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BULKY CONTINUOUS FILAMENT YARN OF DISTINCT PLIES HAVING
DIFFERENT SHRINKAGE CHARACTERISTICS
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FIG. 1

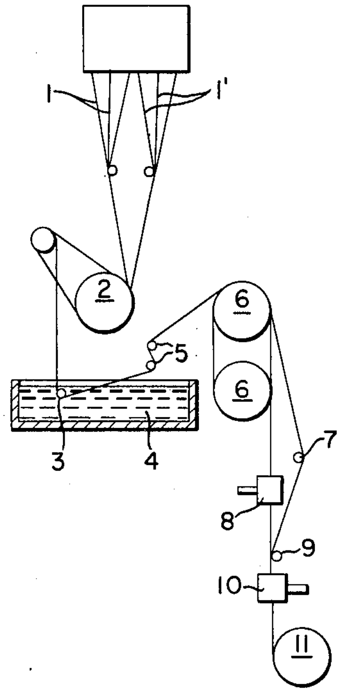
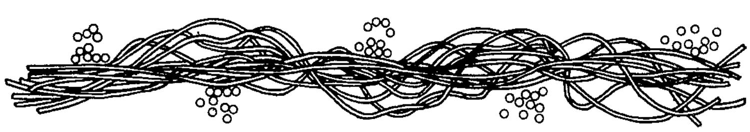


FIG. 2

FIG. 3



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BULKY CONTINUOUS FILAMENT YARN OF DISTINCT PLIES HAVING DIFFERENT SHRINKAGE CHARACTERISTICS

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The present application is a continuation-in-part of our copending application Serial No. 141,945, filed September 27, 1961, as a continuation-in-part of our application Serial No. 53,224, filed August 31, 1960, and now abandoned. This invention relates to bulky continuous filament yarns and to fabrics thereof.

The aforementioned earlier applications disclose the method of providing bulky continuous filament yarns and fabrics by preparing a composite yarn of filaments which have different amounts of residual shrinkage and treating the yarn, preferably after it is made into fabric, to shrink the filaments. The filaments of greater shrinkage then pull the other filaments into a bulky configuration of three-dimensional filament loops.

The invention of our copending application is concerned with accomplishing this differential shrinkage so that small, relatively uniform loops are formed. In accordance with that invention, the yarn is composed of a plurality of filaments of at least two species: (1) A filament species characterized by a zero load residual shrinkage in the range of 0.0 to about 20% and a residual shrinkage at 0.05 gram per denier load at least about 1.2% less than the zero load residual shrinkage, and (2) a filament species characterized by a zero load residual shrinkage at least 2% higher than the zero load residual shrinkage of the first filament species. When yarn so characterized is woven or knitted into fabric, boiled off or scoured, and then ironed or heat set, bulky fabrics are obtained which have a soft, supple, staple-like hand and a high degree of opacity and covering power. In contrast thereto, when fabric is prepared from yarn in which the less shrinkable filament species differs from (1) in having a zero load shrinkage only slightly greater (less than 1.2% greater) than the residual shrinkage at 0.05 gram per denier load, the fabrics are buckled or puckered and have a harsh hand.

There is an additional problem in preparing woven fabrics which is not readily solved by critical selection of differentially shrinkable filament components of the yarn. In many textile uses, especially those requiring plain weave fabrics, a non-uniformly in bulkiness occurs due to follow-the-leader looping of filaments. When the fabric is treated to shrink the filaments, interactions of the warp and filling normally determine the location at which the loops of the low shrinkage component occur, creating an undesirable patterning in the surface appearance of the fabric which resembles a moire. Such an effect is completely unacceptable in many fabrics, such as taffeta, for example. The use of highly twisted yarn does not avoid objectionable patterning although it is reduced in magnitude, and the twist seriously impedes the development of bulk.

An object of the present invention is an improvement in yarn which bulks by differential shrinkage of component filaments to provide yarn suitable for preparing bulky woven fabrics free from objectionable patterning. Another object is to accomplish this improvement without significant sacrifice in bulkiness. It is a still further object to provide a fabric with the bulk, cover and tactile

hand of fine staple fabrics conjointly with uniformity achievable only with continuous filament yarns. Other objects will appear hereinafter.

These and other objects are achieved in this invention by subjecting at least two plies of continuous filament yarn, which have from 2% to 20% differential shrinkage necessary to produce the desired bulk, to the action of an interlacing jet such that the resultant interlaced yarn has a split count of less than 12 and preferably from 1 to 3.

The split count is a measure, in inches, of the average distance between interlacings of the several plies of yarn. It has been found that even after passage through the interlacing jet, individual yarn plies are occasionally, along the length of interlaced yarn, identifiable. To measure the split count, a pin is inserted through the interlaced yarn in such a way as to isolate all of the filaments of one yarn ply on one side of the pin and all of the other yarn filaments on the other. All of the filaments of one ply are grasped by the fingers of one hand, while all of the filaments of the other ply are grasped with the other hand. The two plys are then gently pulled apart several times until it is obvious that a definite limit of easy separation has been reached at each end of the split. The distance between such limits is measured in inches and taken as the split count. Several such measurements are averaged in the evaluation of each sample.

In the drawing, FIGURE 1 is a schematic illustration of one embodiment of the above process, and of apparatus suitable for use in the process.

FIGURE 2 is a greatly enlarged view of a yarn of this invention and

FIGURE 3 is a corresponding view of the yarn after it has been woven into a fabric and subjected to shrinking conditions. FIGURE 3 represents a cross-section taken through the fabric along the yarn, in which ends of fibers perpendicular to the plane of the paper appear as circles. Shrinkage of the yarn has caused the lesser shrinking component, filaments to buckle randomly into projecting loops, imparting a uniform bulk to the yarn.

Examples I and II serve to illustrate this invention.

EXAMPLE I

Two yarns, each a continuous filament, zero-twist polyester yarn of 25 filaments, 1.4 denier per filament, but having different residual boil-off shrinkages of 15% and 5%, respectively, were plied on a modified drawing machine through an interlacing jet such as is depicted in FIGURES 1 and 3 of Bunting et al. U.S. Patent No. 2,985,995 dated May 30, 1961. Tensions on the yarn plies were adjusted to a low level (3 to 15 grams) during passage through the jet. The plied yarn was wound up at 304 yards per minute as a zero-twist package.

The plied yarn was analyzed for split count at 5-yard intervals until 10 analyses had been made. The average split count was 3.5 inches.

The plied yarn was flat woven to yield a taffeta of 94 x 72 count (ends per inch) which was finished by immersion in water at 100 C. for 30 minutes, drying and ironing flat. After this treatment, the fabric prepared from this mixed shrinkage yarn exhibited considerably higher bulk than a comparable fabric prepared from yarns of homogeneous shrinkage (2.6 vs. 2.0 cc./gm.).

The fabric prepared from the interlaced mixed shrinkage yarn was then carefully inspected under good fabric evaluation lighting and found to have a moire rating of 1.5. Without interlacing, the moire rating of the mixed shrinkage yarn was 5. No moire was evident in fabrics prepared from yarns of homogeneous shrinkage, whether interlaced or not.

In the foregoing and subsequent fabric inspection ratings, the following definitions apply:

Moire rating:

- 5________ Frequent and very obvious defects resembling a micromoire or herringbone pattern. Pattern repeat frequency is as short as ⅛ inch to ¼ inch. At this defect level, no special lighting normally is required for detection.
- 4________ Similar to 5, above, but with a somewhat reduced severity. At this level, the trained observer detects the defect on the fabric inspection table with no hesitation.
- 3________ Still apparent to the trained observer when viewed on the inspection table, but detection from normal viewing angle requires very careful consideration.
- 2________ Detection most difficult. The defect can be seen only when the fabric is viewed from the spectral angle of above 30°. Defects of this magnitude generally will be missed by the untrained observer.
- 1________ Complete absence of moire or herringbone defects under the most ideal viewing conditions to the expert viewer.

Several additional lots of yarns were interlaced as described above, but with variations in air pressure to the interlacing jet, and evaluated in fabric as described above. Table 1 summarizes the data obtained.

Table 1

Item	Air Pressure (p.s.i.g.)	Split Count	Moire Rating
A	50	2	1.0
B	20	3.5	1.5
C	15	6	2.0
D	12	11	3.0
E	10	15	3.5
F	0	>200	5.0

All items in the foregoing tabulation had a wind-up speed of 304 yards per minute. In other tests it has been shown that wind-up speed influences split count also, a higher speed tending to increase split count.

EXAMPLE II

Two yarns of differing residual shrinkage are prepared simultaneously as part of a process of spinning 50 trilobal filaments of a copolymer of ethylene terephthalate with 2 mol percent sulfoisophthalate of 19.5 relative viscosity, along with 0.45% TiO_2, after the manner described by Griffing et al. in U.S. Patent No. 3,018,272 dated January 23, 1962. The extruded filaments were divided into two bundles 1 and 1′ of 25 filaments each and processed separately and continuously in accordance with the process illustrated in the drawing. Both filament bundles were taken up by feed roll 2 operating at a peripheral speed of 900 yards per minute, passed under a draw pin 3, immersed in a bath of water 4 maintained at 90° C., and passed out of the bath via a pair of guides 5 to a pair of draw rolls 6 maintained at a temperature of 100° C. (contact time on the rolls 0.3 second) and operating at a peripheral speed of 2700 yards per minute. The draw ratio accordingly is 3.0. One of the two filament bundles is passed from the hot rolls over guide 7, while the other bundle of filaments passes through a relaxing jet wherein it is exposed to a heated fluid. On exiting from the jet, this bundle of filaments is combined over a guide pin 9 with the unrelaxed bundle. The composite yarn is then passed through interlacing jet 10 and wound up on yarn package 11.

Samples of the ends, taken before the interlacing jet, are wound up separately to measure their separate yarn properties. The filament bundle which passed through the relaxing jet was found to have a denier of 35 (3.89 tex.), a tenacity of 2.8 g.p.d., an elongation of 29.5%, a yield point of 2.1 g.p.d., a boil-off shrinkage of 3.5%, and an initial modulus of 68 g.p.d. The filament bundle wound directly from the hot rolls had a denier of 35 (3.89 tex.), a tenacity of 2.6 g.p.d., an elongation of 34%, a yield point of 2.0 g.p.d, a boil-off shrinkage of 14%, and an initial modulus of 65 g.p.d.

The composite yarn had a split count of 6 inches. A 1 x 1 plain weave fabric containing 94 ends per inch in the warp (7 turns per inch of Z twist) and 72 ends per inch in the filling (3 turns per inch of Z twist) is then prepared from the composite yarn. The fabric is then immersed in water at 100° C. for 30 minutes, dried and heat set at 160° C. for 30 seconds. The resulting fabric exhibits a bulk of 2.4 cc./gram and a weight of 1.9 oz./yd.^{2}. Its moire rating was found to be 2.0.

For comparison, a series of yarns with higher split counts were obtained via the process described in Example II, and fabrics were prepared as described in Example II. The fabrics were then carefully inspected under critical fabric evaluation lighting and were found to have the moire ratings listed in Table 2. Data from Example II is also included in the table.

Table 2

Items	Split Count, Inches	Moire Rating
Example II	6	2.0
Comparison A	11	3.5
Comparison B	24	4.5
Comparison C	36	5.0

The following examples illustrate the inadequacy of ordinary twist in inhibiting the development of moire.

EXAMPLE III

Two continuous filament, zero-twist polyester yarns of 15 filaments, 2.3 denier per filament, having residual shrinkages of 12% and 5%, respectively, were plied on a down-twister at 3, 7, 13, and 21 turns per inch of Z twist.

The plied yarn, at each twist level, was woven to yield a 1 x 1 plain weave taffeta of 92 x 76 count (ends per inch) which was finished by immersion in water at 60° C., which was then raised to 100° C. over 15 minutes and held for 30 minutes, drying, and ironing flat. When compared to a taffeta fabric prepared from yarns of homogeneous shrinkage filaments, the bulk of mixed shrinkage yarn was much improved (2.5 vs. 1.8 cc. per gram).

The fabrics were then carefully inspected under critical fabric evaluation lighting and all were found to have a moire rating of 5. As twist increased, the moire pattern became smaller, although it remained equally evident and objectionable.

EXAMPLE IV

Yarns prepared as in Example II, with a 6-inch split count, were twisted in varying degree prior to being woven into a series of 1 x 1 plain weave fabrics. As shown in Table 3, the split count was unchanged by addition of twist, and the differences in twist served only to change the size of the fabric irregularities and not to diminish their intensity.

Table 3

Twist, Z turns/in.		Split Count, Inches	Moire Rating
Warp	Filling		
5	0	6	3
7	3	6	2
12	5	6	3
18	7	6	3

The patterning described herein as a micromoire or herringbone can be assumed to be the result of fabric luster variations as influenced by specific repetitive orientation of groups of filaments in concert in fabrics. For an as-yet-unexplained reason, a critical amount of interlacing, as measured by a split count of 12 or less, prevents the degree of filament organization in the woven fabric necessary to produce the objectionable patterning. It is surprising that so coarse an adjustment in degree of interlacing can accomplish the critical improvement on such a micro scale. It also is not apparent why ordinary twist of reasonable magnitude does not accomplish the same effect.

While a split count of less than 3 is generally preferred, it has been found that the ability of the average observer to detect moire is sufficiently limited that a split count as high as 12 can be tolerated for some fabrics.

Since many different embodiments of the invention may be made without departing from the spirit and scope thereof, it is to be understood that the invention is not limited by the specific illustrations except to the extent defined in the following claims.

We claim:

1. A composite plied yarn of linear condensation polymer continuous filaments varying in residual shrinkage, the yarn being characterized by distinct plies of at least two species differing in residual shrinkage by from 2% to 20%

and interlaced together at intervals to a split count of less than 12.

2. An interlaced composite yarn as defined in claim 1 which has a split count of 1 to 3.

3. An interlaced composite yarn as defined in claim 1 composed of polyester filaments.

4. An interlaced composite yarn as defined in claim 3 wherein the polyester is predominately polyethylene terephthalate.

5. A fabric comprising interlaced composite yarn as defined in claim 1.

6. A fabric woven of interlaced composite yarn as defined in claim 1 and subjected to shrinking conditions.

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MERVIN STEIN, *Primary Examiner.*