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A. F. SMITH

2,298,071

STIFFENED FABRIC

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Fig. 1.

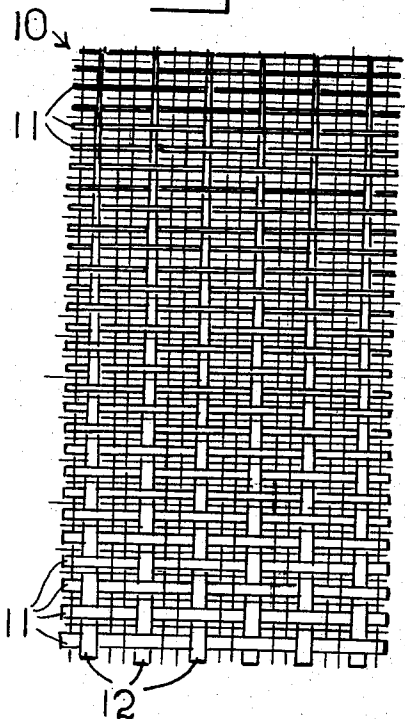


Fig. 2.

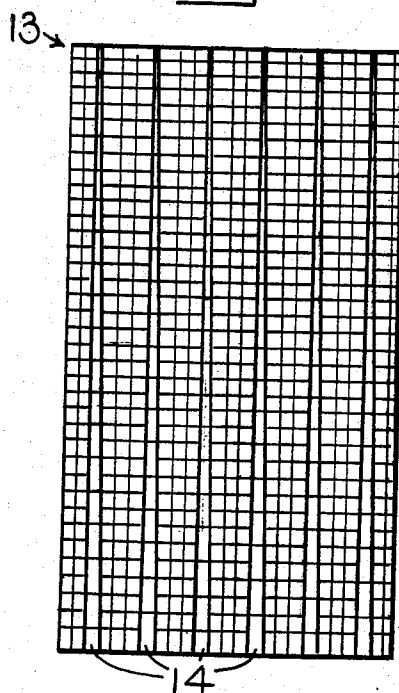
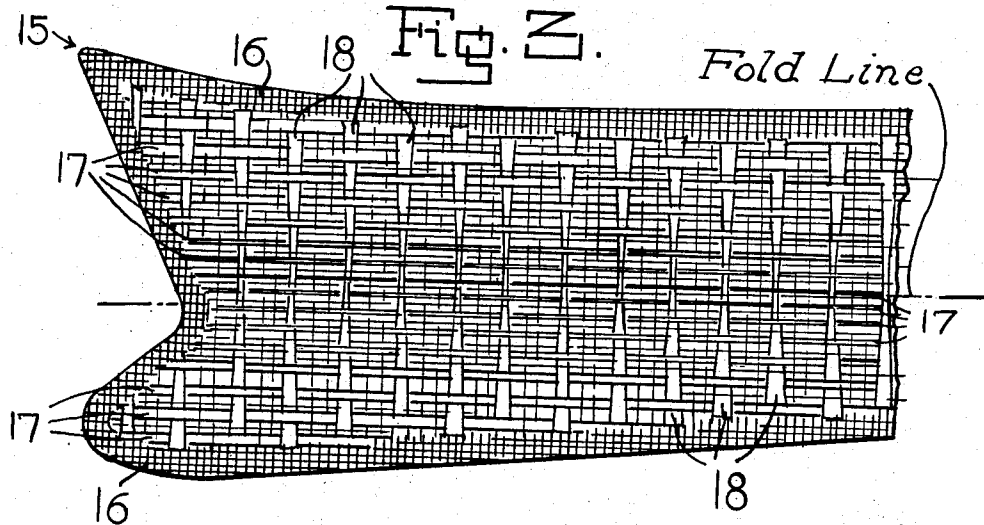


Fig. 3.



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UNITED STATES PATENT OFFICE

2,298,071

STIFFENED FABRIC

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Application October 18, 1940, Serial No. 361,783

14 Claims. (Cl. 139—420)

This invention relates to improvements in stiffened or stiffening fabric, and more particularly to methods of imparting to fabric material predetermined stiffness in predetermined areas.

The present application is a continuation-in-part of my application Serial No. 283,082, filed July 6, 1939, which is a continuation-in-part of my abandoned application Serial No. 232,683, filed September 30, 1938.

Heretofore horsehair has been widely used as a stiffener element for fabrics, e. g., such as are employed for interlinings in coats, dresses, upholstery, or the like. Horsehair, however, is essentially a staple fiber and works out of the fabric so that its projecting ends cause considerable discomfort to the user. Besides causing such discomfort, the displacement or total removal of the particular strand results in weakening and loosening of the fabric structure, with consequently increasing likelihood of tearing and fraying thereof. Moreover, horsehair often is excessively bulky and does not dye satisfactorily, even white horsehair being non-uniform in its dyeing characteristics. In addition, the use of horsehair as a filler is attended by technical difficulties in fabrication which make special procedures necessary.

Various expedients have been tried, for the purpose of circumventing the aforesaid difficulties, or some of them. For instance, artificially formed threads of cellulose derivatives have been employed. But these entail many of the same disadvantages as the natural horsehair. In particular, they are very deficient in that their stiffness is greatly reduced by moisture, and as a rule they are excessively brittle. Furthermore, their resilience is very poor. Nor has impregnation of threads formed from natural materials met with appreciable success, in imparting increased rigidity to fabrics into which the same have been incorporated.

In the case of collars, in particular, the problem of imparting adequate stiffness to the fabric and at the same time avoiding the disadvantages inherent in the use of starch or other cementitious materials has become so acute that it has been proposed to use wires in the said fabric. Such wires, however serviceable they may be in general, necessarily are more or less deficient by reason of their metallic nature and their consequent inability to withstand repeated flexing, or corrosion.

This invention has as an object not only the minimization of the foregoing disadvantages but also the achievement of certain novel advantages hereinafter pointed out. More specifically, this invention has as a further object the construction of a stiffened or stiffening fabric in which monofilaments of any desired length are employed as the stiffener elements, the said monofilaments having

a higher degree of stiffness than polyfils of similar composition and overall denier, but being capable of readily assuming a relatively permanent set when subjected to simple and economical treatment such as specified hereinafter. A still further object of the invention is the provision of a simple and economic method for varying the stiffness or flexibility of the fabric structure in any desired degree or gradation, as for instance by gradually increasing the rigidity from areas where greater flexibility is desired toward areas where greater rigidity is desired.

The foregoing objects, as well as others which will appear either expressly or impliedly hereinbelow, are accomplished by incorporating in the fabric, or employing in re-enforcing association therewith, monofilaments consisting of or comprising synthetic linear polyamide such as specified hereinafter, the diameter or denier of the said monofilaments, as well as their modulus of bending elasticity, being chosen or varied in accordance with the relative degrees and locations of the rigidity or flexibility desired in the fabric. Usually the said monofilaments, which may be employed as warp or filler, or both, e. g., are between 50 and 600 denier. For many ordinary purposes, also, a range of from 20 to 150 ends per inch will be found satisfactory.

Where the completed fabric is to be employed as a garment interliner, e. g., for stiffening coats, the monofilaments preferably should possess a degree of intrinsic stiffness corresponding to a modulus of bending elasticity, which presently will be defined, of at least 0.30×10^6 lbs./sq. in. at 50% relative humidity and at least 0.10×10^6 at 100% relative humidity, or preferably of at least 0.40×10^6 and 0.15×10^6 lbs./sq. in. at 50% and 100% relative humidity, respectively. The said intrinsic stiffness of the monofilaments, in terms of the said modulus, is determined by placing the monofilament to be tested across two supports, one inch apart, applying a known weight on the monofilament midway between these supports, and observing with a traveling microscope the deflection of the monofilament one minute after the application of the weight. From the value of this deflection, the intrinsic stiffness of the monofilament in terms of the said modulus is determined by means of the following equation:

$$E = \frac{4WI^3}{3\pi D^4 Y_c}$$

where E=the said modulus of bending elasticity, W=the weight in pounds, I=the length in inches between the supports, D=the diameter of the monofilament, and Y_c =the deflection of the center in inches.

Further, the degree of elastic recovery from bending should be at least 85%, in such case, and the monofilament should be of such a composition as

not to exhibit softening or retraction even when subjected to temperatures as high as 100° C. The said degree of elastic recovery from bending may be measured by wrapping a 600 denier monofil ten times (angle 3600°) around a mandrel 0.111 inch in diameter, holding the monofil in this position for two minutes, releasing the monofil, and then measuring the angle retained, i. e., the angle of residual deformation (α), after the monofil has ceased to recover. The degree of elastic recovery then may be determined by means of the following equation:

Recovery in per cent=

$$\frac{(3600^\circ - \alpha) \times 100}{3600^\circ}$$

Although in some instances no variation of flexibility or rigidity will be desired, preferred embodiments of the invention making provision for such variation utilize the distinctive ability of the aforesaid polyamides to be extruded into relatively large monofilaments of whatever diameter, within wide limits, may be desired. Thus, the polyamide stiffener monofilaments may be disposed in mutually parallel relationship, each having a constant diameter throughout its length, but with the diameters of the different monofilaments becoming successively smaller as the areas are approached where greater flexibility is desired, and successively larger as the areas are approached where greater rigidity is desired. Or, monofilaments fashioned with a gradual taper, in accordance with processes described in my hereinabove cited parent application, may be placed in mutually parallel juxtaposition, with their tapers all pointing in the same direction. In such case, the cross-sectional sizes of the monofilaments being the same for any given distance from the line formed by their minimum cross-sections, the rigidity of the fabric will uniformly increase as the said distance increases, and will uniformly decrease as the said distance decreases.

The polyamides which are suitable for use in this invention are of the types described in U. S. P. 2,071,250, 2,071,253, 2,130,523, and 2,130,948. It may be observed, in passing, with respect to the structure of the polyamides, that they contain amide groups



where R is hydrogen or a monovalent hydrocarbon radical) as an integral part of the main chain of atoms in the polymer. It also may be observed that in these polyamides the average number of carbon atoms in the segments of the chain separating the amide groups is at least two. Accordingly, in this specification and the claims appended hereto, the expression, synthetic linear polyamide, is to be understood as applying to polyamides not only belonging to types described in the aforesaid patents, but also coming within the limitations pointed out in this paragraph. It will be apparent therefore that in the claims the expression "synthetic linear polyamide" is not intended to include non-carbon-amide polymers, or polymers such as are formed by the condensation of urea and formaldehyde.

As indicated in the above-mentioned patents, the high molecular weight synthetic linear polyamides may be formed into useful filaments which upon application of tensile stress are permanently stretched or "cold-drawn" into pliable, strong fibers which show by characteristic X-ray diffraction patterns that they are microcrystal-

line in structure and are oriented along their fiber axes. Orientation may also be effected by the application of compressive stress such as that which takes place in the process of cold rolling as described in Miles Ser. No. 170,470, filed October 22, 1937, and assigned to the assignee hereof, or by a combination of tensile and compressive stresses such as takes place in the die drawing which is described in Brubaker Ser. No. 284,556, filed July 14, 1939, also assigned to the assignee hereof.

The conditioning or setting treatment which is given to the filaments after their orientation is an important factor in determining their properties. Thus, subsection of the monofilaments or the fabric containing them to heat treatment in the presence of water or other mild swelling agent therefor, greatly improves their ability to recover from wrinkling or other deformation encountered in normal use. This operation may be carried out while the fabric is stretched on a tentering frame or on mandrels, or by pressing the fabric between formed surfaces in the presence of steam or hot water. At 100° C. treatment for about one-half hour generally is desirable. At higher temperatures treatments for shorter periods of time may be utilized, however. For further details of this setting treatment, reference may be had to Miles U. S. P. 2,157,119.

The drawing, Figs. 1-3, illustrate the invention both in its broader aspects and in certain of the preferred embodiments mentioned hereinabove.

Fig. 1 shows a fabric 10 with which there are incorporated parallel stiffener monofilaments 11, each of which has a constant diameter throughout its length, but the diameters of which, as a group, are of successively smaller sizes. At right angles to the monofilaments 11 are tapered monofilaments 12, these being aligned in parallel relationship with each other and having their tapers pointing in the same direction. Both by reason of the successive decrease in the diameters of the monofilaments 11 and the parallel tapering of the monofilaments 12, the stiffness of the fabric gradually recedes from a maximum, as depicted at the foot of the drawing, to a minimum, as depicted at top of the drawing.

Fig. 2 shows a fabric 13 in which gradual decrease of rigidity is effected merely by the parallel juxtaposition of tapered stiffener monofilaments 14.

Fig. 3 shows a collar 15 having a conventional collar fabric 16 with which there are associated parallel, constant diameter monofilaments 17, the same having diameter sizes which successively decrease as proximity to the fold line increases. At right angles to the monofilaments 17 are tapered stiffener monofilaments 18, which taper both from above and below the fold line to a minimum diameter at the fold line. It will be noted that Fig. 3 represents a particular adaptation of the stiffened fabric of Fig. 1, the maximum flexibility and minimum rigidity being provided in the region of the fold line of the collar, and the minimum flexibility and maximum rigidity being provided at the portions farthest therefrom.

Slippage at the intersections may be prevented by subjecting the fabric to pressure in the presence of steam or hot water to give a permanent crimp to the monofilaments at the points of intersection. Or, adherence between the monofilaments and the rest of the fabric may be effected by the application of adhesives, or solvents for the polyamide of which the monofilament is formed or for both the said polyamide and the material of the fabric.

A still further expedient for preventing slip-

page involves the incorporation of a melting point depressor in the surface polyamide, at the points where the monofilaments cross each other or cross other filaments or threads with which adherence is desired. Subjection of the fabric containing the polyamide monofilaments to a temperature above the resultant lowered melting point of the said surface polyamide, but nevertheless below the melting point of the rest of the polyamide, consequently causes melting of the polyamide at the said surfaces but not at other points; which melting suffices to effect the said adherence without impairing any pre-existent orientation of the other portions of the monofilaments. As a rule, substances which function as plasticizers for the polyamide will suffice as such melting point depressors, e. g., phenols, or aryl sulfonamides boiling above 200° C. The incorporation of the melting point depressor conveniently may be effected merely by applying a solution of the same in an inert solvent, as, e. g., a saturated 50% aqueous ethyl alcohol solution of phenol, to the surface portions of the monofilaments corresponding to the desired points of adherence.

Although the drawing shows straight monofilaments only, it will be understood that the stiffener monofilaments of the invention, whether or not tapered, may be disposed in any desired manner in the fabric structures. It also will be understood that for some constructions the monofilaments advantageously may be wrapped with polyfilaments of cotton, nylon, or other fibers prior to the weaving or other fabric-forming operation. Usually, the monofilaments are most advantageously incorporated in the wrap.

The following examples are illustrative of the invention:

Example I

A 10-mil (500 denier) polyhexamethylene adipamide oriented monofilament is prepared by the usual process of extrusion, quenching, and cold-drawing. A fabric then is constructed, using lengths of this monofilament as the filler element (20 ends per inch) with a 600 denier cotton yarn as the warp (45 ends per inch). The resulting fabric is "set" by boiling in water for one-half hour, while being held under tension. The setting process greatly improves the ability of the fabric to recover from wrinkling or other deformation encountered in normal use.

Example II

A 7.5-mil (300 denier) oriented monofilament is prepared from polyhexamethylene adipamide in the usual manner, care being taken that the drawn filament is not exposed to high temperatures or brought in contact with hot water or steam until the fabric is in its final form. The setting of undesirable permanent kinks or wrinkles thus is avoided. A fabric is constructed, using lengths of this monofilament as the filler (65 ends per inch) with a 400 denier cotton warp (60 ends per inch). The fabric is steam pressed to set it in its final form.

Example III

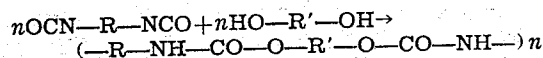
A monofilament is prepared which is in all respects similar to that of Example I, except that it tapers gradually from a maximum diameter of 0.015 inch to a minimum diameter 0.005 inch, at 4-inch intervals along its axis. The taper is imparted in accordance with the process of Example I in the hereinabove-cited application, Ser. No. 283,082, of which this application is a continuation-in-part. A fabric then is constructed, using the said monofilaments as the warp (40 ends per inch). Cotton denier

yarn, of 600 denier, also is used as warp (40 ends per inch), being disposed in alternating relationship with the aforesaid monofilaments, and in addition is employed as filler (40 ends per inch). After subjection to the setting treatment described in Example I hereinabove, this fabric shows marked ability to recover from deformation. On being cut along the line connecting the thick sections of the warp, the pieces exhibit a gradual decrease in stiffness from the margin containing the maximum diameter ends of the 4-inch monofilaments to the center and an increase toward the opposite margin. These pieces are suitable for the manufacture of collars as shown in Fig. 3.

In addition to filaments formed from polyhexamethylene adipamide, those prepared from polyhexamethylene sebacamide as well as from polydecamethylene sebacamide have been found especially useful in the practice of the invention, since they also have a high modulus of bending elasticity, and one that decreases relatively little upon subjection of the fabrics to conditions of high humidity. Filaments made from other polyamides of the types described in the hereinabove-cited patents likewise may be used, however, e. g., filaments derived from 6-aminocaproic acid polymer, and from interpolyamides.

Instead of the polyamides mentioned hereinabove, which are obtainable from bifunctional polyamide-forming reactants alone, there also may be used linear polyamides which are obtained by including with the polyamide-forming reactants from which the polyamide is prepared, other bifunctional reactants, such as amino alcohols, glycols, and hydroxy acids. Notwithstanding the fact that these products contain ester linkages, they still may be referred to as polyamides, since they contain a plurality of amide linkages in the main chain and retain many of the desirable properties of the simple polyamides. In general these polyester-amides, like the simple synthetic linear polyamides, do not possess fiber-forming properties unless they have an intrinsic viscosity above 0.4, where intrinsic viscosity is defined as in U. S. P. 2,130,948. Polyamides having an intrinsic viscosity between 0.6 and 2.0 are particularly suitable for use in the practice of this invention.

A further type of polyamide suitable for use in preparing the monofilaments of the invention consists of the polyurethanes which are obtainable by reacting diisocyanates with glycols, the reaction involved being represented as follows:



wherein n is an integer and R and R' are divalent organic radicals which may be identical or different.

It is within the scope of the invention to employ monofilaments which have been modified by the addition of resins, cellulose derivatives, pigments, or agents added for the purpose of increasing the stability of the polymer when exposed for long periods to sunlight or elevated temperatures. Among such stabilizing agents are phenothiazine, phenyl- α -naphthylamine, β -naphthylamine, diphenyl guanidine, and nonheat-hardening resins of the phenol-formaldehyde type such as fusible, soluble resins prepared from p-tertiary-butylphenol and formaldehyde with the aid of an acid catalyst. Resins contribute materially to stiffening the monofilaments and consequently increase their utility.

The products of this invention are especially

useful as garment re-enforcing and stiffening fabrics. When so used, they not only minimize or avoid altogether the hereinabove-mentioned disadvantages of the prior art materials, while at the same time providing a number of new and unique advantages, but also, as brought out in, and in connection with, Figs. 1 and 3 in particular, lend themselves to an exceedingly simple solution of the problem of avoiding "edges" between the stiffened portions and the non-stiffened portions of garments such as coats, collars, girdles, brassières, or the like. Heretofore this problem has elicited many efforts toward solution, but all of the prior proposals of which the applicant is aware call for expedients and operations which are costly and cumbersome, as compared with the solution depicted in the aforesaid drawing.

Particular fields of usefulness for fabric structures such as those shown in the drawing, i. e., where the avoidance of such "edges" is of especial importance, include shoe counters, where flexibility advantageously decreases gradually from the lowermost to the topmost portions, and stand-up fabric bags—e. g., cloth golf bags—where the necessary stiffness of the monofilaments, for maintaining the walls in a vertical position, decreases gradually from the lowermost to the topmost portions of the bag. Likewise, in the case of flags, the expedient of having maximum stiffness in the portions of the flag fabric nearest the flag-pole, and gradually decreasing stiffness at points of increasing distances therefrom, can be put into effect very conveniently by utilizing, as the fabric, textile material such as shown in Fig. 1 or in Fig. 2. Flags so fabricated unfurl more easily and more gracefully, other things being equal, than conventional flags.

As regards collars, in particular, it may be observed that, if desired, the horizontal constant diameter monofilaments 17, of Fig. 3, e. g., may be selected and placed so as to have those of greatest rather than least diameter in closest proximity to the fold line, with the respective diameters becoming successively smaller, at increasing distances therefrom. Or, still further relationships of widely varying scope easily can be effected, in respect of the arrangement of the tapering and/or the constant diameter monofilaments. Usually, however, a design will be chosen which, like that shown in Fig. 3, is calculated to facilitate the operation of turning a shirt collar up, before tying of a necktie in place, and turning the shirt collar down, after such tying; i. e., so as to minimize the wrinkling usually involved or threatened in such operations. It is to be noted, in this connection, that where the necessary stiffness in collars is secured by means of this invention, rather than by means of starch, e. g., the collars are substantially non-wilttable in use, even in the hottest weather.

Over and above their special usefulness in the elimination of the "edges" in question, according to the methods set forth hereinabove, the stiffener monofilaments of the invention exhibit outstanding superiority over prior art fabric stiffeners, generally, and consequently are appropriate for use in a wide variety of materials in addition to those already mentioned, e. g., in neckbands, shirt fronts, hats, necktie interlinings, and upholstery fabrics, as well as in mechanical fabrics such as belting and press cloths. Thus, for instance, the said fabrics generally will be found particularly well adapted for application where hair cloth heretofore has been em-

ployed, e. g., as garment interliners, and as or for stiffened portions in suits, e. g., coat lapels. In short, wherever it is desired to impart a high degree of strength and resiliency to the fabric structures, the stiffener monofilaments of the invention will be found useful.

Since many apparently widely different embodiments of this invention may be made without departing from the spirit and scope thereof, it is to be understood that I do not limit myself to the specific embodiments thereof except as defined in the appended claims.

I claim:

1. A woven fabric containing, as stiffener elements, monofilaments consisting principally of synthetic linear polyamide, said monofilaments varying in their respective diameters and having heat-set crimps therein to prevent slippage out of said fabric and having a count of 20 to 150 ends per inch, each of said monofilaments having a substantially constant denier in the range from 50 to 600, a capacity for recovering from bending of at least 85%, and a modulus of bending elasticity of at least 0.3×10^6 lbs./sq. in. at 50% relative humidity.

2. The woven fabric of claim 1 in which the said synthetic linear polyamide is polyhexamethylene adipamide.

3. The woven fabric set forth in claim 1 in which the said monofilaments are present in the warp.

4. The woven fabric set forth in claim 1 in which a resin is substantially uniformly incorporated in and through the said synthetic linear polyamide.

5. The woven fabric set forth in claim 1 in which the said synthetic linear polyamide contains, in substantially uniform admixture therewith, a phenol-formaldehyde resin.

6. A woven fabric containing, as stiffener elements, monofilaments consisting principally of synthetic linear polyamide, each of said monofilaments tapering gradually from a maximum diameter to a minimum diameter and being disposed throughout one direction of said fabric with their tapers pointing in the same direction and having the small sections of said monofilaments in lateral alignment.

7. A woven fabric containing, as stiffener elements, monofilaments consisting principally of synthetic linear polyamide, each of said monofilaments tapering gradually from a maximum diameter to a minimum diameter and again to a maximum diameter, said tapered monofilaments being disposed throughout one direction of said fabric with their tapers pointing in the same direction and having the small sections of said monofilaments in lateral alignment.

8. A woven fabric containing, as stiffener elements, monofilaments consisting principally of synthetic linear polyamide, each of said monofilaments having a plurality of recurrent portions gradually tapering from a maximum diameter to a minimum diameter and again to a maximum diameter, said tapered monofilaments being disposed throughout one direction of said fabric with their tapered portions pointing in the same direction and having the small sections of said monofilaments in lateral alignment.

9. A woven fabric containing, as stiffener elements, monofilaments consisting principally of synthetic linear polyamide, certain of said monofilaments tapering gradually from a maximum diameter to a minimum diameter and being disposed throughout one direction of said fabric with

their tapers pointing in the same direction and having the small sections of said monofilaments in lateral alignment, certain other of said monofilaments having a substantially uniform diameter along their length and being disposed throughout the other direction of said fabric in substantially mutual parallel relationship.

10. A woven fabric containing, as stiffener elements, monofilaments consisting principally of synthetic linear polyamide, each of said monofilaments having a substantially uniform diameter along its length, said monofilaments varying in their respective diameters and being disposed throughout one direction of said fabric substantially in the order in which their diameters successively decrease.

11. In a stand-up container, a woven wall fabric containing, as stiffener elements, monofilaments consisting principally of synthetic linear polyamide, each of said monofilaments tapering gradually from a maximum diameter at the bottom of said wall fabric to a minimum diameter at the top thereof, said tapered monofilaments being vertically disposed in said wall fabric with their small sections in lateral alignment whereby greater stiffness is obtained at the bottom of said wall fabric than at the top thereof.

12. In a collar, a woven fabric containing as stiffener elements, monofilaments consisting principally of synthetic linear polyamide, each of said monofilaments having a substantially uniform diameter along its length, and being disposed in substantially parallel relationship with the fold line of said collar, said monofilaments having diameter sizes which successively decrease with proximity to said fold line whereby maximum flexibility is obtained at said fold line.

13. A woven fabric containing, as stiffener elements, monofilaments consisting principally of synthetic linear polyamide, said monofilaments having heat-set crimps therein to prevent slippage out of said fabric, certain of said monofilaments tapering gradually from a maximum diameter to a minimum diameter and being disposed throughout one direction of said fabric with their tapers pointing in the same direction and having the small sections of the monofilaments in lateral alignment, certain other of said monofilaments varying in their respective diameters but each monofilament having a substantially uniform diameter along its length, said last mentioned monofilaments being disposed throughout the other direction of said fabric with their diameters decreasing toward the small sections of the tapered monofilaments.

14. A woven fabric containing, as stiffener elements, monofilaments consisting principally of synthetic linear polyamide, said monofilaments having heat-set crimps therein to prevent slippage out of said fabric, certain of said monofilaments tapering gradually from a maximum diameter to a minimum diameter and being disposed throughout one direction of said fabric with their tapers pointing in the same direction and having the small sections of the monofilaments in lateral alignment, certain other of said monofilaments being disposed throughout the other direction of said fabric and having a count of 20 to 150 ends per inch, each of said other monofilaments having a substantially constant denier in the range from 50 to 600, a capacity for recovering from bending of at least 85%, and a modulus of bending elasticity of at least 0.3×10^6 lbs./sq. in. at 50% relative humidity.

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