April 18, 1950 M. HARRIS ET AL 2,504,523

FABRIC-MAKING MATERIAL

Filed May 28, 1948

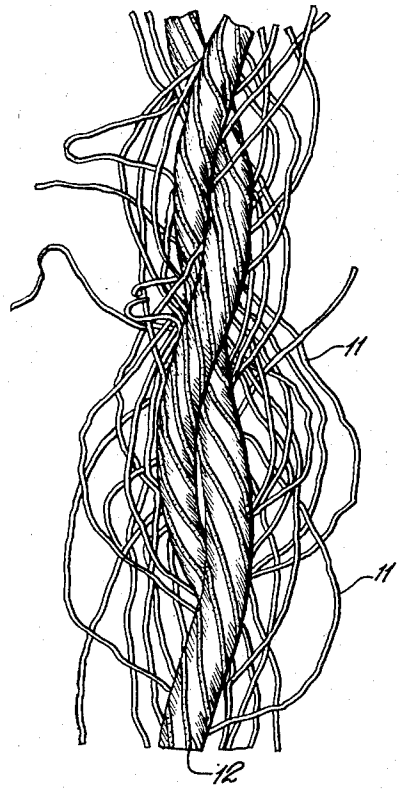



Fig. 1.

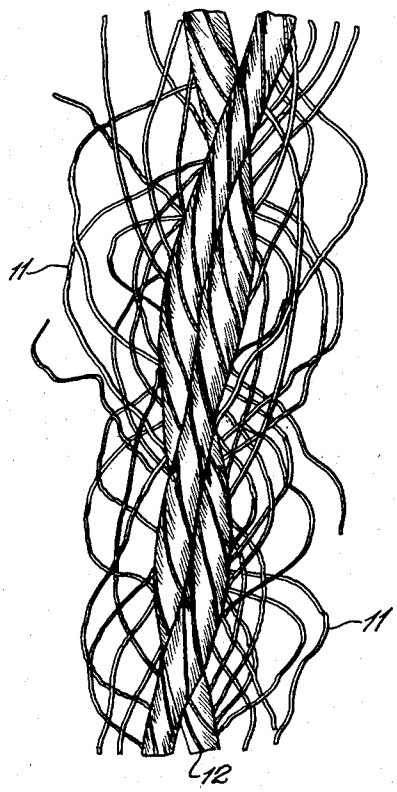



Fig. 2.

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Patented Apr. 18, 1950

2,504,523

# UNITED STATES PATENT OFFICE

2,504,523

## FABRIC-MAKING MATERIAL

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Application May 28, 1948, Serial No. 29,804

11 Claims. (Cl. 57—140)

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This invention relates to fabrics and fabric-making materials and the methods of producing such products. More especially, the invention pertains to fabrics and fabric-making materials composed of at least two kinds of textile fibers, one of which can be caused to shorten more than the other and the other of which preferably is chemically similar in composition to wool. This application is a continuation-in-part of our co-pending application Ser. No. 753,966 filed June 11, 1947, now abandoned.

An object of this invention is to impart fluffiness, increased resilience in diameter and in length and wool-like characteristics to yarns composed of at least two kinds of textile fibers one of which is preferably regenerated protein fiber. Another object of the invention is to introduce permanent warmth characteristics into such a fabric or yarn.

Heretofore bulkiness has been imparted to artificial fiber fabrics or yarns by creating a crimp or crinkle therein by shrinking the fibers or filaments comprising the yarn. In fabric or yarn produced according to the present invention bulkiness is imparted thereto by shrinking certain of the fibers to a greater extent than the remaining fibers which are preferably of protein to cause the latter fibers or filaments to assume arch-like or bowed configuration, and it is these fibers rather than the shrunken fibers which impart the added bulkiness to the yarn. The use or treatment of protein fibers in this manner is found to give a quite unique result. By virtue of having chemistry similar to wool, protein fibers approximate wool in many ways. It has heretofore been impossible, however, to attain adequate curl or crimp in protein fibers as has been done with fibers of other chemical composition. The present invention embodies a way of crimping protein fibers and at the same time putting these fibers with their chemical composition similar to wool on the outside of the yarn. The use of protein fibers has been found to have an additional unique result, in that the protein fibers respond better to the system of treatment by differential shrinkage than do other types of relatively non-shrinking fibers.

According to this invention fabric or yarn composed of at least two kinds of textile fibers is treated with water and suitable reagents at

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ordinary temperatures or with heating to effect greater contraction of the textile fibers of one kind than the other. It is desirable also to soften the uncontracted or less contracted fibers which is one of the purposes served by water. Alternately, such fabrics or yarns can be treated by heat alone to cause contraction of one kind of fiber. The contraction of the fibers which occurs is believed to result from relieving the stress developed in them during their formation. The selective contraction of one of the two or more kinds of fibers in the fabrics or yarns results in shortening of the yarn with the uncontracted fibers being bent into arch-like loops, thereby forming air pockets which make the yarn fluffy and wool-like and give to it a desired warmth characteristic in some embodiments.

Although this result can be obtained with fabric or with single yarns composed of a blend of at least two kinds of fibers, best results in yarn are obtained by the treatment of two or more yarns plied together in such manner that the ply twist is the reverse of the individual yarn twist, and that thereby the twist forces are balanced. Also, the fiber shortening treatment should be effected substantially without tension on the fabrics, yarns or fibers. This requirement may be satisfied in treating yarn by soaking a skein of the plied yarn in a bath containing water and the proper reagents, although the plied yarns may be treated in the bath by use of a continuous system providing the yarns are fed from feed rollers to take-up rollers in such manner that there is no tension on the yarns except that resulting from the weight thereof and the unsupported extent of the plied yarns is kept small.

Examples of fibers suitable for shortening and the general conditions under which they can be caused to shorten are:

| Fiber | Conditions |
|---|---|
| Cellulose acetate<br>Cellulose acetate-butyrate<br>Vinyl chloride-vinyl acetate copolymer (Vinyon).<br>Vinyl chloride-acrylic nitrile copolymer (Vinyon N).<br>Vinylidene chloride polymer | Heat or organic non-ionic swelling agents. |

Other suitable fibers may be chosen from the

class of fibers which in their formation have unrelieved strains potentially capable of causing shortening when the fiber is softened by heat or swelling agents. Examples of such other suitable synthetic fibers are:

Polyamides (nylons)
Polymers of acrylic nitrile (Fiber A)
PC chlorinated vinyl chloride polymer
Polyethylene
Terylene (polymer of ethylene glycol and terphthalic acid)
Polyurethane
Polyvinylidene

Further suitable fibers are natural fibers with a structure such that shortening can be produced by swelling agents. Cotton is an example of a natural fiber which can be caused to shorten by swelling with aqueous alkali.

These potentially shortenable fibers are, according to this invention, mixed and blended in the individual yarns with protein fibers which do not shorten, or do not shorten as much, under the treatment to which the blended yarns are to be subjected. Fibers of the same chemical composition which have been stretched to different extents in manufacture are capable of differential shrinkage.

The essential discovery of this invention is that a unique increase in bulkiness, wooliness, thermal insulating capacity, and resilience or elasticity, both in length and diameter, can be secured by causing a non-protein component of a blended yarn to shorten substantially more than a protein component. A second discovery is that where the treatment is in the yarn rather than in fabric the effect is more advantageously realized in 2-ply or multiple ply yarns in which the ply twist opposes and balances the singles twist, rather than in singles yarns or unbalanced ply yarns.

In the specification and claims, the term yarn is intended to mean any yarn-like structure, whether single or multiple ply, comprising any permutation or combination of continuous or spun fibers as well as any combination of lengths thereof, blends, mixtures of sizes (or denier) or twists as to amount and direction. The twists may be right or left with any combinations of plying in the same or opposite directions of the components. The filaments or fibers may be natural or synthetic, of any lengths or combination of lengths, any thickness or deniers or combinations of thickness, any fibers or combinations of fibers. Such components may have different twists or fiber content than others and the treatment may be applied to one component before or after it is combined with the other component for use or further treatment. Blends or combinations of fibers may contain various gradations of differential shrinkage because of the fiber content of various forms or sizes of the fibers. The fibers may be thick and thin or crimped. Any of the yarns made according to this invention may be combined with any continuous filament yarns before processing, for use, or for further processing, and twist and direction of ply may be selected to obtain various results desired for use or processing.

Other objects, novel features and advantages of this invention will become apparent from the following specification and accompanying drawings, wherein:

Fig. 1 illustrates a two-ply yarn embodying the invention, and



Fig. 2 is a view of the yarn taken at right angles to Fig. 1.

The yarn shown in the drawing consists of two plies each of which comprises two kinds of fiber of which one kind has been contracted more than the other, which consists chemically of regenerated protein fiber. The protein fibers which have either not been contracted or only slightly contracted are labeled 11 and are shown plain while the fibers which have been substantially contracted are labeled 12 and are shown stippled.

In the production of the single yarns, whether to be used as singles or to be plied, potentially contractile fibers and protein fibers either substantially non-contractile or potentially less contractile than the first-mentioned fibers are blended together by the usual methods of mixing and spinning. It is desirable that the blend be as uniform as possible from point to point along the yarn but satisfactory yarns are produced by any spinning system, conventional or as modified in modernized versions. Upon subjecting the fabric or yarn to the fiber-shortening treatment later to be described, a decrease in yarn length results, the number of turns per inch is increased and some of the non-shortening protein fibers form loops or arches running around the central core. The ends of these arches are anchored by the penetration of the protein fibers into the central core which is composed of both kinds of fibers with the shortened fibers in substantially the same kind of helical arrangement as in the untreated yarn but somewhat increased in density and in twist. Additional anchorage of the arches may be effected by resin treatment or by adhesion effected either by heat or solvents as described in the one tine copending application of G. Bloch, Ser. No. 701,270, filed October 4, 1946, now U. S. Patent No. 2,465,996, granted April 5, 1949. If shortening is limited or prevented, or if stretching is imposed by tension, the effect is to produce a dense tight yarn with little or no increase in twist. However, if a substantial part of the potential shortening is effected and if this shortening is greater than about 5%, a bulking of the yarn by increase of twist and formation of arches is secured. At the lower degrees of shortening of yarn, the arches and bulking of each ply cause a separation or looseness of the two plies around each other. The relatively denser cores of the single yarns tend to be held apart by the arches or loops of the non-contracting or less-contracting fibers about the individual plies and this bulky structure formed by arches or bows of fibers gives the ply yarn as a whole a springiness both in diameter and length. A greater percentage of shortening results in a more compact core with the plies more tightly twisted about each other. This tighter central structure gives additional anchorage to the loops or arches of non-contracted or less-contracted protein fibers, anchoring these at points where one of the cores crosses the other as well as the usual anchorages where the fibers emerge from or penetrate into the main mass.

It is to be understood that the effects described here grade into each other and can be modified by such factors of choice as original twist in the yarn, length and diameter or denier of each kind of fiber blended, potential shortening tendency introduced in forming the fibers, maximum contractile tendency securable under the chosen method of treatment, and the portion of this maximum shortening which tension condition during treatment permit to be realized.

Effects of this kind may also be secured by treatment of the fabric.

Effects of this kind may also be secured by treatment of yarn with heat by use of a device in which the yarn is drawn from a suitable package through a conventional tension device by a pair of feed rollers from which it passes through a treatment chamber to a second pair of nip rolls, which are connected to move it at a fixed fraction (less than unity) of the peripheral speed of the feed rolls. One or both nip rolls may be covered with plush to secure light traction without crushing or flattening yarns in a hot plastic state, and take-up rolls revolving at the same peripheral speed as the nip rolls may serve for further traction after the yarn has become cool. After passing the nip or take-up rolls, the yarn is wound up on a conventional winding and package forming device. In the treating chamber, the yarn is exposed to hot air and radiant heat from the walls of a tube surrounding the yarn, which can be heated by electricity flowing through resistance wires or other suitable means. The most suitable arrangement is vertical, with the yarn passing downwards and the heater located just below the feed rolls. The heating chamber must be as short as possible to prevent tension of unsupported yarn from opposing or modifying the shortening tendency of the shortenable fiber component. Preferably the heating chamber should not exceed four inches in length. Preheating before entering the treating chamber by passing over warm surfaces or through chambers of warm air or steam are additional features useful with certain yarns in increasing the speed of treatment.

The improvement in yarns and fabrics according to this invention can be accomplished in several ways, depending on the kinds of fibers and type of effect desired. The treatment may be carried on in conjunction with dyeing the yarn or fabric. Yarns treated according to this invention may be additionally twisted after completion of the treatment either by themselves or in combination with other treated or untreated yarns. One purpose of such hard twisting would be to obtain a yarn suitable for use in making a substitute for tropical worsted, which are made of hard twisted or twist-on-twist yarns. By hard twisted yarn is meant yarn twisted hard either in singles, in plying or both, in any direction of plying. It is considered that presently made suitings and slack cloths especially spun rayon twist-on-twist and spun rayon twisted with filament rayon are suitable as substitutes for tropical worsted as the words are used herein.

*Example 1.—Heating of yarn containing cellulose acetate as potentially shortening fiber*

A two ply yarn, 2/24 worsted count, in which the ply twist balances the twist of the individual yarns, is passed through the device above described. Each strand of the two ply yarn is composed of a blend of 50% regenerated protein fiber (casein-aralac) and 50% cellulose acetate staple. The nip rolls are geared to turn at 80% of the peripheral speed of the feed rolls, allowing a 20% shortening of the yarn. The walls of the heating tube are heated to 410–420° F. by electric current and the yarn passes through the system at from 3 to 6 feet per minute. Since the maximum potential shortening of the yarn used, as determined by passing it through at a very low rate, is some 30% the operation proceeds evenly and continuously. As the yarn passes through the heated zone the cellulose acetate contracts, throwing the protein fiber into arches. The resulting yarn is 20% shorter and is more bulky and resilient.



*Example 2.—Treatment of yarns containing cellulose acetate with organic non-ionic swelling agents*

In all the subdivisions of this example, each strand of a blended two ply yarn, balanced as to twist forces, is composed of 50% cellulose acetate and 50% regenerated protein fiber prepared from the casein of milk (aralac) or from vegetable protein (peanuts or soybeans). This yarn is treated in the form of loose skeins. A skein of the yarn is immersed in the treating mixture for 5 minutes care being taken to wet all parts of the skein. The treating mixture is largely removed by centrifuging, after which the skein is washed with water to remove the remaining treating mixture and dried. With some mixtures more shortening is secured by plunging the yarn while still wet with warm reagent into warm water. The exact choice of conditions depends on economic factors, as will be appreciated by those familiar with textile processing. The skein of yarn is materially shortened by the treatment with a corresponding increase in bulkiness due to the arching of the relatively non-contracted fibers.

Many of the treating mixtures examined and found to be effective have contained water as one constituent. However, it is within the scope of this invention that organic non-ionic swelling agents in the absence of water also cause contraction of the cellulose acetate and throw the protein fibers into arches without dissolving the cellulose acetate. Nevertheless, it is preferred to use water, since water softens both kinds of fibers and is an economical diluent for the organic non-ionic swelling agents. Some of these organic materials are solvents for cellulose acetate when allowed to act for longer periods, or at higher temperatures or concentrations, but for the purpose of this invention they can be used at such concentrations and temperatures that during the time of treatment they are merely absorbed into the acetate, causing it to swell and soften rather than dissolve. In these examples, the effect of the mixtures is shown at room temperature (20–25° C.) and at the temperatures at which the lowest boiling constituent boils at normal atmospheric pressures. It will be obvious that intermediate effects will be obtained at intermediate temperatures and that more drastic effects, or effects at lower concentrations of organic swelling agent can be obtained by heating under pressure, to secure higher temperatures with low boiling reagents. The extent of the effect is indicated in the following tables by the percent of shortening as measured on a loop of yarn. The length of this loop was measured before and after treatment by placing it over a wedge of stiff cross section paper, pushing the yarn down to an approximately constant degree of tautness sufficient to just begin to bow the paper, but not to affect the measured length by more than 0.2%. In the following tables the composition of the treating mixture is indicated by volumes of each component. Each component is designated by a letter, as A=water, B=95% ethyl alcohol, 5% water (constant boiling mixture). It is to be understod that these results from actual trials are representative and that variations will occur from trial to trial with the same kind of yarn. Larger

variations will be seen in comparing yarns containing fibers from different sources, of different sizes, or with different amounts of internal strain.

*Table I*

[Water=A, B=methyl alcohol.]

| Volumes A (Water) | Volumes B ($CH_3OH$) | at 20° C. 10 minutes, per cent | at boil 5 minutes, per cent | Quality of Product at boil |
|---|---|---|---|---|
| 100 | 0 | 1 | 2 | No useful shortening. |
| 80 | 20 | 1 | | |
| 60 | 40 | 2 | | Good effect with negligible solvent action. |
| 50 | 50 | 3 | 10 | |
| 40 | 60 | 3 | 14 | |
| 30 | 70 | 3 | 18 | Good effect with increasing solvent action. |
| 20 | 80 | 3 | 20 | |
| 10 | 90 | 3 | 18 | Very slightly wiry. |
| 0 | 100 | 3 | 15 | Slightly wiry. |

This table, and judgment based on related experience, indicates that the effective range of compositions for treating at the boiling point is from 30% methyl alcohol to 90%. To reduce loss of methyl alcohol by evaporation, a temperature lower than the boiling point of this reagent (64.70° C.) is preferable. Lowering the temperature tends to reduce the effective range at the lower range of alcohol concentrations, but to extend it in the direction of higher alcohol concentrations by lessening the tendency to dissolve. For economic reasons it is desirable to use as low a concentration of organic non-ionic swelling agent as will secure the desired degree of shortening and arch formation, and therefore it is preferred to treat with less than 50% alcohol at temperatures below 64° C.

There is a certain range of compositions in which the effect is greater than on either side. If maximum shortening and bulking is desired, the treating solution must fall in the range near 80% methyl alcohol. However, the resilience and bulking secured by 10% shortening is often more desirable, and has the economic advantage of not sacrificing so much of the length and fineness of the original yarn.

Above the composition of maximum shortening effect, the shortening decreases and the tendency for the treating mixture to dissolve the cellulose acetate increases. This decrease in the tendency to shorten is interpreted as an excessive softening of the cellulose acetate so that, instead of shortening to relieve the strains imposed in forming the fibers, the cellulose acetate fibers exert insufficient shortening force or are prevented from shortening by the stiffness of the non-shortening fibers. In addition, it is conceivable that an initial shortening tendency is cancelled by the subsequent action of the non-shortening fibers on the cellulose acetate as these fibers are still further softened or reduced in size by solvent action.

The range of compositions producing maximum shortening, a given lesser degree of shortening, or solvent action, can be shifted by addition of other organic non-ionic swelling agents, to make more complex mixtures. Thus, if instead of pure methyl alcohol as component B a mixture of 100 parts pure methyl alcohol plus 5 parts ethyl acetate is used, the maximum shortening at the boil is found between 60 and 70% by volume of B, instead of near 80%.

*Table II*

[A=water, B=ethyl alcohol, 190 proof (95% alcohol, 5% water).]

| Parts A | Parts B | Shortening in percent: Room temp. 10 min. | Shortening in percent: At the boil 5 min. | Quality of product at the boil |
|---|---|---|---|---|
| 100 | 0 | 1 | 2 | no useful shortening. |
| 80 | 20 | 2 | 2 | Do. |
| 70 | 30 | | 6 | |
| 60 | 40 | 3 | 11 | good bulking and resilience without wiriness or excessive solvent action. |
| 50 | 50 | | 14 | |
| 40 | 60 | 3 | 19–21 | increasing solvent action and wiriness. |
| 30 | 70 | | 22 | |
| 20 | 80 | 4 | not measurable | excessive solvent action. Horney mass or complete removal of the cellulose acetate. |
| 10 | 90 | | | |
| 0 | 100 | 5 | | |

The effect of adding other organic, non-ionic swelling agents is involved in the industrial use of ethyl alcohol plus denaturing agents. An example of such a completely denatured industrial alcohol is "Solox" a commercial mixture composed, in the anhydrous grade used, of 100 parts by volume anhydrous ethyl alcohol to which has been added 5 parts of ethyl acetate and 1 part aviation gasoline. Comparison of the data on mixtures of pure ethyl alcohol and water with similar mixtures of denatured alcohol containing the additional swelling agent, ethyl acetate shows a shift of the point of maximum shortening from between 60–70% to about 50% by volume organic mixture.

Additional organic non-ionic swelling agents and mixtures of these have been examined and found to cause varying degrees of shortening, bulking, and increase in resilience at room temperature. A mixture composed, in parts by volume of

10 parts butyl acetate
25 parts denatured alcohol containing 5/106's ethyl acetate (Solox)
25 parts water
7.5 parts diethylene glycol

is found to produce shortening, bulking, and increased resilience on yarns soaked in it for 7 minutes at room temperature (20–25° C.), followed

by washing in water and drying at room temperature. The following results were obtained on two types of yarns, each 2 ply and balanced as to twist.

| | Yarn Composition | Equivalent Yarn Count in the Worsted System | | Percent Shortening in Length |
|---|---|---|---|---|
| | | Originally | After Treatment | |
| A | 50% regenerated milk protein fiber (Aralac)<br>50% cellulose acetate | 12.2 | 10.1 | 17 |
| B | 50% regenerated vegetable protein fiber<br>50% cellulose acetate | 17.8 | 16.6 | 10 |

These yarns all showed increases of bulkiness and resilience, but were soft and flexible with a wool-like character.

Other reagents which give similar results with cellulose acetate blends are listed below. In this listing cold means room temperature or 20° to 25° C., and hot means the boiling point of the lowest boiling member of the mixture if below 100° C., or else 100° C., if no component boils below 100° C.

| Chemical Class | Reagent used as example | Effective Conditions |
|---|---|---|
| water soluble alcohols | isopropyl alcohol | hot, 15 to 40 parts alcohol in 100 parts mixture with water. |
| glycols | ethylene glycol | at 115° C., without water plunging into warm water adds to the effect. |
| alcohol-ethers | dipropylene glycol | hot, from 40 parts to 100 parts in 100 parts mixture with water. |
| | ethylene glycol monomethyl ether ("methyl cellosolve"). | cold, 60 to 80 parts in 100 parts mixture with water. |
| | diethylene glycol monobutyl ether ("butyl carbitol"). | hot, 50–80 parts in 100 parts mixture with water. |
| acetals and formals | acetal of monomethyl ether of ethylene glycol (dimethyl cellosolve acetal). | hot, 5 to 95 parts in 100 parts mixture with water.<br>cold, 50 to 70 parts in 100 parts mixture with water.<br>hot, 10 to 60 parts in 100 parts mixture with water; also, pure reagent at 100° C. |
| ketones | acetones | cold, 35 to 50 parts in 100 parts mixture with water. |
| | methyl ethyl ketone | hot, 10 to 50 parts in 100 parts mixture with water.<br>cold, 20 to 25 parts in 100 parts mixture with water. |
| alcohol-ketones | diacetone alcohol | hot, 10 to 15 parts in 100 parts mixture with water. |
| chlorinated hydrocarbons | chloroform | cold, 35 to 60 parts in 100 parts mixture with water.<br>cold, 70 to 80 parts in 100 parts mixture with hydrocarbon solvent "varsol." |
| | ethylene dichloride | hot, 60 to 80 parts in 100 parts mixture with hydrocarbon solvent "varsol."<br>cold, 70 to 80 parts in 100 parts mixture with hydrocarbon solvent "varsol." |
| esters, water soluble | mono-acetin | hot, 50 to 60 parts in 100 parts with "varsol." |
| esters, sparingly soluble in water | ethyl acetate | cold, 25 to 50 parts in 100 parts mixture with water.<br>hot, 15 to 40 parts in 100 parts with water. |
| cyclic ethers and oxides | dioxane | added effect when used in mixtures of alcohol and water, or other solvent mixtures.<br>cold or hot in dilutions with water. |

It is also in the scope of this invention that mixtures of reagents may be used, including mixtures containing reagents which are only sparingly water soluble but which are brought into solution by other constituents. Swelling agents which are ionic may also be used, on cellulose acetate, although the swelling character arises from the organic part of the molecule. Still other reagents which can be used can be chosen from the class of reagents known to dissolve or swell cellulose acetate or the other fibers used instead of cellulose acetate.

In yarns produced according to this invention, either by treatment of the yarn itself or by its treatment in fabrics, one set of fibers predominantly constitutes the core of the yarn and another set of fibers predominantly constitutes a series of arch-like structures exterior of but anchored to the core. The two sets of fibers differ from each other in respect of unrelieved internal strain and ease of extension. The arch-like structures are sufficient in number to impart to the yarn bulkiness and resiliency which are the concomitants of warmth. Ordinary yarns without special treatment or characteristics have, by



virtue of the ordinary irregularities of spinning, a few stray fibers which assume arch-like configuration. These are not of sufficient number and extent to impart to the yarn the bulkiness and resiliency resulting from the invention herein described. The arch-like structures are in generally helical relation to the core and the actual shape of them is altered by the subsequent use of such yarns in combination with other yarns or by other conditions of use, e. g., finishing processes, brushing or napping. The configuration of the fibers is termed "arch-like" for convenience even though they may be somewhat distorted from arch shape by the subsequent treatment or use of the yarns.

The words "bulkiness and resiliency" are herein used as characteristic of the qualities of the yarn of this invention, even though it is recognized that the bulkiness may be mitigated or eliminated in particular applications as by hard twisting including twist-on-twist, especially with continuous filament or twisted with crepe yarns or by particular handling in making cloth. It is well known that in bulky yarns, e. g. worsteds, the bulkiness may be reduced by hard twist but greater resilience results. The word "bulkiness" is used for convenience as the best description of the basic yarn structure of this invention and the term is used as though the quality of bulkiness was still present even when twist or compression obscures it.

The term "spinning" is intended to include any and all systems of forming discontinuous fibers into yarn structures and spun yarns or spun fibers are the products thereof. As herein used, the words "set of fibers" may include more than one kind of fiber provided that for the purpose of this invention they act together.

In the following claims, napping refers to brushing, napping or raising fibers on the surface of a fabric by any other method, and napped fabrics designate the fabrics produced by any such methods.

By protein or regenerated protein fibers is meant artificially formed fibers produced by dissolving protein material, with or without extensive chemical alteration, and recovering this material, or altered material, in fibrous form, and the claims are meant to designate such fibers where used as a group by themselves, or with admixture of other fibers which for the purposes of this patent act with them. In the claims the word "synthetic" before "fibers" is a limitation of fibers to artificial or manufactured fibers as distinguished from natural fibers; it is not a limitation on the protein from which the fibers are made.

Forming fabrics designates putting yarns into textile fabrics by weaving, knitting or any other method.

Wherever the sequence of processes may be altered, the method claims are intended to cover the combination of processes regardless of the order in which they are performed.

It is of course understood that various changes may be made in the material above described and in the procedure for producing it without departing from the spirit of the invention as defined in the appended claims.

We claim:

1. Spun yarn comprising two sets of fibers, one set predominantly constituting a core, and the other set being of synthetic fibers of protein and constituting a series of arches exterior to but anchored to the core, said arches being sufficient in number to impart bulkiness and resiliency to the yarn.

2. Plied yarns, at least one ply of which consists of spun yarn plied in a direction opposite to the twist of the spun yarn, such ply comprising two sets of fibers, one set predominantly constituting a core and the other set predominantly constituting a series of arches exterior of but anchored to the core, the two sets of fibers differing from each other in composition, said arches being of synthetic fibers of protein and sufficient in number to impart bulkiness and resiliency to the yarn.

3. Spun yarn comprising two sets of fibers, one set comprising cellulose acetate fibers and constituting a core, and the other set being of synthetic fibers of protein and constituting a series of arches exterior to but anchored to the core, said arches being sufficient in number to impart bulkiness and resiliency to the yarn.

4. Spun yarn comprising two sets of fibers, one set comprising nylon fibers and constituting a core, and the other set being of synthetic fibers of protein and constituting a series of arches exterior to but anchored to the core, said arches being sufficient in number to impart bulkiness and resiliency to the yarn.

5. Fabric comprising spun yarn comprising two sets of fibers, one set predominantly constituting a core, and the other set constituting a series of arches of synthetic fibers of protein exterior to but anchored to the core, said arches being sufficient in number to impart bulkiness and resiliency to the yarn and in which at least some of the fibers have additional anchorage of the arches effected by resin treatment.



6. Fabric comprising spun yarn comprising two sets of fibers, one set predominantly constituting a core, and the other set being of synthetic fibers of protein and constituting a series of arches exterior to but anchored to the core, said arches being sufficient in number to impart bulkiness and resiliency to the yarn.

7. Fabric comprising spun yarn comprising two sets of fibers, one set comprising cellulose acetate fibers and constituting a core, and the other set being of synthetic fibers of protein and constituting a series of arches exterior to but anchored to the core, said arches being sufficient in number to impart bulkiness and resiliency to the yarn.

8. Fabric suitable for use as a substitute for tropical worsted comprising yarn comprising plies which are hard twisted together at least one of said plies comprising two sets of fibers, one set predominantly constituting a core and the other set predominantly constituting a series of arches of synthetic fibers of protein exterior of and anchored to the core, the two sets differing from each other in unrelieved internal strain, said arch fibers being sufficient in number to impart resiliency to the yarn.

9. A napped or brushed fabric comprising a yarn structure comprising two sets of fibers differing from each other, one set of fibers predominantly constituting a core and the other set of synthetic fibers of protein predominantly constituting a series of arches exterior of and anchored to the core, said arch fibers being sufficient in number to impart bulkiness and resiliency to the yarn.

10. Fabric suitable for use as a substitute for tropical worsted comprising plies of yarn hard twisted together, at least one of said plies comprising fibers of two chemically distinct compositions, the fibers of one set predominantly constituting a core, and the fibers of the other set being of synthetic fibers of protein and predominantly constituting a series of arches exterior of and anchored to the core, said arch fibers being sufficient in number to impart resiliency to the yarn.

11. Fabric comprising spun yarn comprising two sets of fibers, one set predominantly constituting a core, and the other set constituting a series of arches of synthetic fibers of protein exterior to but anchored to the core, said arches being sufficient in number to impart bulkiness and resiliency to the yarn and in which at least some of the fibers are additionally anchored to other fibers by adhesion.

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