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ARTIFICIAL YARN AND METHOD OF PRODUCING THE SAME

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Fig. 1.



Fig. 2.



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ARTIFICIAL YARN AND METHOD OF PRODUCING THE SAME

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This invention is a continuation-in-part of application Serial No. 354,064, filed August 24, 1940, and relates to artificial or synthetic yarns, particularly rayon yarns, the method of producing the same, and fabric made therefrom.

An object of this invention is to, in some instances, substantially reduce, by counter-balancing, the torsional forces in the yarn and, in other instances, to create in the yarn torsional forces in a direction opposite to that which results from twisting a yarn directly to the same finished twist and opposite to that which would be expected from a twist determination, as determined by a standard twist tester.

Another object of this invention is to accurately control the torsional forces of knitting or weaving yarns whereby said yarns possess new and useful characteristics.

Another object of this invention is to provide yarns having substantially reduced and/or controlled torsional forces to facilitate operations subsequent to twisting, for example coning and/or quilling, and the knitting or weaving operations, by substantially eliminating and/or controlling the curling, kinking or flying of the yarn.

A further object of this invention is to provide yarns having the torsional forces substantially reduced and/or controlled, which makes possible new knitted and woven fabrics.

A still further object of this invention is to provide yarns having the torsional forces substantially reduced and/or controlled, which makes possible knitted and woven fabrics in which the crepeing, shrinking, curling or twisting on a bias is substantially reduced and/or controlled.

Another object of this invention is to provide yarns, and fabrics formed thereof, of increased resiliency and elasticity.

Another object of our invention is to provide more compact yarns with the torsional forces reduced and/or controlled.

Another object of this invention is to provide sheerer, duller, and more snag-resistant fabrics.

Another object of this invention is to provide yarns of the maximum compactness and minimum torsional forces.

Another object of this invention is to provide a method of making the yarns having the aforementioned characteristics.

Another object of this invention is to provide a method in which rayon yarns have been twisted beyond the finished twist desired, twist-set to the necessary or desired degree and then untwisted to the desired twist, and finally the twist set to produce yarns whose superficies do not differ from that of a yarn that has been twisted directly to the same finished twist.

Another object of this invention is to provide a method wherein rayon yarns are twisted in one direction to impart a twist of from 3% to 60%

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greater than the desired finished twist, the twist set, the yarn subjected to a twisting operation in a direction opposite to the original twist to produce the desired finished twist, and finally the twist set, the twists and the degree of setting thereof depending on the torsional forces desired in the final yarn.

Other and further objects will become apparent from the following description and appended claims.

The above objects are broadly obtained by twisting a yarn beyond the finished twist desired, setting the twist, reverse-twisting the yarn to produce the desired finished twist, and setting the twist, the magnitude of the twist and the degree of setting the twist being such as to control the torsional forces of that yarn very accurately. By appropriate twisting operations in the opposite directions and the degree of setting of the respective twists, the knitting or weaving yarn can be made, as desired, to have (*a*) either or both the active and/or latent torsional forces practically eliminated or reduced to the desired or required degree, or (*b*) active torsional forces resulting from S-twist in a yarn showing a Z-twist only by conventional twist-testing methods, together with latent torsional forces practically eliminated or reduced the desired or required degree.

We have further discovered that when the aforementioned process is applied to rayon yarn, for best results the inherent characteristics of rayon that effect its resistance to twisting, its tendency to untwist after having been twisted, and the amount of twist that may be inserted and set without having an objectionable degree of tendency to untwist should be considered with respect to the various steps of the process.

The term "rayon" employed herein is intended to include all yarns formed of a cellulose or cellulosic material such as, for example, prepared by the viscose, cuprammonium or cellulose acetate process, irrespective of whether the yarns are formed of continuous filaments or staple fibers.

If rayon were perfectly elastic, then the torsion in a twisted rayon yarn would follow Hook's law, i. e. the torsion is proportional to the turns. However, rayon being far from perfectly elastic, the torsion of twisted rayon yarn varies considerably from Hook's law.

When referring to all of the many types of natural and artificial yarns, the "size × twist × strength factor" (size in denier × twist in turns per inch × strength in grams per denier) gives a good over-all relative indication of the resistance of a yarn to twisting and the tendency to untwist after having been twisted and the amount of twist that may be inserted and set, without having an objectionable degree of tendency to untwist. Rayon, however, possesses certain pe-

culiar characteristics which must especially be taken into consideration, said relevant characteristics being the elongation and plastic flow of the rayon at stress strain loads of spinning various amounts of twist under various percentages of relative humidity, and the degree of ductility, plastic flow or permanent elongation resulting from twist-setting.

Rayon, being synthetic, can and is being made to vary considerably in strength and elongation, but of special importance in the utilization of our invention is the fact that the elongation does not always have approximately the same relationship to the strength, and for this reason it is necessary to include the elongation of the yarn in any formula dealing with the resistance of various rayons to twisting and the tendency to untwist after having been twisted.

Tensile strength is the measure of the resistance of a yarn to elongation at the breaking point and, since no single or multi-filament yarn can be twisted without elongating the fiber in a helical form around its axis, it is quite evident that the strength or resistance to elongation is an important factor when dealing with torsion of a yarn. However, since the elongation of various rayon yarns varies so considerably under the same stress strain load, the factor of the elongation at the stress strain load of twisting must also be taken into consideration.

A comparison of stress strain load curves of both conventional and high tenacity continuous filament rayon of the several types, such as viscose, cuprammonium, and acetate process, and from various producers, readily shows the marked difference in elongation under the same stress strain load. It is true that these curves show the elongation as a result of load strain applied longitudinally along the yarn's axis, but each yarn resists elongation in a helical form around its axis, necessarily resulting from twisting, approximately the same as it resists longitudinal elongation. The marked differences mentioned above, between various kinds of continuous filament rayons are also present in rayon staple fiber yarns of various kinds.

Generally speaking, the elongation at the breaking point of various rayon yarns is proportional to the elongation at lower stress strains, such as conventional spinning loads, but for more accurate determination of the resistance of various rayon yarns to twisting and the tendency to untwist, the elongation at the twisting load must be specifically considered. It is customary in the art of rayon yarn processing not to use a twisting load in excess of ⅓ of that required to break the yarn, but generally the twisting load is 15% to 25% of the breaking strength, and it is therefore the elongation at these stress strain loads that particularly concerns us.

We have found that a very practical formula to use in comparing the relative torsion to be expected from various twisted rayon yarns is the

$$\frac{\text{"size} \times \text{twist"}}{\text{strength} \times \%\ \text{elongation at stress strain load of twisting}}$$

For accurate comparisons, the elongation at the stress strain load of twisting is necessary, but in most instances a good practical formula has been found to be

$$\frac{\text{"size} \times \text{twist"}}{\text{strength} \times \%\ \text{elongation (at the breaking point)}}$$

Since the property of elongation has been necessarily introduced into the aforementioned formula, the numerical values resulting therefrom are necessarily of a different magnitude than when the "size × twist × strength factor" is used. In connection with this formula, it is important to consider the atmospheric conditions under which the twisting load is applied, since rayon generally elongates up to 50% more when wet than when dry and consequently more twist may be evenly inserted under a given twisting load if the atmospheric conditions cause the rayon yarns to absorb more moisture, and the more moisture present in a rayon yarn being twisted under a given twisting load, the less tendency there will be to untwist from a given amount of twist. In other words, the elastic recovery of rayon after the removal of various stress strain loads varies considerably with the moisture content of the rayon when being twisted.

It is also important, when considering the torsion to be expected from a twisted rayon yarn, to take into consideration the degree of setting of the twist, since it is customary in the art of rayon yarn manufacturing to set the twist for the deliberate purpose of reducing the active torsion resulting from twisting. It can readily be appreciated that the degree of twist-setting, including the time that the yarn is exposed to the artificial atmosphere or to water, has a considerable effect upon the production of twisted rayon yarns. However, there are definite limitations to the control by twist-setting of the torsional forces of a twisted rayon yarn. We can best illustrate this by the following examples:

A 100-denier continuous filament viscose process rayon yarn was twisted 20 turns per inch and the twist set in a conventional manner, with the resultant yarn being a practical knitting yarn from the standpoint of being capable of being knit without kinking, snarling or flying of the yarn while knitting. A more improved knitting yarn was then produced by utilizing the very best known method of twist-setting, but still this improved yarn was found to be inferior, as hereafter set forth, to the same 100-denier rayon yarn which we produced, in accordance with this invention, by twisting the yarn 30 turns per inch in one direction, then setting the twist by the same very best known method of twist-setting, then twisting the yarn in the opposite direction 10 turns per inch, and then setting the twist just sufficiently to leave in the yarn a decided tendency to turn on its own axis in a direction opposite to that of the last twisting, i. e. though it contained Z-twist only when tested by conventional twist-testing methods, it also possesses S-twist active torsional forces. This latter yarn, produced in accordance with this invention, can be knit with greater tension without kinking and the knitted fabric knit therefrom shrunk less, had less bias, and was more resilient and elastic than the prior art yarns and fabrics formed thereof, respectively.

In certain embodiments of this invention, we have found it to be very advantageous for a knitting or weaving rayon yarn to have substantial active or visible torsional forces in a direction opposite to that which would result from twisting a yarn directly to a given twist. This can be accomplished in a yarn in which there is ply twist only in no other way than by the principles of this invention, i. e. by first twisting the necessary degree beyond the finished twist desired, setting the twist the required degree, and subsequently twisting in the opposite direction, and thereafter setting the twist the required degree

to produce the desired torsional forces in the final twisted yarn. In a one-way prior art twisted yarn, as for example a yarn twisted directly to the desired Z-twist, the torsional forces resulting from the twisting causes the yarn to tend to fly in an S-direction and any disturbance of the set of the twist, such as by stretching, change in atmospheric conditions, etc., adds to this tendency to fly in an S-direction. Also, since any contact with the spiral formation of the yarn surface mechanically tends to untwist the yarn, the frictional contact with said yarn while knitting or weaving exaggerates this tendency to fly.

In a yarn contemplated by the instant invention, and particularly that embodiment wherein the yarn contains S-twist active torsional forces even though the yarn shows Z-twist only, when tested by conventional twist-testing methods, any disturbance of the set of the twist as previously mentioned will counter-balance the S-twist torsional forces and the yarn will be prevented from flying in the S-direction, and indeed in any direction, either Z or S.

As is shown from the foregoing, the principles of this invention are applicable to the production of rayon yarns having either a finished low or high twist or indeed a twist higher than that which could be obtained by the prior art procedures. For purposes of this invention, a twisted rayon yarn having a

$$\left(\frac{\text{size}\times\text{twist}}{\text{strength}\times\text{elongation}}\right)$$

factor in excess of 60, such as 75 or more, is considered a highly twisted rayon yarn. The embodiment of the invention which contemplates a twisted yarn having a high twist or twist higher than the prior art yarn, in addition to possessing the aforementioned properties, will, when formed into fabrics, woven or knitted, result in fabrics having greater sheerness, dullness, snag resistance, resiliency and elasticity when compared to prior art fabrics formed of the prior art rayon yarns.

We have discovered that, by twisting beyond the finished twist desired, then setting the twist and then untwisting to the desired twist, and finally setting the twist to the desired degree, rayon yarns, due to their generally poor elastic recovery, will become substantially more permanently elongated and thus the fabrics produced therefrom will have substantially less opportunity or tendency to become further permanently elongated or baggy during use. We have also found that the greater permanent elongation of yarn produced by our method results in a closer relationship of the rayon micells, thus further adding resiliency to the yarn and fabrics made therefrom.

The mechanical formation of higher twist in rayon yarn causes greater elasticity due to the spring-like effect of the twist formation, but we have discovered that due to the greater permanent elongation of rayon yarns produced by our method, much of the plastic flow is removed and any further stretch of the yarn per se or in the fabric produced therefrom will result in greater recovery or elasticity.

The yarns contemplated and made in accordance with this invention are straight and have substantially the same compactness and surface appearance throughout their length as that of a like rayon yarn that has been twisted directly to the same finished twist. Herein, the term "straight yarn," or equivalent terminology, means a yarn which is free of crimps, curls or waves to substantially the same degree as possessed by a like yarn directly twisted to the same finished twist.

Rayon yarn can be directly twisted to produce a

$$\left(\frac{\text{size}\times\text{twist}}{\text{strength}\times\text{elongation}}\right)$$

factor" of 60 without encountering the serious difficulties due to the torsional forces resulting from twisting, whereby such rayon yarn can be used for many purposes. However, when rayon yarn is directly twisted to produce a

$$\left(\frac{\text{size}\times\text{twist}}{\text{strength}\times\text{elongation}}\right)$$

factor in excess of 60, such as, for example, 75, the yarn has a decided tendency to curl, kink, snarl or fly during operations subsequent to twisting, knitting or weaving of the fabric knit or woven therefrom and said yarn cannot be satisfactorily used for many purposes. According to the instant invention, there can be readily obtained a twisted rayon yarn having a

$$\left(\frac{\text{size}\times\text{twist}}{\text{strength}\times\text{elongation}}\right)$$

factor in excess of 60, such as, for example 75, and in which the tendency to curl, kink, snarl or fly during operations subsequent to twisting, knitting or weaving of the fabric therefrom is inhibited to substantially the same degree as that possessed by a rayon yarn twisted directly to a

$$\left(\frac{\text{size}\times\text{twist}}{\text{strength}\times\text{elongation}}\right)$$

factor of 60 or less. Further, according to this invention, there can be obtained a twisted rayon yarn having a

$$\left(\frac{\text{size}\times\text{twist}}{\text{strength}\times\text{elongation}}\right)$$

factor of 60 or less and which is substantially free of many of the undesirable and unavoidable features which characterize a directly twisted yarn of the same factor.

With rayon yarn, we have found in practice that with any degree of twisting, certain desirable benefits, as hereinbefore and hereinafter mentioned, result from our method of counter-balancing and/or controlling the torsional forces to various degrees. For example, in some instances on high, medium or low twisted rayon yarns, it may be desired to merely slightly minimize the active torsion to enable the twist setting to be minimized and/or to facilitate further processing; in other instances, it may be desired to create an opposite torque force just sufficient to enable the twist-setting to be minimized and/or to facilitate processing; but in still other instances, it may be the chief object to control the crepeing, or the shrinking, or the curling, or the twisting on a bias of the fabric knit or woven therefrom, while at the same time counter-balance the torsional forces resulting from twisting to a degree that will inhibit the yarn from curling, kinking, snarling or flying during operations subsequent to twisting or while knitting or weaving. It can thus readily be appreciated that the degree of counter-balancing desirable or necessary varies greatly depending upon the further processing or eventual use to which the yarn is to be put.

The correlationship between the twisting in the Z-direction, the degree of setting of the Z-

twist, the twisting in the S-direction, and the degree of setting of the resultant yarn depends on the torsional forces required in the final product. It will be clear to those familiar with the art that the embodiments of our invention for a given purpose and/or given effect, or various combinations thereof, are enumerable.

For any given purpose, the above relation of twist, degree of setting, counter-twisting, and degree of setting to produce the desired torsional forces may be determined by simple empirical experiments. Experiments have shown that the twisted rayon yarn can be counter-twisted from 3% to 60% of the original twist, depending on the nature of the twist setting and the torsional forces desired in the final product.

In the drawing:

Figure 1 is an enlarged diagrammatic elevation of a multi-filament rayon yarn resulting from twisting in the Z-direction 3% to 60% in excess of the desired final twist and setting; and

Figure 2 is an enlarged diagrammatic elevation of the rayon yarn shown in Figure 1 after twisting in the S-direction to the desired final twist and with or without setting.

Enumerable examples could be given to illustrate the many useful embodiments of our invention hereinbefore and hereinafter referred to. It is to be understood that the several embodiments hereinafter set forth are merely illustrative and in no way limitative of the invention.

Example A

Purpose.—To substantially reduce the degree of twist-setting of a rayon yarn having a

$$\left(\frac{\text{size}\times\text{twist}}{\text{strength}\times\text{elongation}}\right)$$

factor of 50, while the the same time have no greater torsional forces than is characteristic of the same yarn twisted directly to a

$$\left(\frac{\text{size}\times\text{twist}}{\text{strength}\times\text{elongation}}\right)$$

factor of 50, and then thoroughly set by conventional twist-setting methods.

Highly satisfactory results were obtained by (*a*) twisting a 100-denier rayon yarn of 2 grams per denier strength and 20% elongation to 22½ turns per inch, and (*b*) then setting the twist to a low degree, i. e. in an atmosphere of 120° F. dry with temperature at 110° F. with bulb temperature for 30 minutes, and (*c*) then twisting in an opposite direction 2 turns per inch, and (*d*) then coning the yarn without any further twist-setting.

In this example, the yarn was counter-twisted approximately 10% to the final

$$\left(\frac{\text{size}\times\text{twist}}{\text{strength}\times\text{elongation}}\right)$$

factor desired.

However, to meet some conditions, including reduction in twist-setting, we have found that counter-twisting to an amount of as little as 3% of the original twist gave the most beneficial results, especially in rayon yarns of a high

$$\left(\frac{\text{size}\times\text{twist}}{\text{strength}\times\text{elongation}}\right)$$

factor, such as 150.

To meet other conditions, such as when practically no twist-setting was to be used, we have found that counter-twisting as high as 60% of the original twist gave the most beneficial results.

Example B

Purpose.—To produce a high twist rayon woven fabric, which entailed a sufficient reduction in the active torsion of a rayon yarn having a

$$\left(\frac{\text{size}\times\text{twist}}{\text{strength}\times\text{elongation}}\right)$$

factor of 150, in order to facilitate the copping and weaving after using normal twist-setting methods.

Satisfactory results are obtained by (*a*) twisting a 100-denier rayon yarn of 1.8 grams per denier strength and 20% elongation to a

$$\left(\frac{\text{size}\times\text{twist}}{\text{strength}\times\text{elongation}}\right)$$

factor of approximately 155 and (*b*) then setting the twist in a normal manner, and (*c*) then twisting in an opposite direction to a

$$\left(\frac{\text{size}\times\text{twist}}{\text{strength}\times\text{elongation}}\right)$$

factor of 150, and (*d*) then copping the yarn and (*e*) then weaving the yarn.

In this example, the yarn was counter-twisted to an amount approximately 3% of the original twist, but it can readily be appreciated that to meet some conditions or combination of conditions, a very much greater degree of counter-twisting may be desirable or necessary and, in fact, we have found certain combinations of conditions that required as much as 60% counter-twisting.

Example C

Purpose.—To produce a rayon hosiery welt improved in resiliency and reduced in bagginess by the utilization of higher than conventional twist, but without the creases, etc., at the upper edge of the stocking, characteristic of rayon hosiery welts knit from rayon yarns having a

$$\left(\frac{\text{size}\times\text{twist}}{\text{strength}\times\text{elongation}}\right)$$

factor of approximately 60.

A highly satisfactory welt yarn having a final

$$\left(\frac{\text{size}\times\text{twist}}{\text{strength}\times\text{elongation}}\right)$$

factor of approximately 60 was produced by (*a*) twisting a 150-denier rayon yarn of 2 grams per denier strength and 18% elongation to a

$$\left(\frac{\text{size}\times\text{twist}}{\text{strength}\times\text{elongation}}\right)$$

factor of approximately 90, and (*b*) then setting the twist, and (*c*) then counter-twisting to the required twist, and (*d*) then setting the twist in an atmosphere of 170° F. dry bulb temperature and 160° F. wet bulb temperature for 2 hours, and (*e*) then coning the yarn.

In this example, the yarn was counter-twisted to an amount approximately 33½% of the original twist.

It is to be noted that we cannot utilize extremely high twisted rayon yarns in welts even though such yarns are perfectly balanced when dry because the twisted condition of the welts while wet, caused by the swelling of the yarn, prevents the welt from drying smoothly on the hosiery forms when boarding in a conventional manner, even though the welts when dried loose return to a perfectly smooth condition.

Example D

Purpose.—To produce a substantially shrink-proof rayon "crepe" fabric, processing the properties normally associated with "crepe," and also having the torsional forces so controlled that after washing and drying the fabric is substantially the same in size and appearance as before washing.

Highly satisfactory results were obtained by (*a*) twisting a 100-denier viscose rayon yarn of 1.8 grams per denier strength and 20% elongation to a

$$\left(\frac{\text{size}\times\text{twist}}{\text{strength}\times\text{elongation}}\right)$$

factor of 208, and (*b*) then setting the twist in an atmosphere of 175° F. dry bulb temperature and 165° F. wet bulb temperature, and (*c*) then twisting in an opposite direction to a

$$\left(\frac{\text{size}\times\text{twist}}{\text{strength}\times\text{elongation}}\right)$$

factor of 180, and (*d*) then setting the twist the same as used in step (*a*) above, and (*e*) then copping the yarn and (*f*) then weaving the yarn as hereafter described.

Two picks alternately of S-twisted and Z-counter-twisted and Z-twisted and S-counter-twisted yarn, prepared as described in the paragraph immediately preceding, were woven into the filling of an acetate warp viscose-filled crepe, for example a fabric 45 inches in the greige containing 6075 ends in the warp and 64 picks per inch in the filling. The woven fabric was boiled off and dyed in a conventional manner. The boiled-off and dyed fabric was straightened and dried loose, after which it was framed.

Prior to drying loose, the fabric was especially well straightened out so as not to interfere with action of the torsional forces in causing the fabric, which shrunk appreciably during boil-off and dyeing, to come back substantially toward its original width during drying, and thus producing the shrink-proof effect desired.

Under one normal boil-off, dyeing, and drying procedure, the fabric shrunk from 45½ inches in the greige to 32 inches after dyeing, and recovered to 37½ inches during drying and was framed to 39 inches.

Example E

Purpose.—To produce a substantially shrink-proof combination "crepe" fabric, processing the other properties normally associated with combination yarn fabrics.

Satisfactory results were obtained by (*a*) S-twisting a 100-denier rayon yarn of 1.8 grams per denier strength and 20% elongation to a

$$\left(\frac{\text{size}\times\text{twist}}{\text{strength}\times\text{elongation}}\right)$$

factor of 180, and (*b*) then setting the twist in an atmosphere of 175° F. dry bulb temperature and 165° F. wet bulb temperature, and (*c*) then Z-twisting the yarn to a

$$\left(\frac{\text{size}\times\text{twist}}{\text{strength}\times\text{elongation}}\right)$$

factor of 153, and (*d*) then setting the twist the same as used in step (*a*) above, and (*e*) then doubling and S-twisting, with 12 turns per inch, the yarn from (*d*) with 100-denier acetate yarn, and (*e*) then setting the twist, and (*f*) then repeating (*a*) to (*e*) starting with Z-twist and ending with S-twist, and (*g*) copping each combination yarn separately, and (*h*) weaving with a plain weave with 50 picks per inch using a suitable warp of approximately 3200 ends, and (*i*) boiling off and dyeing as usual (due to the control of the torsional forces, the fabric can be dyed on a continuous machine, thus substantially reducing production costs), and (*j*) then drying and framing as usual.

Example F

Purpose.—To produce a rayon hosiery yarn of maximum compactness, sheerness, lack of longitudinal waviness, and having the active torsional forces practically eliminated and the latent torsion substantially reduced.

Very satisfactory results were obtained by (*a*) Z-twisting various kinds and sizes of rayon to a

$$\left(\frac{\text{size}\times\text{twist}}{\text{strength}\times\text{elongation}}\right)$$

factor of from 107 to 120, (*b*) setting the twist in an atmosphere of 180° F. dry bulb temperature and 170° F. wet bulb temperature for 2 hours, and (*c*) then S-twisting the yarn to a

$$\left(\frac{\text{size}\times\text{twist}}{\text{strength}\times\text{elongation}}\right)$$

factor of from 75 to 87, (*d*) setting the twist for 1 hour in an atmosphere of 140° F. dry bulb temperature and 130° F. wet bulb temperature, and (*e*) then coning the yarn.

In this example, the yarn was counter-twisted approximately 30%.

It is, however, understood that to meet various conditions, considerably more or less counter-twisting may be used as required.

Example G

Purpose.—To produce a 75-denier rayon hosiery yarn of 40 turns per inch delivered Z-twist, said yarn having a substantial amount of active S-torsion and the latent Z-torsion substantially reduced.

Very satisfactory results were obtained by (*a*) Z-twisting the 75-denier rayon yarn which had a strength of 1.8 grams per denier and an elongation of 20% to a

$$\left(\frac{\text{size}\times\text{twist}}{\text{strength}\times\text{elongation}}\right)$$

factor of 135, (*b*) setting the twist for 1 hour in an atmosphere of 180° F. dry bulb temperature and 170° F. wet bulb temperature and (*c*) counter-twisting to a

$$\left(\frac{\text{size}\times\text{twist}}{\text{strength}\times\text{elongation}}\right)$$

factor of 83.3, (*d*) then setting the twist for 10 minutes in an atmosphere of 140° F. dry bulb temperature and 130° F. wet bulb temperature, (*e*) coning the yarn.

In this example, the counter-twisting was approximately 38% of the original

$$\left(\frac{\text{size}\times\text{twist}}{\text{strength}\times\text{elongation}}\right)$$

factor, but this percentage of counter-twisting may be increased or decreased substantially depending upon the condition to be met, the characteristics of the rayon, and the conditions under which it must be processed, as hereinbefore described.

In reference to the examples herein given, we have found that when rayon of other sizes, strength and elongation are to be used, very simi-

lar results may be obtained if said yarns are twisted and counter-twisted approximately to the same

$$\left(\frac{\text{size}\times\text{twist}}{\text{strength}\times\text{elongation}}\right)$$

factors used in our examples and otherwise similarly processed.

In this specification, the expression "Z-twist" defines a twist resulting from twisting the yarn in one (the left) direction, and the expression "S-twist" defines a twist resulting from subjecting the yarn to a twist in a direction opposite (i. e. right) to that of the Z-twist. Likewise, the expressions "Z-direction" and "S-direction" used herein define subjecting the yarn to a twisting operation in one (the left) direction and subjecting the twisted yarn to a twisting operation in the opposite (right) direction, respectively. It is, however, to be understood that the expression "Z-twist" as appearing herein is not intended to be restricted thereto, since it will be obvious to a person skilled in the art that the twist in the yarn as delivered may have an S-twist and subjected to counter-twisting in the Z-direction in accordance with this invention. In other words, the expressions "Z-twist" and "Z-direction" are used for convenience only and may define an "S-twist" and "S-direction" respectively.

Herein, wherever reference to "size" is made, it is intended to refer to denier. Also herein, wherever reference is made to "turns" or "twists," it is intended to mean turns per inch. Also herein, wherever reference is made to "strength," it is intended to refer to grams per denier. Also herein, wherever reference is made to "elongation," it is intended to refer to the percent of elongation at the breaking point, as determined by conventional methods.

As is apparent from the foregoing description, the principles of the instant invention have been described in connection with artificial yarns, and specifically rayon. It is, however, to be understood that the principles of this invention are, as set forth in application Serial No. 354,064, equally applicable to natural and synthetic or artificial yarns other than rayon.

Since it is obvious that various changes and modifications may be made in the above description without departing from the nature or spirit thereof, this invention is not restricted thereto except as set forth in the appended claims.

We claim:

1. A method of producing a straight, compact, twisted rayon yarn which, when tested by conventional twist-testing methods, shows twists in one direction only, which comprises subjecting a rayon yarn to a twisting operation in one direction to produce a twist of approximately from 3% to 60% in excess of the desired finished twist, setting said twist, subjecting said yarn to a twisting operation in the opposite direction to produce the desired finished twist, and setting the resulting yarn, the twisting operation in the said opposite direction and the setting of the twists being of such magnitude and degrees as to produce a twisted yarn in which the torsional forces are counter-balanced in accordance with the ultimate use of the yarn.

2. A method of producing a straight, compact, twisted rayon yarn which, when tested by conventional twist-testing methods, shows twists in one direction only, which comprises subjecting a rayon yarn to a twisting operation in one direction to produce a twisted yarn having a

$$\left(\frac{\text{size}\times\text{twist}}{\text{strength}\times\text{elongation}}\right)$$

factor in excess of 75, setting said twist, subjecting said yarn to a twisting operation in the opposite direction to produce a twisted yarn having a

$$\left(\frac{\text{size}\times\text{twist}}{\text{strength}\times\text{elongation}}\right)$$

factor of approximately 75, and setting the resulting yarn, the twisting operation in the said opposite direction and the setting of the twists being of such magnitude and degrees as to produce a twisted yarn in which the torsional forces are counter-balanced in accordance with the ultimate use of the yarn.

3. A method of producing a straight, compact, twisted rayon yarn which, when tested by conventional twist-testing methods, shows twists in one direction only, which comprises subjecting a rayon yarn to a twisting operation in one direction to produce a twisted yarn having a

$$\left(\frac{\text{size}\times\text{twist}}{\text{strength}\times\text{elongation}}\right)$$

factor of from 3% to 60% in excess of 75, setting said twist, subjecting said yarn to a twisting operation in the opposite direction to produce a twisted yarn having a

$$\left(\frac{\text{size}\times\text{twist}}{\text{strength}\times\text{elongation}}\right)$$

factor of 75, and setting the resulting yarn, the twisting operation in the said opposite direction and the setting of the twists being of such magnitude and degrees as to produce a twisted yarn in which the torsional forces are counter-balanced in accordance with the ultimate use of the yarn.

4. A method of producing straight, compact, twisted rayon yarns which comprises subjecting a rayon yarn to a twisting operation in one direction to produce a number of turns per inch of twist of from approximately 3% to 60% beyond the twist desired in the final yarn, setting the twist, subjecting the yarn to a twisting operation in the opposite direction a number of turns sufficient to produce a yarn having the desired number of turns per inch of twist and substantially free of the objectionable active and latent torsional forces which normally result from subjecting a yarn of like kind directly to the same twist in the final yarn and normally remaining after the setting of said direct twist, to thereby substantially inhibit the tendency of the yarn to curl, kink, snarl or fly during operations subsequent to twisting, knitting or weaving thereof and the creping, shrinking, curling, or twisting on a bias of the fabric formed from said yarn.

5. A method of producing straight, compact, twisted rayon yarns which comprises subjecting a rayon yarn to a twisting operation in one direction to produce a number of turns per inch of twist of from approximately 3% to 60% beyond the twist desired in the final yarn, setting the twist, subjecting said yarn to a twisting operation in the opposite direction a number of turns sufficient to create in the yarn an active torsional force in the desired direction, and setting the twist sufficiently to maintain said active torsional force in the yarn and to substantially inhibit the yarn from curling, kinking, snarling or flying during operations subsequent to twisting, knitting or weaving thereof and the crepeing, shrink-

ing, curling, or twisting on a bias of the fabric formed from said yarn.

6. A method of producing straight, compact, twisted rayon yarns which comprises subjecting a rayon yarn to a twisting operation in one direction to produce a number of turns per inch of twist of from approximately 3% to 60% beyond the twist desired in the final yarn, setting the twist, subjecting said yarn to a twisting operation in the opposite direction a number of turns sufficient to not only eliminate the active torsional forces normally resulting from the twisting of a like kind of yarn directly to the same twist in the final yarn and normally remaining after setting of the direct twist but also to create in the yarn an inherent tendency to twist in the direction of the first-named twist, and setting the twist sufficiently to maintain in the yarn a tendency to twist in the direction of the first named twist and to substantially inhibit the yarn from curling, kinking, snarling or flying during operations subsequent to twisting, knitting or weaving thereof and the crepeing, shrinking, curling, or twisting on a bias of the fabric formed from said yarn.

7. A method of producing straight, compact, twisted rayon yarns which comprises subjecting a yarn to a twisting operation in one direction to produce a rayon yarn having a

$$\left(\frac{\text{size}\times\text{twist}}{\text{strength}\times\text{elongation}}\right)$$

factor of from approximately 3% to 60% in excess of 75, setting the twist, subjecting the yarn to a twisting operation in the opposite direction a number of turns sufficient to produce a yarn having a

$$\left(\frac{\text{size}\times\text{twist}}{\text{strength}\times\text{elongation}}\right)$$

factor not less than 75 and substantially free of the objectionable active and latent torsional forces which normally result from subjecting a yarn of like kind directly to the same twist in the final yarn and normally remaining after the setting of said direct twist, to thereby substantially inhibit the tendency of the yarn to curl, kink, snarl or fly during operations subsequent to twisting, knitting or weaving thereof and the crepeing, shrinking, curling or twisting on a bias of the fabric formed from said yarn.

8. A method of producing straight, compact, twisted rayon yarns which comprises subjecting a rayon yarn to a twisting operation in one direction to produce a yarn having a

$$\left(\frac{\text{size}\times\text{twist}}{\text{strength}\times\text{elongation}}\right)$$

factor of from approximately 3% to 60% in excess of 75, setting the twist, subjecting said yarn to a twisting operation in the opposite direction to produce a yarn having a

$$\left(\frac{\text{size}\times\text{twist}}{\text{strength}\times\text{elongation}}\right)$$

factor not less than 75 and also to create in the yarn an active torsional force in the desired direction, and setting the twist sufficiently to maintain said active torsional force in the yarn and to substantially inhibit the yarn from curling, kinking, snarling or flying during operations subsequent to twisting, knitting or weaving thereof and the crepeing, shrinking, curling or twisting on a bias of the fabric formed from said yarn.

9. A method of producing straight, compact, twisted knitting or weaving yarns which comprises subjecting a rayon yarn to a twisting operation in one direction to produce a yarn having a

$$\left(\frac{\text{size}\times\text{twist}}{\text{strength}\times\text{elongation}}\right)$$

factor of from approximately 3% to 60% in excess of 75, setting the twist, subjecting said yarn to a twisting operation in the opposite direction to produce a yarn having a

$$\left(\frac{\text{size}\times\text{twist}}{\text{strength}\times\text{elongation}}\right)$$

factor not less than 75 and to eliminate the active torsional forces normally resulting from the twisting of a like kind of yarn directly to the same twist in the final yarn and normally remaining after setting of the direct twist and also to create in the yarn an inherent tendency to twist in the direction of the first-named twist, and setting the twist sufficiently to maintain in the yarn a tendency to twist in the direction of the first-named twist and to substantially inhibit the yarn from curling, kinking, snarling or flying during operations subsequent to twisting, knitting or weaving thereof and the crepeing, shrinking, curling, or twisting on a bias of the fabric formed from said yarn.

10. A method of producing straight, compact, twisted rayon yarns which comprises subjecting a rayon yarn to a twisting operation in one direction to produce a yarn having a

$$\left(\frac{\text{size}\times\text{twist}}{\text{strength}\times\text{elongation}}\right)$$

factor of from approximately 3% to 60% in excess of 75, setting the twist, subjecting the yarn to a twisting operation in the opposite direction a number of turns sufficient to produce a yarn having a

$$\left(\frac{\text{size}\times\text{twist}}{\text{strength}\times\text{elongation}}\right)$$

factor not less than 75 and active and latent torsional forces which normally result from twisting a yarn of like kind directly to a

$$\left(\frac{\text{size}\times\text{twist}}{\text{strength}\times\text{elongation}}\right)$$

factor of 60 or less and normally remaining after the setting of said direct twist, to substantially inhibit the yarn from curling, kinking, snarling or flying during operations subsequent to twisting, knitting or weaving and the crepeing, shrinking, curling, or twisting on a bias of the fabric formed from said yarn to at least substantially the same as that possessed by a like yarn directly twisted to a

$$\left(\frac{\text{size}\times\text{twist}}{\text{strength}\times\text{elongation}}\right)$$

factor of approximately not more than 60.

11. A method of preparing a straight, compact, twisted rayon yarn which, when tested by conventional twist-testing methods, shows twist in one direction only, which comprises twisting rayon yarn in one direction to produce a yarn having a

$$\left(\frac{\text{size}\times\text{twist}}{\text{strength}\times\text{elongation}}\right)$$

factor of approximately 135, setting said twist in the yarn, subjecting the yarn to a twisting operation in the opposite direction to produce a yarn having a

$$\left(\frac{\text{size}\times\text{twist}}{\text{strength}\times\text{elongation}}\right)$$

factor of approximately 83.3 and setting the twist.

12. A method as set forth in claim 11 wherein the original twist is set by subjecting the yarn one hour in an atmosphere of 180° F. (dry bulb temperature) and 170° F. (wet bulb temperature) and the twist in the yarn after the second twisting operation is set by subjecting the yarn for 10 minutes in an atmosphere of 140° F. (dry bulb temperature) and 130° F. (wet bulb temperature).

13. A method of preparing a straight, compact, twisted rayon yarn which, when tested by conventional twist-testing methods, shows twist in one direction only, which comprises twisting rayon yarn in one direction to produce a yarn having a

$$\left(\frac{\text{size}\times\text{twist}}{\text{strength}\times\text{elongation}}\right)$$

factor of approximately from 107 to 120, setting said twist in the yarn, subjecting the yarn to a twisting operation in the opposite direction to produce a yarn having a

$$\left(\frac{\text{size}\times\text{twist}}{\text{strength}\times\text{elongation}}\right)$$

factor of approximately from 75 to 87, and setting the twist.

14. A method as set forth in claim 13 wherein the twist in the yarn resulting from the original twist is set by subjecting said yarn for two hours to an atmosphere of 180° F. (dry bulb temperature) and 170° F. (wet bulb temperature) and the yarn resulting from the second twisting operation set by subjecting said yarn for one hour in an atmosphere of 140° F. (dry bulb temperature) and 130° F. (wet bulb temperature).

15. A yarn resulting from the method defined in claim 1.

16. A yarn resulting from the method defined in claim 3.

17. A yarn resulting from the method defined in claim 4.

18. A yarn resulting from the method defined in claim 5.

19. A yarn resulting from the method defined in claim 6.

20. A yarn resulting from the method defined in claim 7.

21. A yarn resulting from the method defined in claim 9.

22. A yarn resulting from the method defined in claim 11.

23. A yarn resulting from the method defined in claim 13.

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