufacturing improved nonwoven fabrics having the properties mentioned above.

Other objects and advantages of the invention will become apparent as the description progresses in connection with the several figures of the drawing wherein:

Figs. 1 and 1-A are plan views, on an enlarged scale, diagrammatically showing relaxed portions of a nonwoven fabric having a binder pattern in accordance with one embodiment of the present invention;

Figs. 2 and 2-A are similar views, also on an enlarged scale, diagrammatically showing portions of the fabric of Figs. 1 and 1-A when uniformly stretched or extended beyond its elastic limit in a direction transverse to the direction of fiber orientation;

Figs. 3 and 3-A are similar views, also on an enlarged scale, diagrammatically showing portions of the fabric of Figs. 1 and 1-A, after the fabric has been uniformly stretched or extended beyond its elastic limit in a direction transverse to the direction of fiber orientation, and then permitted to relax;

Fig. 4 is a plan view, approximately full scale, showing the geometry of the binder pattern involving annu-

lar binder areas in accordance with a preferred embodiment of the present invention;

Figs. 5 and 6 are similar views, also approximately full scale, showing an alternative binder pattern involving, respectively, hexagonal-shaped "rings" and oval-shaped "rings" in accordance with other embodiments of the present invention.

In accordance with the present invention, a web of oriented textile fibers containing a substantial but minor proportion of non-oriented fibers is bonded into a fabric by means of a novel binder pattern that may conveniently be characterized as "lazy tong multiannulate bonding." Such a binder pattern is composed of a multiplicity of discrete, physically separated, cyclic or ringlike binder areas infused locally into the body of the web and so interrelated as to coact with each other and with some of the non-oriented fibers of the web to form "lazy tong parallelograms" whose diagonals are, respectively, parallel and transverse to the primary fiber orientation of the web. The resulting fabric exhibits a high degree of lateral extensibility, acting on the lazy tongs principle.

The base web from which our laterally extensible fabric is produced consists of a sheet of loosely associated textile fibers that are, in the main, predominantly parallelized or substantially oriented in one direction. Such a web may be formed by using a conventional cotton or wool card or a garnetting machine. In handling the web formed by either of these conventional sheet forming devices, it is preferable to avoid, insofar as possible, those operations (e. g., long drafting) that tend substantially to increase the degree of fiber parallelization, and desirable to employ those operations (e. g., across drafting) which tend to reduce somewhat the degree of fiber parallelization. The optimum web in accordance with the present invention desirably contains a substantial but minor portion of non-oriented fibers in addition to the predominantly oriented fibers which constitute the major component of the sheet. When such a web is examined microscopically it is evident that very few, if any, of the fibers are 100% straight and 100% parallel, in the precise Euclidean sense of these terms. Nevertheless, when such a web is viewed macroscopically (e. g., with the naked eye), it will clearly be evident that it is comprised in the main of fibers oriented predominantly in one direction and also that it contains a substantial but minor proportion of non-oriented or random fibers more or less loosely interfelted or interlaced with the oriented fibers.

In bonding such a web according to the present invention, discrete, physically separated binder areas are utilized, each area consisting of an inherently elastic, compressible, closed linear figure or curve. The closed figure may be polyhedral (e. g., octagonal), cyclic (e. g., oval), ring- or doughnut-shape in configuration and preferably but not necessarily should have a single point of symmetry. In any event, all such cyclic structures, whether perfectly symmetrical or substantially so, will hereinafter be termed "annular." Each discrete, annular area may be likened to an "atoll" or coral reef island comprising, so to speak, a small "lagoon" of unbonded lengths of parallelized fibers entirely surrounded by binder, the "atoll" itself being an "island" in a "sea" of otherwise unbonded lengths of fibers.

The atoll analogy suggested above is helpful in describing the geometry of the binder area. However, like all analogies, it has its limitations: it is not useful in explaining the "dynamics" or "kinematics" of the system when an annulate bonded oriented web according to our invention is subject to extensional stress. Accordingly, in the ensuing discussion, the atoll analogy will be used at times in describing the system in a state of rest, while entirely different analogies will be suggested in describing the system in motion. It should be clearly understood, however, that the present invention is in no way dependent upon the aptness or inaptness of any analogies that are herein suggested for the purpose of relating the invention to more familiar concepts.

Referring now particularly to Fig. 1, the over-all binder pattern of the present invention comprises a multiplicity of discrete, physically separated, inherently elastic, annular binder areas or atolls 10, 12, 14, 16, 18, 20, 22 and 24 infused locally into the body of an oriented web containing a substantial but minor proportion (e. g., 15% or 40%) of randomly disposed fibers in addition to the oriented or parallelized fibers constituting the

major component (e. g., 60% to 85%) of the web. In order to attain otherwise desirable textile-like properties and cross-extensibility in the bonded fabric, the total lateral surface of the binder areas should cover not substantially more than about 35% of the total lateral surface of the web.

The binder areas, "atolls" or "islands" are uniformly spaced from each other preferably in parallel courses or rows (R, S, T, U and V) extending across the web in a direction preferably transverse to the direction of orientation of the fibers. The binder areas in one course (e. g., T) should be positioned in staggered relationship with respect to corresponding areas in the courses immediately above and below it (e. g., S and U) and so dimensioned and positioned relative to each other that the transverse width (D) of any given binder area or "island" (e. g., 18) is substantially equal to the transverse distance (a) between the adjacent-most binder areas (e. g., 24 and 16; 22 and 20) in the rows of courses (e. g., T and V) immediately above and below the area in question. This is most conveniently accomplished by disposing annular binder areas of equal diameter not only in horizontal courses or rows (R, S, T, U and V) extending across the oriented fibers of the web, but also in a series of contiguous columns (M, N and O) that are substantially parallel to each other and to the direction of fiber orientation as shown in Fig. 1.

By virtue of the foregoing relationship between binder areas, each area is separated from every other area by fiber lengths that are otherwise substantially unbonded. Nevertheless, as shown in Fig. 1, because of the non-oriented fibers in the base web, each annular area (e. g., 18) is "hinged," "jointed" or "articulated" with respect to the two adjacent-most areas (e. g., 16 and 24, 20 and 22) in each of the adjacent courses, (e. g., T and V), i. e., in the courses immediately above and immediately below the area in question. "Articulation" between corresponding areas in adjacent courses is effected by lengths of non-oriented fibers interconnecting the binder areas in question. The right hand side of any given binder area (e. g., 18) will thus be "jointed" or "articulated" with the left hand sides of the closest areas (e. g., 16 and 20) in the courses (T and V) immediately above and immediately below it. The "joint" or "articulation" consists of a bundle or group of non-oriented fibers (e. g., 31 and 32). On the left hand side of the given binder area (e. g., 18) the relationship of the fibers to the given area and to the adjacent-most "atolls" immediately above and below it will, in effect, be the mirror image or reflection of the relationship on the right hand side of the same area. In other words, a bundle or group of non-oriented fibers (e. g., 34 and 35) will interconnect the left side of the given area (18) with the right side of the two areas (22 and 24) immediately above and below it and closest to that side. The middle portion of the given binder area will be connected by a bundle of parallelized or oriented fibers (e. g., 38) to the closest areas (14 and 21) in the second courses (S and W) above and below it. Thus, the third bundle (38) comprising parallelized fibers hinged interconnects corresponding areas (14 and 21) in alternate courses, passing through the central portion of each binder area.

In order to understand the dynamics or kinematics of this binder arrangement, a wholly different analogy may be helpful. When an annulate bonded web as described above is stretched in a crosswire direction, its action is suggestive of a "parallel-motion mechanism" or "parallelogram-type device" familiar as "lazy tongs," "collapsible gates" or the "pantograph" device utilized in drafting. Referring to Fig. 1, in the web of the present invention, the non-parallel fibers (e. g., 30, 32, 34 and 36) interconnect the binder areas (e. g., 14, 16, 18 and 24) in three adjacent courses (S, T and U) to form a parallelogram; the fibers act as the linkages in a "collapsible gate" acting on the "lazy tong" principle, while the annular binder areas (14, 16, 18 and 24) act, in effect, as the pivotal joints holding the links of the parallelogram together. As the web is stretched in the cross direction the bundle of parallel or oriented fibers (38) interconnecting corresponding areas (14 and 18) in alternate courses (S and U) tends to pucker. This puckering of oriented fibers (38) connecting diagonally opposed points (14 and 18) in the parallelogram (14, 16, 18 and 24) tends to restrain further extension of the collapsible

gate and to restore the extended collapsible gate to its original unextended position.

Regardless of the aptness of the analogy suggested above, the individual annular binder areas and the fibers comprising the web are so positioned and interrelated as to interact in a novel manner when the web is stressed in a crosswise direction. By virtue of this mode of interaction, an extraordinary combination of properties is attainable in the bonded web, including among other characteristics, high cross elongation coupled with good cross strength and high energy absorption to break. By virtue of the character of the base web and the great proportion of lateral surface that is free of binder area, these properties are attained to a high degree without sacrifice of textile-like properties such as hand, drape or loft. In addition, when the thus bonded web is stretched in the crosswise direction beyond its elastic limit, the web expands uniformly into an open, lacelike, reticular fabric.

An interesting and profound change in fiber orientation takes place as the web is extended. Three types of fiber reorientation occur as the fabric is stretched in the cross direction. In the first place, the oriented fibers interconnecting corresponding "islands" in alternate courses form the "diminishing diagonals" of the collapsing parallelograms. As the parallelogram continues to collapse, such fibers tend to pucker or bend out of the original plane of the fabric, forming a uniformly puckered or quilted appearance. In the second place, the non-oriented fibers forming the sides of the collapsing parallelogram come under varying degrees of tension; i. e., the "slack" is taken up (compare, e. g., fibers 36 and 44 in Fig. 1-A). That portion of the length of each such fiber which forms a side of the parallelogram changes in its angular relation to the direction of primary fiber orientation. This action tends to increase the extent or degree to which such non-oriented fibers are interlaced or interfelted with the oriented fibers. In addition, some of the non-oriented fibers forming the sides of the collapsing parallelogram may rupture (e. g., 44' in Fig. 2): when the fabric is permitted to relax, the ends formed by rupture of such fibers tend to bend out of the plane of the fabric, producing a napped or downy-like "peach fuzz" effect (e. g., 36" in Fig. 3). In the third place, those non-oriented fibers which happen to lie along the lengthening diagonal of the collapsing parallelogram (e. g., 40, Fig. 1-A; 40', Fig. 2-A; and 40", Fig. 3-A) will also be ruptured. The ends of these broken fibers also tend to move out of the plane of the fabric, forming a uniform nap or down. The puckered oriented fibers, (e. g., 38, 38' and 38"; Figs. 1 and 1-A, 2 and 2-A, and 3 and 3-A, respectively) plus the ruptured non-oriented fibers (e. g., 36' and 42' in Figs. 2 and 2-A; 36" and 42" in Figs. 3 and 3-A) impart a high degree of loft and softness to the resultant fabric, rendering it especially attractive in applications where these properties are important.

Referring again to Figs. 1 and 2, the number of non-oriented fibers forming the sides of the collapsible parallelograms will depend partly upon the number of fibers which deviate from the theoretically perfect condition of straightness and parallelism, but which, nevertheless, from a macroscopic point of view may be said to be substantially or predominantly oriented or parallelized; and partly upon the relative ratio of non-oriented or random fibers to oriented fibers. Thus an increase in the proportion of random fibers to oriented fibers will tend to increase the cross strength of the bonded fabric. Accordingly, we prefer to use a base web containing a substantial although minor proportion of non-oriented fibers. For that reason it is desirable to use a base web that has been cross drafted before being bonded.

The elongation of the fabric is influenced by the inter-island distances (Y and C, Fig. 1) and the dimensions of the annular areas (D and d). In general, the greater the inter-island distances Y and C, the greater the elongation.

Energy absorption to rupture is indicative of the amount of work necessary to rupture the fabric and is approximately equal to one-half the breaking load times the elongation. In general, previous fabrics have been characterized by either high strength and low elongation, or low strength and high elongation. Both of these give relatively small and approximately equal work loads of

energy absorption capacity. The present invention permits substantially increasing the work load by achieving a proper balance of cross strength and elongation. This property is controlled by the factors effecting the two properties discussed above.

Development of a uniform lace-like or reticular pattern obtained by uniformly stretching a web bonded in accordance with the invention is effected by the same factors mentioned in elongation, i. e., the inter-island distances. The uniformity depends upon the symmetry of the applied pattern, while the inter-island distances determine the extent of openness, or lace-like structure. The more extendible, the more open the network.

The qualitative textile fabric properties of flexibility, drape, softness, and three-dimensional effect, or loft are enhanced by increasing the inter-resin area distances (Y and C) and by increasing the ratio of the internal diameter (d) to the external diameter (D) of the annular binder area. A basic factor in softness is of course the extent to which the lateral surface of the web is covered by binder. Generally speaking, desirable textile properties are attained to a substantial degree only if substantially less than about 35% of the lateral surface of the web is bonded. With the present binder pattern the binder may be, and preferably is, used sparingly, with the bonded areas covering 5-25% of the total area of the web or sheet. The three-dimensional effect, or loft, is enhanced by the ability of the fabric to be extended crosswise with development of a uniform lace-like structure. The amount of loft, or three-dimensional effect is controlled by the shape of the reticular fabric structure which is, in turn, controlled by the interannular distances and the ratio of non-oriented to oriented fibers in the web. Increasing the proportion of oriented fibers tends to increase the "quilting effect." Increasing the proportion of non-oriented fibers tends to increase the "peach fuzz effect."

Referring now to Figs. 4, 5 and 6, these are plan views, roughly full scale, showing a portion of a typical annulate binder pattern in accordance with the invention. In Fig. 4, the annuli are completely symmetrical rings. In Fig. 5 the annuli are substantially symmetrical hollow hexagons. In Fig. 6 the annuli are slightly oval in configuration. In each figure the central portion of each annulus is substantially free of binder, with the result that the properties of the original web are not detrimentally affected by the binder in respect to softness, drape and hand. Thus the annulate binder pattern imparts cross strengths, cross elongation and cross elasticity to a web that originally was devoid of these characteristics, with minimal loss of the textile-like properties of the original web. In addition, during manufacture, the annular binder areas afford a substantial saving of binder and render it much simpler to "doctor" the intaglio print roll that conveniently may be used to imprint the binder pattern on the web.

In carrying the present invention into practice, any of the conventional web-forming, web cross-drafting, web-printing and drying operations, well known in the art, and any of the conventional binder media of the prior art may be used. Typical procedures and binder media of the general type applicable in the practice of the present invention include those disclosed in the Joshua Goldman Patent 2,039,312 or the Joseph Goldman Patent 2,407,548, or the Esther Goldman Patent 2,545,952. These operations and media, being well known and conventional, need not be described herein, since reference may readily be made to the prior art, including the patents mentioned.

Assuming the use of an engraved printing roll of the intaglio type (as described, for example, in the Esther Goldman patent) the surface of the print roll is engraved with a pattern such that, when the binder carried in the binder-receiving recesses is transferred to the base fabric, it imprints thereon an annulate binder pattern corresponding to any one of those shown in the several figures of the drawings or their equivalents.

The dimensions of the individual binder areas and the inter-island distances may, of course, vary within wide limits. However, a typical fabric illustratively embodying the principles of the present invention may have, for example, the dimensions shown in the table.

7
TABLE

Code No.	Basic Type	Pattern Geometry—Dimensions			
		D (In.)	d (In.)	Y (In.)	C (In.)
A.....	Fig. 4....	0.095	.003	0.31	0.075
B.....	Fig. 4....	0.135	.007	0.38	0.075
C.....	Fig. 4....	0.16	.003	0.44	0.06

Having now described the invention in specific detail and indicated the manner in which it may be carried into practice, it will be readily apparent to those skilled in the art that innumerable variations, applications, modifications and extensions of the basic principles involved may be made without departing from its spirit or scope. Thus the fabrics of the present invention may be laminated with other fabrics, with paper or with other materials, or employed in a host of ways that will be readily apparent to the skilled artisan. We therefore intend to be limited only in accordance with the appended patent claims.

The term "textile fibers" as used herein includes the conventional textile fibers which are capable of being spun into yarn and woven into cloth. Generally speaking, this includes fibers whose average length is about one-half inch or longer.

We claim:

1. A web comprising a major proportion of textile fibers oriented predominantly in one direction and a minor but substantial proportion of random fibers, said oriented and random fibers being bonded together to form a fabric by a uniform binder pattern occupying less than about 35% of the lateral surface of said web and comprising a multiplicity of annular areas of binder, uniformly separated from each other by substantially unbonded fibers and arranged uniformly in contiguous non-overlapping columns that are substantially parallel to each other and to the direction of fiber orientation, the individual annuli being interconnected effectively to form interconnected parallelograms that are collapsible

on the "lazy tongs" principle when the fabric is stretched in a direction normal to the direction in which said major proportion of fibers is oriented, the interconnection between said annuli substantially comprising unbonded fiber lengths composed predominantly of the non-oriented fibers of the web.

2. A laterally extensible web of carded fibers containing a major proportion of parallelized fibers and a substantial but minor proportion of non-parallelized fibers, said fibers being bonded together into a laterally extensible fabric by means of a discontinuous but articulated multi-annulate binder pattern infused locally into the body of the web and occupying less than 35% of the lateral surface thereof, said pattern comprising a multiplicity of annular binder areas uniformly disposed in staggered, non-overlapping relationship with respect to each other, in parallel courses extending substantially normal to said parallelized fibers, each annular area being separated from every other area by substantially unbonded areas of the fabric, but articulated into a "lazy tongs" structure with the adjacent-most areas in adjacent courses by a group of unbonded fiber lengths composed predominantly of the non-parallelized fibers of the web, said web being characterized by a substantial capacity for elongation when stressed in a direction normal to said parallelized fibers, with the development of a uniformly open lacelike reticular structure.

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