COMPOSITE YARN STRUCTURES AND METHOD OF PREPARING SAME

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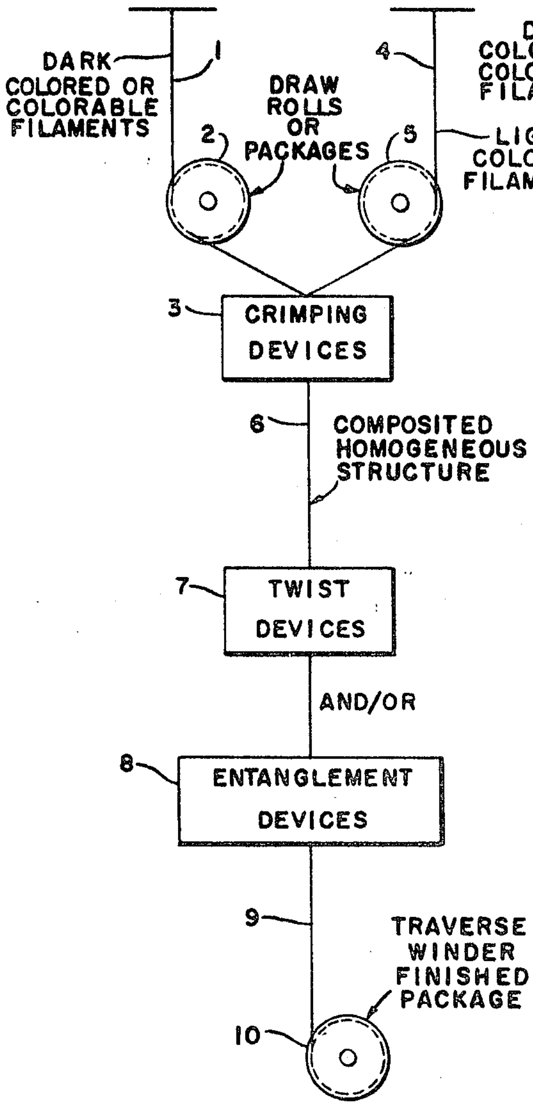

FIG. 1.

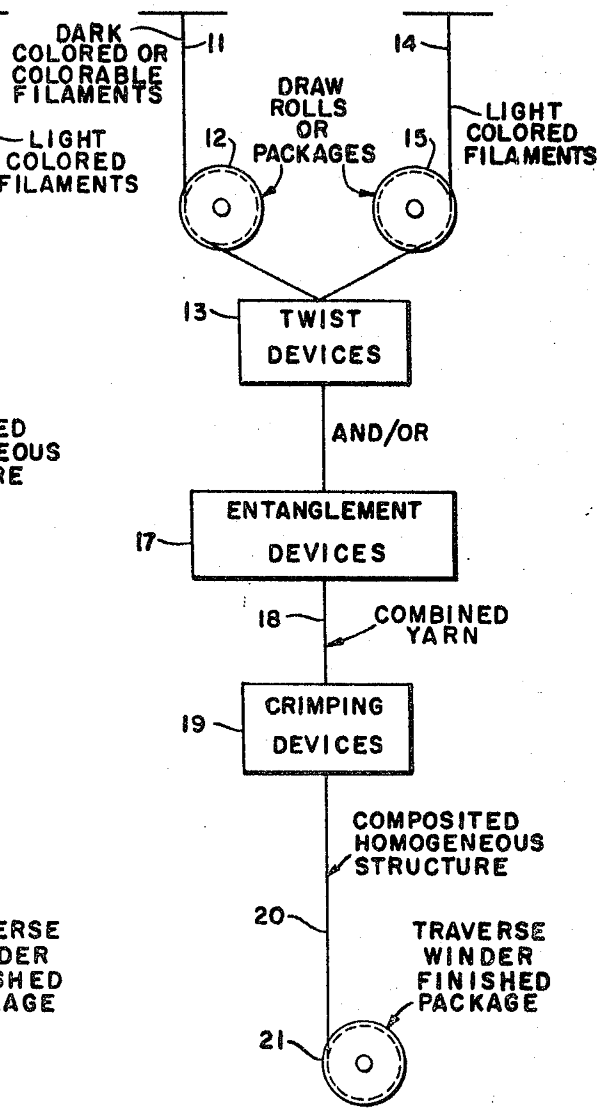

FIG. 2.

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COMPOSITE YARN STRUCTURES AND METHOD OF PREPARING SAME

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ABSTRACT OF THE DISCLOSURE

This invention is directed to a process for preparing novel, texturized composite-yarn structures and the colored fabrics attained therefrom which comprises forming homogeneous structures by simultaneously crimping at least two filaments of light and dark contrasting colors or colorability and subjecting the composited structures to mechanical operations including twisting, entangling or twisting and entangling, in any order. The contrasting colored or colorable filaments include the synthetic filaments having a color contrast of at least six Gardner units. The colored fabrics prepared from the textured composite-yarn structures may be characterized as having the dark contrasting filaments composited in the yarn to impart to the total fabric a random, three-dimensional effect. The dark contrasting filaments are composited in the yarn in a manner such that the fabric has a visual color effect substantially greater than the color that would normally be seen by the actual amount of the dark filaments present in the fabric.

This invention is directed to a process for preparing texturized, composite-yarn structures and to the variety of colored yarns and fabrics attained therefrom. More specifically, this invention is directed to a process for preparing novel yarn structures comprising at least two filaments of contrasting colors or colorability to be used in the preparation of colored fabrics characterized as having a random, three-dimensional design effect.

It is generally known that it would be an ideal machine that would be capable of combining several ends of different colored yarns to produce, for example, an exciting marl or mottled effect. There are, however, various known methods concerned with the production of novel yarns by combining different colored filaments.

The present technology includes, for example, the preparation of these yarns by utilizing jets, e.g., either the loop or whorl-type methods, stuffer box crimpers, false twist methods, high-twist levels, e.g., raise twist and jet combinations, and finally, yarns prepared by a variety of twist methods whereby a non-random color effect may be obtained. To improve on these techniques, this invention provides means of preparing composited yarn structures useful for the production of fabrics having a variety of designs at substantially lower costs and by comparatively simple procedures.

Thus, while it is known that various design effects may be obtained by combining different colored yarns by using different twist procedures, it was unexpected to find that the design effects obtained by this invention would be so dramatically different that they could not be reproduced by the other known methods. Moreover, by the instant process, it is possible to obtain decisive design effects with each type of fabric manufacturing process. Heretofore, to achieve similar results, it was necessary to use the more expensive components, including the various dope-dyed yarns, metallized synthetic yarns, novel craft sectional yarns, metallic yarns, etc. The use of these materials, however, was limited to a large extent because of the increase in cost of the more expensive components.

In accordance with this invention, however, by utilizing as little as 0.5%, for example, of the more expensive component, it is possible to obtain excellent design effects which are optically equivalent to fabric which, in fact, contain as high as 50% of the more expensive component.

There are still other problems with many of the presently available textured or bulk yarns, wherein a texturizing streak or pirn barré may occur with the different yarn laps. However, by the instant process where the filaments of contrasting color or colorability are separated within the composite structure, the problem of pirn barré and texturizing variation are reduced to a relative insignificant level by the random patterns produced. Thus, this invention may serve as an excellent means of utilizing nonuniform feeder yarns to produce an improved quality product where a non-commercial product would have been produced otherwise. Normally, texturized yarns are plied to improve their uniformity and to minimize their inherent barré. The random effect obtained by the instant process resulting from the combination of two or more colored filaments mask the barré to the extent that plying is not necessary.

It has been found that special design effects can be obtained with each level of twist prior to texturizing or in the alternative, a different design may be obtained with each level of twist subsequent to texturizing. Moreover, an entirely different design may be obtained by utilizing entanglements rather than twists which change also with the degree of entanglements per meter. It is known also that by plying yarns under various conditions and at various twist levels, different designs may be used in combination with different manufacturing processes. However, these design changes are relatively costly and have specific limitations with respect to the economical variety which can be obtained.

Previously, in order to simulate the effect of natural staple fabrics, it was necessary to cut-up the continuous filament yarns and recombine these multiple staple ends into an elongated fibrous structure. This operation represents a number of additional steps and requires additional equipment and labor. Therefore, it is preferable to use continuous filament yarns to simulate staple fabrics. This can be accomplished, for example, by using the composite-yarn structures of this invention in one direction and the natural staple and synthetic fibers in the opposite direction, such that the combined fabric has the appearance that the whole fabric was made of a blended staple yarn, e.g., a polyester and cotton.

Accordingly, it is an object of this invention to provide a process for preparing homogeneous, composite-yarn structures comprising at least two filaments of light and dark contrasting colors or colorability wherein the color contrast is of at least six Gardner units.

It is another object of this invention to provide a process for preparing colored fabrics from textured, composite-yarn structures having at least two filaments of contrasting colors or colorability; said fabrics characterized as having the dark colored filaments present in the yarn in amounts to impart to the fabrics a random, three-dimensional color effect.

It is still another object of this invention to provide colored fabrics prepared from textured composite-yarn structures wherein the dark, contrasting filaments give a visual color effect substantially greater than the color effect that would normally be obtained by the amount of colored filaments actually present in the fabrics.

It is still another object of this invention to provide a process for preparing composite-yarn structures comprising small amounts of dark filaments which, when used in the preparation of fabric, contribute to the fabric a novel, random, three-dimensional design, said dark, contrasting filaments imparting to the total fabric a significantly greater visual color effect than the actual amount in the fabric.

It is still a further object of this invention to provide a process wherein the more expensive filaments of dark, contrasting colors or colorability can be effectively and homogeneously combined with the lighter, less expensive filaments to produce a novel design hitherto possible only by means of the more expensive processes.

It is still a further object of this invention to provide a process of preparing novel texturized, composite-yarn structures whereby a multiplicity of design may be obtained by utilizing the said yarns in the preparation of fabrics without having to rely on the use of multiple colored or colorable yarns. Thus, for example, a single strand or yarn may be circular knit to obtain a wide variety of designs depending upon the twist and/or entanglement level previously inserted.

It is still a further object of this invention to provide texturized, composite-yarn structures comprising dark and light filaments and a method of preparing same, wherein a comparatively small amount of the dark contrasting filaments, which are normally more expensive, are used to obtain a degree of color design which otherwise would require a comparatively larger amount of said dark filaments if prepared in accordance with procedures known heretofore.

These and other objects of the invention will become apparent from a further and more detailed description of the invention to follow.

More specifically, this invention relates to a process of preparing texturized, composite-yarn structures and to a variety of colored fabrics to be obtained therefrom. These yarn structures may be prepared by crimping simultaneously at least two synthetic filaments of light and dark contrasting colors or colorability to a crimp level of 6 to 30 crimps per inch, and more preferably to a crimp level of 9 to 16 crimps per inch. Subsequently, the composited, homogeneous, crimped yarn structures are subjected to a mechanical operation selected from the group consisting of (1) twisting to a level of 0.01 to 3 turns per inch, (2) entangling to a level of 0.01 to 100 entanglements per meter, or (3) as an alternative, twisting and entangling said yarn structures to the levels indicated. It is important that the filaments comprising the yarn structures have at least two filaments, i.e., various synthetic

filaments, wherein the color contrast between them is at least six Gardner units and more preferably, at least twelve Gardner units. The composited-yarn structures of this invention may be further characterized as comprising 0.5 to 49 parts by weight and more preferably, 0.5 to 30 parts by weight of at least one of the dark, contrasting colored or colorable filaments and 51 to 99.5 parts by weight, and more preferably, 70, 99.5 parts by weight of at least one of the lighter colored or colorable filaments with the color contrast between the filaments being at least six Gardner units.

In general, the dark contrasting colored or colorable filaments include filaments which are dark red, brown, blue, green, black, purple, grey, but preferably, the black, brown, blue and purple filaments. The light contrasting colored or colorable filaments include, for example, filaments of white, yellow, orange, light-red, light-grey, light-green, light-blue, light-violet, and more preferably, the lighter yellows, greens, oranges and whites.

More specifically, the dark contrasting colored or colorable filaments may be further defined as having a Munsell lightness value of 0–6 units and a Munsell chroma value of 0–13 with a contrast of at least six Gardner units. Preferably, the dark contrasting colored or colorable filaments may be characterized as having a Munsell value of 0.5 to 3.5 and a Munsell chroma value of 0–5 with a contrast between the light and dark filaments being preferably of at least twelve Gardner units. However, when utilizing black filaments, it may be possible to use filaments having lower contrasting values which may be as low as three but preferably, at least six Gardner units.

The lighter colored or colorable filaments may be further characterized as having a Munsell lightness value of 6–10 and a chroma value of 0–11. More preferably, the lighter colored filaments may have a Munsell color value of 7–10 and a Munsell chroma value of 0–8 with the greys and whites having a maximum chroma value ranging from 0–2.

A more detailed description of the above-mentioned Munsell values may be found in the National Bureau of Standards Circular 553, issued Nov. 1, 1955, entitled "The ISCC–NBS Method of Designating Colors and a Dictionary of Color Names," pp. 2–5.

The color definitions of the light and dark contrasting colored filaments to be employed by this invention are specifically shown in the following Table I.

TABLE I.—COLOR DEFINITIONS

	Visual values Munsell color scale				Gardnor contrast values	
	Munsell value on lightness		Saturation or chroma values		Difference in contrast between light and dark values	
Dark contrasting colors	1R Broad	9R Preferred	Broad	Preferred	Broad	Preferred
Red	.05–5	1–4	.5–13	1–7	12	16
Dark brown	.5–5 1YR–8YR	.5–3.0	.5–9	.7–5.0	7	15
Red purple					9	14
Purple vlue					6	12
Blue	9G–10RP 0–6.5	10BG–9RP .5–3.5	0–14	0–6	6	12
Dark green	1Y–9G .5–4.5	9Y–9G .5–2.5	.7–11	.7–7	10	14
Non-Munsell Color:						
Black	1R–9RP 0–2.5	1R–9RP 0–1.5	0–2	0–1	3	6
Dark grey	1R–9RP 2.5–4.5	1R–9RP 2.5–3.5	0–2	0–1	6	15
Light contrasting colors:						
Light green	8GY–9PR 4.5–10	8GR–10BG 6.5–10	0–14	0–7		
Green yellow	7Y–10BG 8–10	9Y–2G 7–10	0–11	0–6		
Yellow	8YR–9B 6.0–10	8YR–3G 8–10	0–11	9–8		
Yellow red						
Light red	1R–1PB–8YR 6.5–10	10B–1R–4YR 8–10	0–10	0–6		
Non-Munsell color:						
Light grey	1R–9RP 6–9.0	1R–9RP 7.5–8.5	0–2	0–1		
White	1R–9RP 8.5–10	1R–9RP 9–10	0–2	0–1		

The contrast of the colored filaments were determined on the Gardner Model C–4. This colorimeter gave color notations in terms of R_d, A and B. R_d is lightness or darkness on the grey scale wherein 100 is white and 0 is black. The value A can be positive or negative wherein the positive values indicate redness and the negative values indicate greenness. The value B is positive and negative. Positive B values denote yellowness, whereas negative B values denote a blueness. The control system for the blues and yellows are the B values, the control system for the greens are the A values, and the control system for the whites, blacks and greys are the R_d values. Where positive and negative values are simultaneously present such as red and green, the R_d is the preferred scale for color contrast values.

In the drawings:

FIGURE 1 is a schematic diagram illustrating a specific embodiment of preparing the texturized, composite-yarn structures in accordance with this invention.

FIGURE 2 is an alternative schematic diagram illustrating a specific embodiment of preparing the texturized composite-yarn structures in accordance with this invention.

More specifically, referring to FIGURE 1 as a preferred embodiment, at least one or more dark, contrasting colored or colorable filaments and at least one or more lighter colored or colorable filaments **1** and **4**, respectively, pass from the spinnerettes either onto packages or draw rolls **2** and **5** where the filaments may be drawn, if desired, to a ratio of 3 to 6 with respect to the undrawn filaments.

Then the filaments are passed to a crimper **3** wherein the light and dark contrasting filaments are homogeneously composited into a uniform structure by simultaneously crimping the filaments to a crimp level of 6 to 30 crimps per inch. Subsequently, the composited homogeneous yarn structure **6** passes to a twister **7** and/or an entanglement device **8** wherein the composited-yarn structure is either twisted to a level of 0.01 to 3 turns per inch, entangled to a level of 0.01 to 100 entanglements per meter, or twisted and entangled, in any order, to the levels indicated. The texturized, composited-yarn structures **9** are then carried or taken-up on a traverse winder **10** as a finished package.

As an alternative, FIGURE 2 illustrates another specific embodiment of this invention wherein at least one dark colored or colorable filament **11** is drawn on a draw roll **12** while a lighter colored or colorable filament **14** is drawn on a draw roll **15** to draw ratios of 3 to 6, as desired, prior to being subjected to a mechanical operation. The light and dark contrasting colored or colorable filaments are passed from the draw rolls or packages **12** and **15** to a twisting device **13** and/or an entangling device **17**, in any order, wherein the colored or colorable filaments are subjected to either a twist level of 0.01 to 3 turns per inch, an entanglement level of 0.01 to 100 entanglements per meter, or in the alternative, a combination of twisting and entangling to the levels indicated. Subsequently, the combined yarn **18** is withdrawn from the mechanical devices and passed to a crimper **19** wherein the yarn is subjected to a crimp, e.g., saw-tooth crimp, to a level of 6 to 30 crimps per inch. The composited, homogeneous yarn structure **20** is then taken-up on a traverse winder **21** as a finish package.

It should be noted that the material difference between the schematic diagrams of FIGURES 1 and 2 is the subjecting of the filaments in FIGURE 1 to a crimper prior to being subjected to the other mechanical devices, whereas FIGURE 2 subjects the filaments to the mechanical devices before crimping. It should be further noted that while the preferred embodiments illustrate the preparation of the texturized composite-yarn structures by utilizing draw rolls, it is to be understood that drawing of the filaments prior ot subjecting them to the mechanical devices and crimper is not essential and if desired, may be eliminated. Thus, for example, the dark and light contrasting filaments may be passed directly from packages to the crimper and the other mechanical operations, in any order. Moreover, while the preferred embodiments indicate that the contrasting filaments may be twisted, entangled, or in the alternative, twisted and entangled in any order, the least preferred is the latter, in that it contributes the least to the ultimate design.

In accordance with this invention, by utilizing at least two filaments of light and dark contrasting color or colorability in the relative proportions indicated and by subjecting them to the texturizing devices, it is possible to obtain composite-yarn structures wherein the filaments are intermingled but nevertheless retain their contrasting colors and, therefore, contribute to fabrics prepared therefrom a novel, random, three-dimensional design with the darker filaments imparting to the total fabric a significantly greater visual color effect than the amount actually present in the fabric. Thus, since it is possible to obtain greater color effect with only small amounts of the darker filaments, it is desirable to include within the darker filaments other additives which impart desirable characteristics to the final products. These additives may include, for example, electrical conductors, flame-retarding agents, wrinkle-resistant agents, improved hand, improved drape, novel lustre, a higher modulus or stiffness, a reduced soiling tendency, improved bulk, improved heat and weather stability, etc.

The various color combinations which may be employed for purposes of this invention include the different colored yarns such as, for example, dope-dyed, skein-dyed, finished dyed, and the like. The particular filaments having contrasting color or colorability to be used in the process include, for example, nylons, e.g., polycaproamide, polyesters, e.g., polyethylene terephthalate, polyblend filaments comprising blends of the polyesters and nylons, polyolefins, i.e., polypropylene, polyacrylic filaments, and various other known synthetic or man-made fibers such as rayon, rayon acetate, polynosics and the like.

A preferred embodiments, continuous filaments of contrasting color or colorability are texturized into composite structures by crimping to levels of 9–16 crimps per inch, twisting to levels of 0.01 to 1.0 turns per inch, or alternatively, entangling to levels of 0.01 to 50 entanglements per meter. The yarn structures preferably consist essentially of 1 to 30 parts by weight of at least one filament of dark contrasting color or colorability and 99 to 70 parts by weight of at least one lighter colored or colorable filament. The contrasting filaments are simultaneously combined by crimping, e.g., by mechanical means or fluid-jet means, such that the contrasting filaments are structurally commingled but nevertheless retain their distinct contrast in color.

An example of a method which may be employed for producing the colored or colorable filaments comprises the steps of continuously spinning in one spinnerette the colored or colorable filament while simultaneously spinning the lighter filaments in the separate spinnerette, follower by drawing, if desired, and then combining at least two ends in a suitable jet or mechanical crimper. Alternatively, the colored or colorable filaments may be separately obtained from spinnerettes followed by drawing and then simultaneously combining the ends in a suitable crimping device. Still further, the colored or colorable filaments may be commingled by spinning a dope-dyed product, for example, in a separate plant and combining the drawn filament simultaneously in a crimping device with a different colored or colorable filament which is being spun-drawn.

It is an important aspect of this invention that while it is necessary to have a color contrast of at least 6 and preferably 12 Gardner units, it is possible, however, to use dark and light contrasting filaments of the same material, i.e., two different nylon filaments. Thus, since the filaments may be chemically different, the light and dark contrast will be an inherent function of the filaments' susceptibility to the various dyes. In other words, it may be possible to use a combination of different nylons, e.g., Nylon 6 and Nylon 6–6, or a combination of nylons with polyesters, polyblends, i.e., see Belgian Patent No. 661,-783, polyolefins, rayon, or in some cases, even a combination of nylon with natural fibers. Of the nylons, Nylon 6 is particularly preferred primarily because of the lower temperature at which it may be melt-spun to allow the incorporation of heat-sensitive pigment, etc., to the polymer. As an illustration, filaments of nylon having an amine-end group differential of at least 18 amine groups may be used to achieve the degree of contrast required due to the difference in susceptibility of this particular filament to dyes. Moreover, after the yarns are prepared in accordance with this invention, they may be further blended with synthetic and/or natural fibers, such as wool or cotton, in the preparation of the end fabric. In order to have a coherent structure which will not later separate out the colored components, it is necessary, however, to pass the filaments through a crimping device and a mechanical operation, as more particularly pointed out herein. It was found that if the contrasting filaments were not simultaneously crimped, then there was generally separation of the filaments in spite of the more intimate treatments, i.e., entangling and/or twisting. It is the crimping of the filaments which provides the coherent structure which remains uniformly coherent throughout subsequent operations. The twisting and/or entangling provide for a number of different patterns either to increase or decrease the design differential or to change the variety of designs. However, without the combination of either the twisting or entangling with crimping, it is not possible to duplicate the patterns in successive production of yarns. The reason is primarily because it is not possible to maintain the coherency of the structure by any other known method.

It is further essential, in accordance with this invention, that the degree of contrast between the colored or colorable filaments be maintained at least 6, and preferably 12, Gardner units; otherwise, the desired effect of pattern definition, design differential, three-dimensional color effects, etc., will not be obtained. For example, if there is too little contrast between the filaments, the design obtained will be essentially non-distinguishable. Consequently, it is essential to maintain the required contrast between the colored filaments and to provide the critical level of crimping to achieve the needed coherency. While it is not preferred to use a combination of entanglement and twist, it is possible, however, to use this combination, particularly at the lower levels, to obtain entirely different designs. This is possible in preparing tweeds wherein upon employing both an entanglement and twist, a design is obtained which is different from that which would be obtained by employing either one of the two.

The method and apparatus which may be used for entangling the fine denier yarns for purposes of this invention are more particularly pointed out in copending application Ser. No. 388,592, filed on Aug. 10, 1964. Here, for example, an entangled yarn product is obtained by simultaneously treating a light, colored drawn 230/32/0 Nylon 6 yarn and a darker contrasting drawn 70/32/0 Nylon yarn; said yarns having different propensities toward shrinking and dyeing. The specific apparatus employed had the following dimensions:

	Mm.
Guides—	
Distance between guides	20.0
Distance between tip of nozzle and mouth of chamber	10.0
Inside diameter of guides	1.5
Chamber—	
Inside diameter of chamber mouth	4.3
Depth of chamber	15.0
Nozzle—	
Diameter of nozzle orifice	1.5

The chamber member and the yarn guides are fabricated of AlSiMag ceramic material above identified.

In operation, the yarns follow a Z-shaped path in a plane perpendicular to the axis of the nozzle, each yarn passing through the uppermost guide in the same 135° angle and the yarns being withdrawn through the lower guide at a 135° angle to the line between the guides. By means of a constant speed driven takeup roll and upstream tension control means, the tension on the partially drawn yarn is maintained uniformly at 5.0 grams and the tension of the fully drawn yarn is maintained uniformly at 7.0 grams. The rate of yarn throughput for both yarns is 500 yd./min. Air at a pressure of 85 p.s.i.g. is employed as the entangling medium. In the course of yarn treatment the filaments are observed by high speed photography to separate and oscillate and the yarn as a whole to vibrate and contact the upper and lower portions of the mouth of the chamber at least 100 times per second. The entangled yarn obtained has a coherency factor of 312 and an outlier fraction of 0.038.

The yarns to be entangled by the above-described process may include, for example, the nylons such as poly(epsilon - caproamide), poly(hexamethyleneadipamide), viscose rayon, cellulose esters, i.e., cellulose acetate, linear polyesters, e.g., polyesters of terephthalic acid or isophthalic acid, and a lower glycol, e.g., polyethylene terephthalate, polyalkylenes, e.g., polypropylene, polyacrylics, e.g., polyacrylonitrile, as well as the copolymers of acrylonitrile. This entangling device may be employed, in series, with one or more other conventional textile operations including spinning, drawing, winding, plying, packaging, repackaging, crimping, twisting, etc. The yarns which are particularly suitable for entanglement in this gas jet apparatus include yarns having deniers ranging from about 10 to 4,000 denier with individual filament deniers ranging from about 0.5 to 16 denier.

For the heavy denier yarns, i.e., yarns having deniers ranging up to 10,000, the commingling jet apparatus may be used, which is particularly set forth in copending application Ser. No. 535,480, filed on Mar. 18, 1966. Here, the apparatus was employed to entangle untwisted 3600 denier, 210 filament nylon yarns having a zig-zag stufferbox crimp, a packaged crimp index of 8.5% and a relaxed crimp index of 23.5%. The specific apparatus employed had the following characteristics:

Overall length of yarn passageway ____in__	3.5
Length of large diameter segment of yarn passageway ____in__	2.0
Diameter of large diameter segment of yarn passageway ____in__	0.25
Diameter of small diameter segment of yarn passageway ____in__	0.125
Length of small diameter segment of yarn passageway ____in__	1.5
Diameter of gas passageway ____in__	0.20
Ratio of area of gas passageway to area of yarn passageway	0.64
Percent of gas which exits from entrance end of yarn passageway ____percent__	94
Angle of gas passageway ____degrees__	45

The yarn was fed into the apparatus on a straight line path at a rate of 265 yards/minute and a tension of 22 grams (.006 gram per denier). The yarn emerged from the device in a straight line, and a speed of 263 yards per minute. In order to properly center the air stream, the cylindrical air passageway was constructed to be slightly off center within the cylindrical walls of tube and this tube was adjusted by twisting it to achieve smooth operation forming yarn with alternating zones of commingling and no commingling. A deviation of as much as 6 mils in the position of the central axis of air passageway away from the plane which is parallel to said axis and also contains the central axis of yarn passage was found to make the yarn twist off the feed rolls, and failed to give the yarn product of the invention having alternating sites of commingling and no commingling; and even 3 mils deviation caused the device to run less smoothly.

The method employed to determine the level of entanglement is known as the Hook Drop Method described below.

HOOK DROP TEST

Meter lengths of yarn to be tested are clamped at the upper end and allowed to hang in the vertical position under the tension provided by a weight in grams which is 0.20 times the yarn denier (but not greater than 100 grams), inserting through the yarn bundle approximately midway within a region of no apparent commingling a weighted hook having a total weight in grams numerically equal to the mean denier per filament of the yarn (but not weighing more than 10 grams), and lowering the hook at a rate of one to two centimeters per second until the weight of the hook is supported by the yarn. The distance of hook travel is measured. Since the commingling is fairly random in nature, 100 separate meter lengths are tested to define a representative sample for a given package of yarn or for a multitude of presumably identical packages of yarn. Of the 100 separately obtained hook drop distances, the upper 20 and lower 20 values are discarded, and the remaining 60 are averaged to determine the average distance of hook travel. This value, D, measured in centimeters, is essentially one half the average distance between sites of strong enough commingling to stop the hook travel.

The method of texturizing or crimping the yarns in accordance with this invention may include the stuffer box methods, as particularly described in U.S. Patents Nos. 3,037,260 and 3,031,734. Other crimping methods may include the jet process, as particularly described in U.S. Patent No. 3,005,251, and the belt or gear crimping devices as shown in U.S. Patent No. 2,751,661. Other apparatuses including the stuffer box crimper which may be used to produce the saw-tooth, three-dimensional crimp are described in U.S. Patents Nos. 2,862,729 and 2,933,-771.

Of the various methods, a preferred method which may be used for purposes of this invention is particularly set forth in copending application Ser. No. 562,893, filed on July 5, 1966, now U.S. Patent No. 3,409,956.

Here, for example, a 2400-denier, 75-filament drawn yarn in the form of a strand spun from polycaproamide polymer of formic acid, relative viscosity 52 (A.S.T.M. D-789-62T) and a strand of 40-denier, 12-filament dope-dyed black component was delivered simultaneously to the steam-jet texturizing apparatus at 3,000 feet per minute and at a tension of 50 to 100 grams. The angle A of the diverging cone 16 measured 30°. There were 12 equally spaced holes in the rear exhaust which measured 0.0595". Steam at 120 p.s.i.g. and 470° C. temperature was directed from a 0.061 diameter steam nozzle, into a pre-heat tube 4" in length and having a diameter of 0.125 inch. The yarn strand in the pre-heat tube was heated to a temperature of about 125° C. and the steam and yarn strands were thereafter directed into the chamber where a yarn plug was formed. The steam forced the incoming yarn strand against a slower moving textured yarn plug in the texturing chamber. The spent steam escaped to the rear through vent holes and provided a blanket of heat around the pre-heater tube. The temperature of the yarn was found to drop by about 20 to 30° C. as it moved in a compacted mass to the end of the texturizing chamber. After leaving the texturizing chamber, the textured yarn was pulled over several tension bars and wound on a package. The crimp definition of the crimped yarn was. Crimp elongation before boil 10%, crimp elongation after boil 25% and the free shrinkage was 3.0%.

Another method of crimping multicolored yarns in accordance with this invention is described in copending application Ser. No. 510,591, filed on Nov. 30, 1965, now U.S. Patent No. 3,406,436. Here, 20 ends of 1,050-denier, 70-filament, one-half-Z twist polycaproamide, along with 20 ends of 40–12–0 twist dyed yarn at a temperature of 90° C. were fed into a stuffer box at a feed rate of 1425 feet per minute and wound-up on a yarn package at 1160 feet per minute. The gas pressure was varied during the process to vary the resistance against the yarn, thereby maintaining substantially constant yarn volume in the stuffer box. The rates placed on the stuffer varied between 1.5 pounds and 5.0 pounds. The yarn received a uniform crimp having 14 crimps per inch controlled within ±2.0 crimps per inch. Still other methods which may be employed for producing the crimp in accordance with this invention are more specifically described in copending application Ser. No. 570,918, filed on Aug. 8, 1966, and Ser. No. 603,912, filed on Dec. 22, 1966.

The effect of twist and crimp levels and concentration of the various filaments upon the design of the fabrics is illustrated in the examples of Table II.

TABLE II.—EFFECT OF CONCENTRATION AND TWIST LEVEL UPON DESIGN

Ex. No.	Compositing	Percent of More Dark Expensive Contrast Component	Turns per Inch Before Combination	Turns per Inch After Combination	Note 1	Inches Spacings White	Inches Spacings Black	Type Fabric
1	Stuffer box crimper	49	0.7	0	130%	1.5–2	2–2.5	Double knit.
2	do	49	.15	0	140%	.5–1	.5–.75	Do.
3	do	49	.5	0	140%	.12–.25	.15–.3	Do.
3A	do	49	2.5	0	180%	----	----	Do.
4	do	49	0	.5	120%	.3–.4	.3–6	Do.
5	Control, not composited	49	----	----	40%	2–4	.3–6	Do.
6	Stuffer box crimper	49	.07	----	130%	1.5–2	2.0–2.5	3 colors, jersey kinit.
7	do	49	(1)	----	170%	.05–.25	.05–.25	Double knit.
8	do	33/33	.07	----	120%	.5–1.0	.5–1.5	Do.
9	do	33/33	.5	----	130%	.2–.4	[2] .2–4	Do.
10	do	33/33	2.5	----	135%	(3)	----	Do.
11	do	49	.07	----	110%	.5–.75	.5–1.0	Tricot knit.
12	do	33/33	.07	----	105%	.25–0.5	.25–0.5	Do.
13	do	49	.07	----	140%	.75–1.0	.75–1.0	Do.
14	do	49	.07	----	120%	.75–2	.75–2.0	Woven: cotton warp.
15	do	49	.07	----	150%	.25–2.0	[4] .25–2.0	Woven: nylon warp.
16	do	33	.07	----	165%	.5–1.5	[5] .25–2.0	Jersey knit, dark grey tones.
17	do	22	.07	----	205%	.5–1.25	[6] .25–2.0	Jersey knit, light grey tone.
18	do	49	.07	----	120%	.25–1.5	.25–2.0	Jersey knit, grey.
19	Fluid jet crimping	3.0	>0.1	0	1,000%	.25–2.0	(4)	Dark grey tone, circular knit rib.
20	do	1.76	>0.1	0	1,650%	.25–2.0	[7] 2.5–2.0	Circular knit rib.
21	Stuffer box crimper	33/33	.07	0	105%	.25–.75	.25–1.0	Woven.
22	do	33/33	.07	0	110%	.25–1.0	.25–1.0	Do.

Note 1—Percent optical design factors=dark contrast component, its apparent optical contribution to design/weight percent of dark contrast component.

[1] Entanglements. [2] Two colors. [3] Homogeneous blend. [4] Average, .75. [5] Average, 1.0. [6] Average, ¾. [7] Average, .6.

It can be seen from the data in Table II that in Examples 1 and 2, the double knit fabrics have designs, with the same concentration of black yarn, substantially different from each other with as little as 0.07 turn per inch. Likewise, Examples 3 and 4 were dramatically different from each other in that Example 4 showed very short stripes in a plane parallel with the knit direction, whereas Example 3 showed non-regularity of stripes with the stripes moving both in a parallel and in a vertical direction to produce a novel marl effect. Example 5 is a control wherein two separate ends were knitted as one in a fabric. This fabric was characterized by a long, irregular, unattractive stripe with no aesthetic appeal.

Example 6 illustrates a three-colored jersey knit fabric wherein the design spacings are in the direction of the stitch, similar to Example 1, except for a narrower zigzag design. This fabric gave an optical color transition less smooth than the double knits. Example 7 is a composite yarn having 30 entanglements per meter which was crimped and double knitted to give an excellent heather fabric with smooth transition between color zones. Here, there was no distinct white or black areas and the fabric had the appearance of a mixture of light and dark grey. Example 8 is a three-color combination of white, black and red overdyed with green, wherein the spacings are similar to Example 1, in geometric design, except that the stitch spacings are slightly reduced lengthwise and substantially reduced 90° to the stitch plane. Example 9 is a three-color blend combination also as in Example 8, except that it has a twist of 0.5 turn per inch. This gave the fabric a marl design. Example 10 is a double knit, three-color combination, having 2½ turns per inch and illustrates a complete salt and pepper effect. Example 11 is a tricot knit of two colors, i.e., black and white, top bar, white in bottom bar, and then overdyed blue. This fabric has a very attractive marl effect with the pattern more random and with less transition for color contrast in the fabric structure. The length of the contrasting color pattern is ⅓ of that of the control and about 66% of Example 13 without a lower bar knit. Example 12 is a tricot knit of three colors, i.e., black, white and a brownish-red on the top bar and a bottom bar of white.

Example 13 is a two-color combination tricot knit, about one-half the distance between the contrast area as that in Example 1. Example 14 is a woven fabric, two-color nylon composite yarn in the filling and cotton in the warp. This fabric has strong contrasting colors, a random, distinct and pleasing design. Example 15 is a woven fabric, two-color combination in the filling and a continuous filament nylon warp. This fabric is a richer, brighter fabric than the fabrics with cotton in the warp and is an illustration of the novel effect due to the change in the fabric design.

Examples 16, 17 and 18 demonstrate one of the novel aspects of this invention in that while there was a substantial decrease in the amount of the costly dope-dyed component, there was only a minor change in the average geometric dimensions of the random design in the direction of the stitch. There was, however, a little change in the actual character of the designs. Thus, as the concentration was decreased, the shading of the white zones by the dyed zones was less apparent. It has been found that there was an area of maximum contrast, with each manufacturing method, at optimum concentrations of the dark components. The design may be altered further by changing the twist level. A still further softening of contrast may be obtained by decreasing the concentration of the dark component. Examples 19 and 20 illustrate fabrics obtained from yarns crimped through a jet-texturizing device which resulted in a saw-tooth type crimp. It was unexpected to find, for example, that with concentrations as low as 1.5% of a black yarn in the fabric, the same geometric design could be obtained in comparison with a fabric with 49% of of the black yarn. The only basic change was the contrast and the softer tones at the lower levels of concentration of the darker blended component.

The changes in the geometric design, for the dark-colored components in jersey knit fabrics, with changes of concentration, e.g., from 49% to 1½% of the dark-colored component, may be seen in Table III, as follows:

TABLE III

Example No.	Percent White Component	Millimeters Distance Vertical for the Light Areas
18	49	1-3
16	33	1.5-4
17	20	2-6
19	3.0	2-7
20	1.76	4-8

Thus, it should be noted from the data in the tables that at all twist levels, the double knit fabrics are entirely reversible. In the three-color combinations, the double knit fabrics also show a remarkable change in design at the various twist levels. However, on the reverse side, there is substantially less change with the change in the twist level and the change noted is less of geometry and more of a change in texture. There exists, however, on the reverse side a change in design with a change in the twist level. In the jersey knit fabrics, there is a striking change in design with a change in the twist and entanglement levels, but the dark areas exist as a narrow band and are less massive than that characterized by the double knit fabrics. The high contrast areas in the jersey knit fabrics are characterized by a zigzag, stitched design. The jersey knits have a different design on the reverse side which points out the variety, interest level and utility of this invention.

These fabrics, as shown in Examples 16, 17 and 18, are highly useful for shirting, hosiery, dress goods, leotards, etc. The tricot knit fabrics exhibit less design contrast and a more uniform phasing of the design from one contrast level to the other. The stripes or design size is midway between the jersey knit and the double knit fabrics. The tricot (Examples 11, 12 and 13) and the double knit fabrics (Examples 1, 2, 3, 4, 7, 8, 9 and 10) have substantial utility for lingerie, blouses, sweaters, etc. A novel design change was observed also on the reverse side with a reduced contrast. Thus, these fabrics are fully reversible. The circular knit rib fabrics, as illustrated by Examples 19 and 20, show strong, bold contrast with zigzag designs of comparatively narrow bands. These knitted fabrics do not demonstrate, however, a good quality reversible design.

When the composite yarns of this invention were used in a plain weave fabric, as illustrated in Examples 14, 15, 21 and 22, the design was very narrow and of limited contrast, and when used with a staple warp, unless the colors are of deep contrasts in a composite structure, the design was white and subtle. However, when non-modified, continuous filaments of nylon were used in the warp and the composite structure of this invention was used in the filling, then the design was considerably bolder, richer and warmer. The plain weave fabric thus produced has a three-dimensional appearance which does not appear to be duplicable by other processes. By using the continuous filament composite yarns of this invention in one direction and a cotton staple in an opposite direction, for example, a design effect can be obtained which is as if the whole fabric was made of a blend of natural and synthetic stable-spun yarn, e.g., of polyester and cotton.

In woven fabrics where the continuous filament composite yarn of this invention is in one direction and the same or some other synthetic filament yarn is used in the other direction, a novel, three-dimensional, random leather-like design may be obtained. These woven fabrics, employing the novel composite structure, find utility in upholstering, seat belts, automobile seat covers, shirting, dress goods and for many other applications where staple fabrics or design effects are desired. In the woven fabrics where double weaves are used, reversible fabrics may be obtained with different and novel designs on either side. For instance, in a double plain weave, a plaid may be on one side and a plain weave may be on the other side, as in overcoats, with the composite structure of this invention resulting in a different design on both sides of the woven fabric. As an alternative, the yarns obtained by this invention may be employed as a twill face on one side and a plain weave on the other side. Thus, in the construction of seat belts, one side may have a modified double plain weave of one color design and a standard double weave on the other side with a different colored design. In those items where economy and mass production are essential, the composite yarns of this invention achieve their maximum utility since it is possible to use the more expensive components in low concentrations and still obtain the effect as if they were present at the higher concentrations.

Thus, by using various color combinations within the fabric composition, the same general trend may be obtained with each twist level and with each entanglement level. This same general trend is obtained as the design changes with the different methods of manufacture. However, the difference of the dark colored design in a direction 90° from the stitch is changed substantially more than in the design in the direction of the stitch. Thus, with the two-color combination yarns, maximum effectiveness for multi-colored combinations (greater than two) is obtained where the dark colored contrasting components are used in relatively small amounts, since the design is changed primarily in a direction opposite to the stitch direction, and, therefore, larger amounts of the more expensive color components are not very effective optically in changing the design.

As previously stated, the yarns may contain various additives which impart particular properties to the finished fabric. Preferably, the additives are incorporated into the dark contrasting filaments and since they are the more expensive components, they are used in lesser amounts in the total composite-yarn structure. These additives may be incorporated into the filaments either by adding the ingredients to the polymer prior to spinning or by after-treatment of the yarn and include, for example, flame-retardants, e.g., antimony, phosphorus and halogen compounds; delustrants, e.g., titanium dioxide; antistatic agents; adhesion promoting agents, i.e., isocyanates and epoxides; heat and light stabilizers, e.g., inorganic reducing ions, such as manganese, copper, tin, etc. Other additives include the amines, fluorescent agents and brighteners, crosslinking agents, bacteriostats, e.g., phenols and quaternary amines, etc. A more detailed description of the methods employed in incorporating the various additives into the synthetic filaments may be found in U.S. Patent No. 3,279,974 and Canadian Patent No. 882,293.

Heretofore, in the manufacturing of novelty yarns of the type described hereinabove, the processes involved expensive and time-consuming space dyeing or space treating. This invention, however, is concerned with a process and the products obtained therefrom for manufacturing yarns of at least two filaments of contrasting colors or colorability when treated in accordance with this invention, resulting in yarns having light and dark contrasting colored sections. When these yarns are used for knitting into various garments, the random, multicolor effect is pronounced appearing not as a color-blended fabric, which is expected, but appearing unexpectedly as a fabric made from space-dyed or space-treated yarns.

The different dyeing processes which may be used for purposes of this invention to obtain the colored or colorable yarns include, for example, dope-dyed, skein-dyed, finish-dyed, and the like. Continuous filaments of various combinations which are separately colorable include, for example, nylon, nylon-polyester, nylon and nylon-polyester blends, nylon-polypropylene, nylon-acrylic, and a variety of other known combinations.

As stated, the design of the fabrics may be altered by subjecting the filaments to mechanical operations, prior to compositing them in a crimper. The mechanical operations may include ring and traveler twisting, false-twisting, jet-twisting, entanglement by sonic jet, standard jet entanglement, commingling jet entanglement, needling entanglement, hydraulic jet entanglement, etc. The texturizing operation for compositing the filaments may include stuffer box crimping, jet crimping, i.e., to produce a saw-tooth, three-dimensional crimp, gear crimping, edge crimping, thermal-shock crimping, a combination of chemical and jet crimping, etc. Various fabrics and other textile articles may be manufactured from the composite-yarn structures of this invention by utilizing well-known methods including, for example, circular knit, e.g., double-knit, jersey knit, Jacquard-type knit, etc. Alternatively, warp knitting, e.g., tricot knits, Milanese, simplex, raschel, Jacquard, etc., may be employed. In addition, woven goods may be prepared from the composite structures and include the three basic weaves, i.e., plain weave, twill weave and satin weave. Other type weaves which may be considered as plain twill or satin-type include, for example, the Bedford cord, the bird's-eye weave, the waffle weave, the swivel weave, double cloth weave, pile weave, etc.

The yarns and fabrics obtained in accordance with this invention may be dyed and finished by utilizing conventional methods. Thus, for example, where the yarn structure comprises natural white filaments and dope-dyed filaments, the fabric obtained therefrom may be scoured and finished so that there is a contrast between the dope-dyed yarn and the natural color of the other yarns. The scoured fabric may be overdyed in a single dye bath to reduce the yarn to a lower shade level in comparison to the dope-dyed product. Space-dyeing techniques may be used also to achieve a novel and bulkier design interposed over the three-dimensional designs of this invention so as to add massiveness to the design. In addition, over-printing may be utilized as a means of superimposing additional design variations. As part of the fabric finishing operation, the design may be further modified by calendering, beetling, flocking, corduroying, etc.

What is claimed is:

1. A process of preparing texturized, composite yarn structures which comprises forming homogeneous, composite structures from at least two crimped continuous synthetic filaments of light and dark contrasting colors or colorability having a crimp level of 6–30 crimps per inch and subsequently subjecting the composited structures to an entangling operation to impart a level of 0.01 to 100 entanglements per meter; said contrasted colored or colorable filaments having a color contrast of at least six Gardner units; said composited yarn-structure comprising 0.5 to 49 parts by weight of at least one dark contrasting color or colorable filament and 51 to 99.5 parts by weight of at least one lighter colored or colorable filament.

2. The process of claim **1** further characterized in that the homogeneous composite structures are formed by simultaneously crimping a plurality of filaments of light and dark contrasting colors or colorability and subsequently twisting said structure to a level of 0.01 to 3 turns per inch.

3. The process of claim **2** further characterized in that the plurality of light and dark contrasting filaments comprise nylon filaments.

4. The process of claim **3** further characterized in that the nylon filaments comprise polycaproamide.

5. A process for preparing texturized composite-yarn structures which comprises combining at least two continuous synthetic filaments of light and dark contrasting colors or colorability by subjecting said filaments to (1) twisting to a level of 0.01 to 3 turns per inch, (2) entangling to a level of 0.01 to 100 entanglements per meter, and (3) crimping the combined filaments to obtain a homogeneous composite structure to a crimp level of 6–30 crimps per inch; said colored or colorable filaments having a color contrast of at least six Gardner units, said composite-yarn structures comprising 0.5 to 49 parts by weight of at least one dark contrasting colored or colorable filament and 51 to 99.5 parts by weight of at least one lighter colored or colorable filament.

6. The process of claim **5** further characterized in that said light and dark contrasting colored or colorable filaments are selected from the group consisting of nylons, polyesters, polyolefins, and acrylics.

7. The process of claim **6** further characterized in that the dark contrasting filaments comprise nylons and the lighter contrasting filaments comprise polyesters.

8. The process of claim **5** further characterized in that the filaments of light and dark contrasting color or colorability are first composited by crimping to a level of 6 to 30 crimps per inch and then subjected to twisting and entangling to the levels indicated.

9. A process for preparing texturized, composite-yarn structures which comprises forming composited, homogeneous structures by simultaneously crimping at least two synthetic filaments of contrasting colors or colorability wherein the filaments have a color contrast of at least six Gardner units and are crimped to a level of 6 to 30 crimps per inch; subsequently subjecting the filaments to entangling to a level of 1.0 to 100 entanglements per meter and twisting to a level of 0.1 to 3 turns per inch, said composited yarn structures comprising 0.5 to 30 parts by weight of at least one dark, contrasting colored or colorable filament and 70 to 99.5 parts by weight of at least one lighter colored or colorable filament.

10. The process of claim **9** further characterized in that the filaments are drawn to a ratio of 3 to 6 prior to being simultaneously crimped.

11. A texturized composite-yarn structure having an entanglement level of 1 to 100 entanglements per meter and a crimp level of 6–30 crimps per inch; said structure comprising 0.5 to 49 parts by weight of at least one dark contrasting, colored or colorable synthetic filament and 51 to 99.5 parts by weight of at least one lighter colored or colorable synthetic filament; said filaments having a color contrast of at least six Gardner units.

12. A colored fabric prepared from the textured, composite-yarn structures of claim **11** further characterized as having the dark, contrasting colored filaments homogeneously composited in the yarn to impart to the fabric a random, three-dimensional effect.

13. The colored fabric of claim **12** further characterized in that said fabric comprises natural filaments.

14. The colored fabric of claim **13** further characterized in that said natural filaments are selected from the group consisting of wool and cotton.

15. The texturized composite-yarn structure of claim **11** further characterized in that the dark contrasting colored or colorable filaments comprise nylon filaments and the lighter filaments are selected from the group consisting of polycaproamide, polyesters, polyacrylics, and polypropylene.

16. The texturized composite-yarn structure of claim **15** further characterized in that the dark contrasting colored or colorable filaments comprise nylon filaments and the lighter filaments comprise polypropylene.

17. The texturized composite-yarn structure of claim **15** further characterized in that the dark contrasting colored or colorable filaments comprise nylon and the lighter colored or colorable filaments comprise polyesters.

18. The texturized composite-yarn structure of claim **11** further characterized in that the dark contrasting colored or colorable filaments contain effective amounts of additives to improve the ultimate properties of the yarn structures and the fabrics prepared therefrom.

19. The texturized composite-yarn structure of claim **18** further characterized in that the dark contrasting colored or colorable filaments containing the additives are polycaproamide and the lighter colored or colorable filaments are selected from the group consisting of nylons, polyesters, polyacrylics, and polypropylene.

20. The composite-yarn structure of claim **19** further characterized in that the lighter colored or colorable filaments are polyesters.

21. The texturized composite yarn structure of claim **11** further characterized as having 0.01 to 3 turns per inch of twist.

22. The yarn structure of claim **21** further characterized in that the drak contrasting colored or colorable filaments have a Munsell lightness value of 0–6 units and a Munsell chroma value of 0–13 and the lighter colored or colorable filaments have a Munsell lightness value of 6–10 and a Munsell chroma value of 0–11.

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