United States Patent [19]

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[45] **Nov. 27, 1973**

[54] **METHOD FOR PRODUCING SYNTHETIC TORQUE YARNS**

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[22] Filed: **Feb. 17, 1971**

[21] Appl. No.: **116,225**

Related U.S. Application Data

[62] Division of Ser. No. 873,202, Nov. 3, 1969, Pat. No. 3,623,311.

[52] **U.S. Cl.** .... **57/157 TS**

[51] **Int. Cl.** **D02g 1/00**

[58] **Field of Search** .... 57/34 R, 34 HS, 36, 57/51–51.6, 55.5, 156, 157 R, 157 TS, 157 MS, 157 S; 28/72, 71.3

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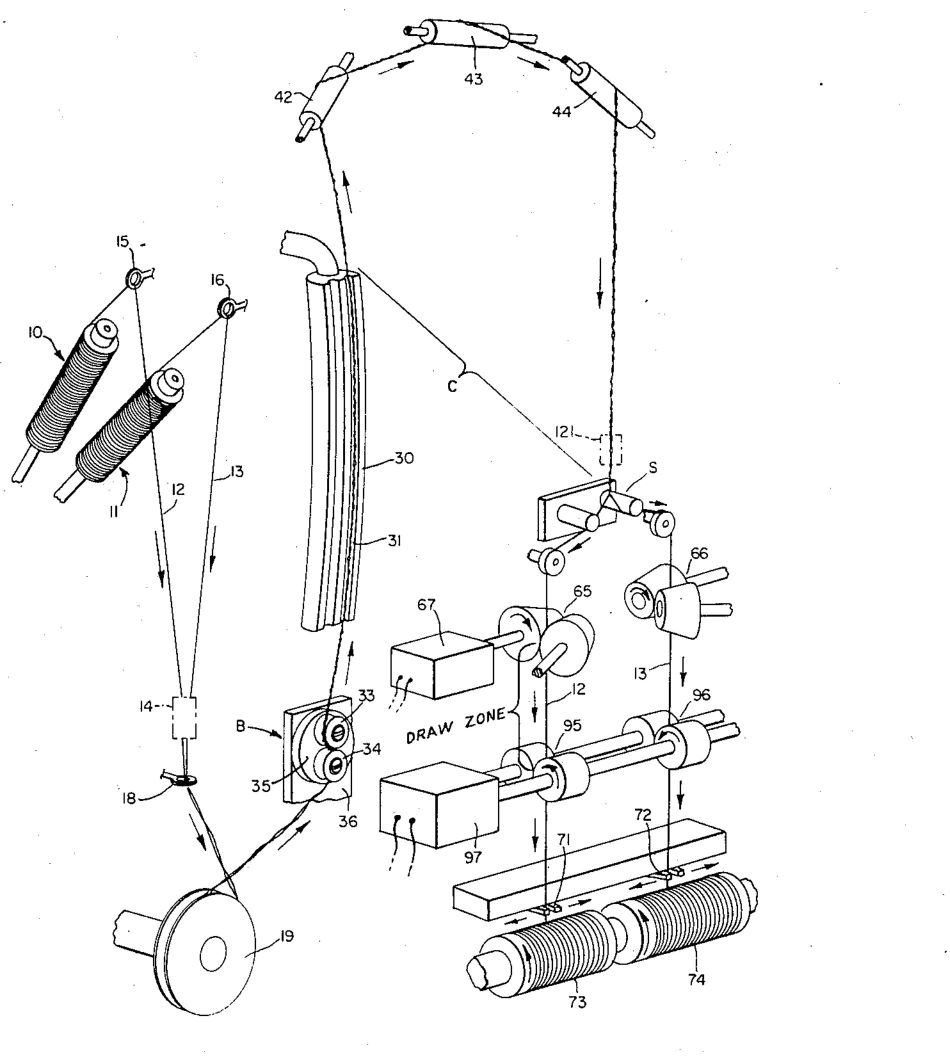
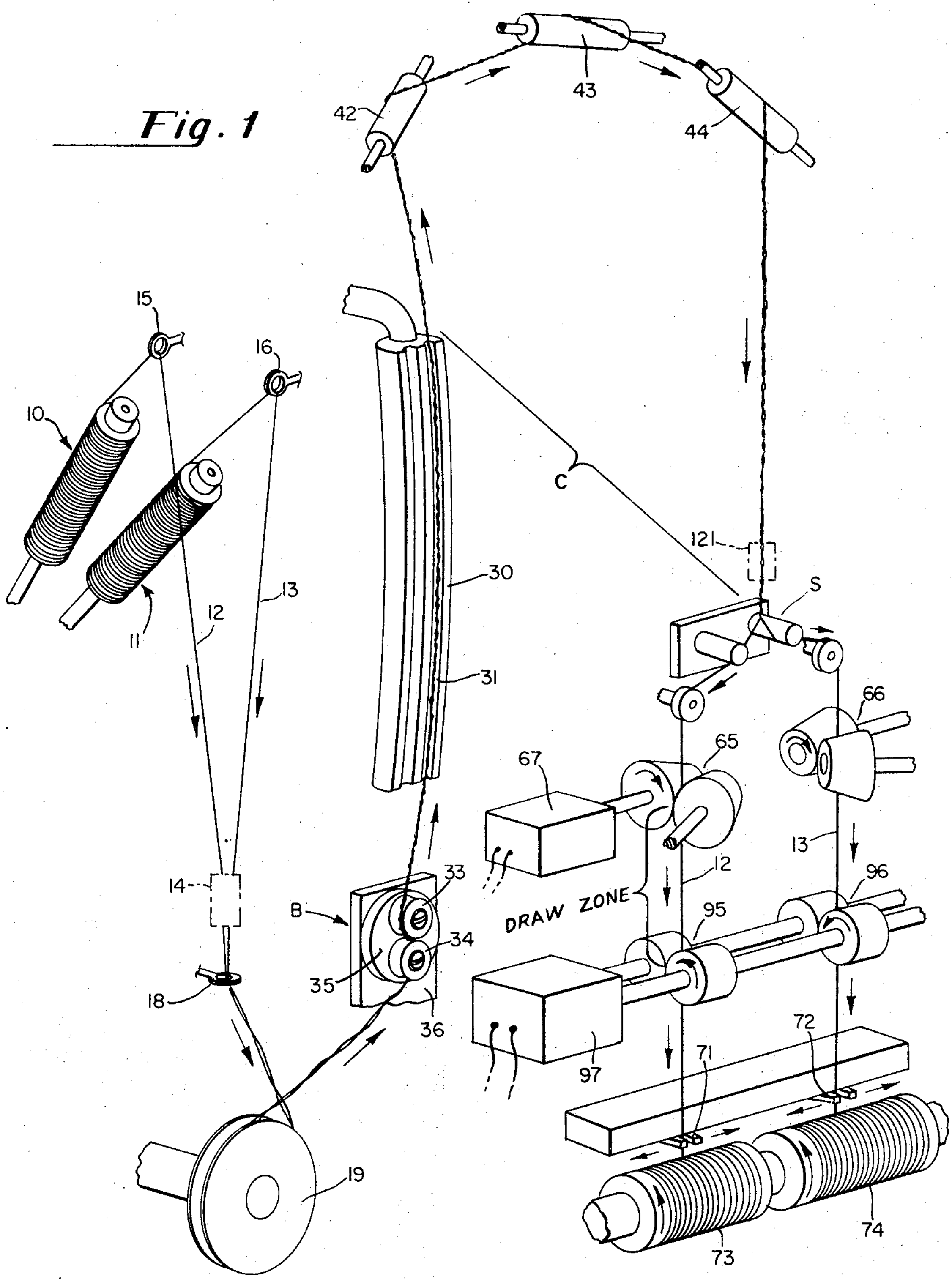
[57] **ABSTRACT**

Textured synthetic torque-lively yarns are cold drawn to eliminate substantially their tendency to snarl during normal knitting or other fabricating operations. The method produces a new product characterized by excellent stretch properties in the fabricated end product. The new yarn is particularly suited for use in the knitting of stretch hosiery and other fabrics.

2 Claims, 7 Drawing Figures





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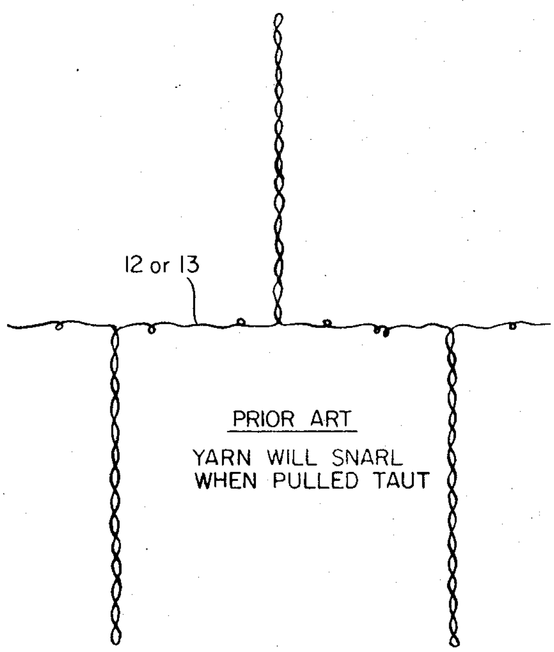
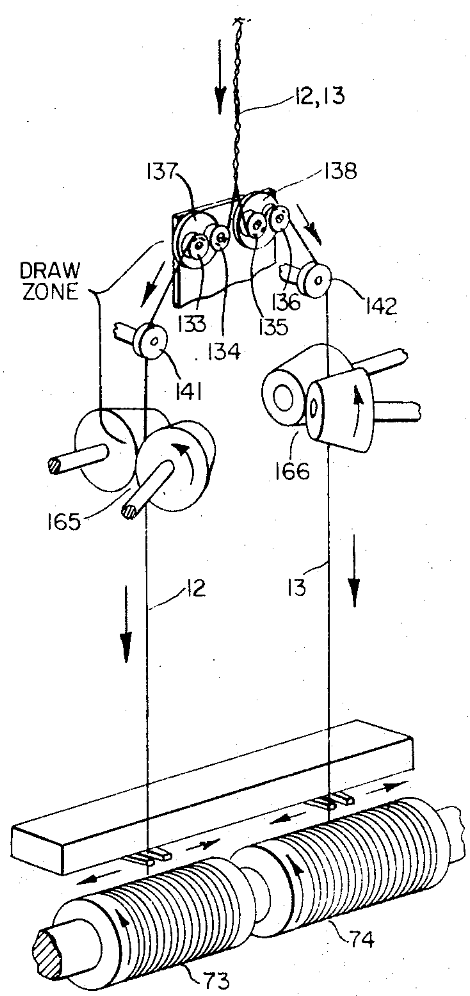


Fig. 3

Fig. 2



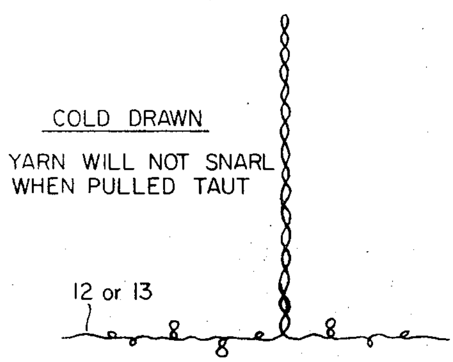


Fig. 4

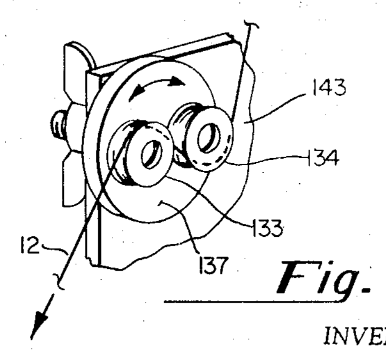


Fig. 6

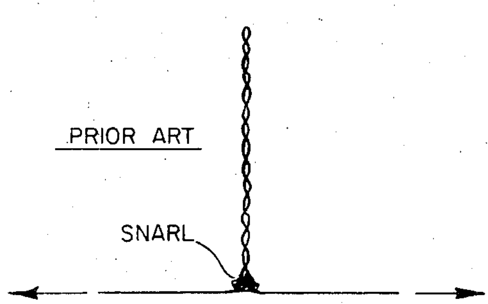


Fig. 5

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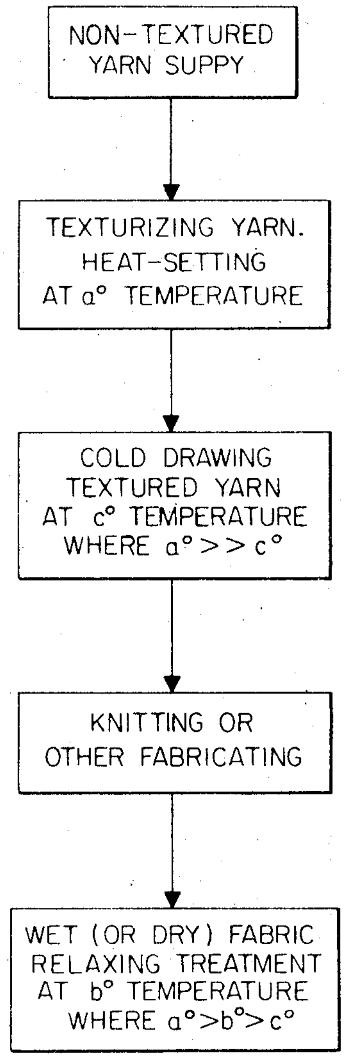

Fig. 7

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METHOD FOR PRODUCING SYNTHETIC TORQUE YARNS

This is a division of application Ser. No. 873,202 filed Nov. 3, 1969, now U.S. Pat. No. 3,623,311.

BACKGROUND OF THE INVENTION

The invention relates generally to apparatus and method for producing synthetic yarns having stretch characteristics and properties, and to a non-snarling stretch yarn product. The term "snarl" is used in this specification to define a tangled mass of yarn which is formed in relaxed condition and does not untangle when the yarn is processed under tension in conventional knitting or other fabricating machines, causing yarn breaks. The term "kink" is used in the specification to define a twisting or doubling of yarn upon itself when the yarn is relaxed but which untangles when the yarn is subsequently tensioned during processing in conventional knitting or other fabricating machines, causing no yarn break.

The yarns to which the invention is applied are synthetic yarns which are subject to heat setting and which, for example, may be produced from synthetic polyamide, polyesters, and the like, such as polyhexamethylene adipamide, polyethylene terephthalate, polycaproamide, and many other polymers useful in the textile industry, including mixtures and structural composites composed of two or more longitudinally extending segments of different polymers. The invention is particularly applicable to heat-settable continuous thermoplastic monofilaments formed from these polymers, and it is also applicable to multi-filament yarns.

It is known in the art to produce a high degree of torque or twist in synthetic yarns as are referred to immediately above. By "torque" or "twist" is meant either a twist along the longitudinal axis of the yarn inserted, for example, by a conventional false twist device, or helical crimp caused by wrapping two (or more) yarns generally spirally around each other. Such processes include heat setting such torqued or twisted yarn to produce yarn having residual torsional forces, i.e., to produce torque-lively yarn.

It has been found that conventional high-torque yarn of the type described above is difficult to knit. Such yarn has a tendency to twist upon itself to such a degree that it snarls when handled by the normal feed mechanism, for knitting machinery, for example. To overcome this undersirable tendency, it has been proposed, for example, in the prior art, to ply together two filament strands or threads, one of which is helically coiled in one direction while the other is helically coiled in the opposite direction, whereupon the tendency of the yarn to twise upon itself, kink and snarl is substantially reduced.

A variety of other methods have also been proposed for reducing the undesirable tendency of a stretch torque yarn to twist upon itself and snarl but these, to the best of my knowledge, have been unsatisfactory for the production of high-stretch hoisery from single-ply torque yarn.

SUMMARY OF THE INVENTION

An important object of the present invention is to provide apparatus and method for producing continuous-filament heat-settable thermoplastic yarn having high stretch but without having the undesirable tendency to snarl when handled by the normal feed mechanism of the textile machinery, such as knitting machines, for example.

Another important object of the invention is to produce a new product, namely, a new continuous-filament synthetic yarn having excellent stretch properties but with substantially reduced tendency to twist upon itself, and, more importantly, having a surprising capability, when twisting and doubling upon itself does occur, of untangling without snarling when processed in conventional knitting or other fabricating machines.

The foregoing, as well as other objects and advantages of the present invention, are accomplished by cold drawing the torque yarn. By "cold drawing" is meant drawing at ambient or room temperature, or at least at a temperature substantially lower than the temperature at which the torque yarn was heat set. Such cold drawing, it has been found, so alters the internal stresses and other physical characteristics of the yarn as to eliminate substantially the tendency to snarl, but the latent stretch qualities and characteristics of the yarn are not reduced, at least not to any extent.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a diagrammatic perspective view of one form of apparatus suitable for performing the method of the present invention;

FIG. 2 shows a modification of the apparatus of FIG. 1. This modification constitutes a presently preferred form of apparatus;

FIG. 3 illustrates the tendency of conventional torque yarn to twist upon itself and snarl;

FIG. 4 illustrates one embodiment of torque stretch yarn according to the invention and illustrates how the yarn either does not twist upon itself to the same extent, or when a long kink does occur, it does not snarl when handled by conventional feed mechanisms;

FIG. 5 shows a long kink having a snarl at its base, such as occurs in prior art torque-lively yarn;

FIG. 6 is an enlarged view of the tension device of FIG. 2.

FIG. 7 is a flow diagram to illustrate the method of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The apparatus diagrammatically shown in FIG. 1 is, except for the cold drawing step introduced by the present invention, substantially similar to that shown and described in U.S. Pat. No. 3,422,613, issued May 8, 1967, to E. J. Berger et al, particularly the modification shown in FIG. 7 of the said patent. Two packages **10** and **11** of yarn **12** and **13** are shown. The yarns **12** and **13** are heat-settable yarn filaments, as for example, continuous filaments of synthetic thermoplastic material. Examples of suitable materials are Nylon (polyhexamethylene adipamide or polycaprolactam), Dacron (polyethylene terephthalete), polypropylene, copolymers of vinyl chloride, and others. The single ends of yarn **12** and **13** may preferably be monofilaments, but may also be multi-filament yarns.

At start-up, the single ends of yarn **12** and **13** may be pre-wrapped helically together as by a form of pretwist device **14** shown and described in Carruthers U.S. Pat. No. 3,237,391. The yarn ends **12** and **13** are passed through guide eyes **15** and **16** to the pretwist device **14**, then through guide eye **18** to a hysteresis or tension-adjusting wheel **19**, then up through a twist-barrier device B, up through the arcuate contact heater **30**, laterally over the guide rollers **42, 43, 44,** and down to a separating device S where the two plies of the yarn **12, 13** are separated.

The pre-twist device **14** puts a predetermined number of turns per inch into the yarn in a texturing zone which extends from the twist barrier device B to the separation device S.

The twist barrier device B may take a number of forms but is shown in FIG. **1** to comprise a pair of pins **33, 34** mounted on the enlarged head **35** of a stud threaded into a support arm **36.** The stud has a wing nut (not seen) so that the stud and its enlarged head **35** may be rotated to adjust the positions of the pins **33, 34.** When the twist in the two ply yarn **12, 13** tries to run upstream beyond the barrier device B, it encounters first pin **33,** then pin **34,** then the tension-adjusting wheel **19,** and finally the guide eye **18.** The pins **33, 34** are equidistant from the axial center of the stud so that rotation of the stud and its head **35** adjusts the positions of pins **33, 34** relative to the yarn path. In FIG. **1,** adjustment of head **35** counterclockwise will increase the angle of departure of the two-ply yarn **12, 13** from the linear path of the yarn. The greater the angle at pin **33** the greater the resistance to the passage of the twist as it tries to run upstream. Pins **33, 34** are preferably hour-glass shaped and may preferably be made of ceramic material. They are fixed, i.e., not rotatable, on their own axis.

In FIG. **1,** the downstream path of the two-ply helically twisted yarn **12, 13** extends upward from the twist barrier device B to a corner roller **42,** above the heater **30,** then laterally over roller **43** to a corner roller **44** above the separation device S. To effect the change in direction from upward to lateral, and from lateral to downward, without affecting the twist, three adjustable freely-rotatable rollers **42, 43** and **44** are employed. Each of the rollers **42, 43** and **44** is so disposed angularly that the helix path of the twist of the yarn is circumferential to the surface of the roller over which it is rolling. When this condition exists the twist is not disturbed by contact with the roller and the helically twisted yarn has the same number of turns per inch when it leaves each of the rollers **42, 43** and **44** as it has when it approaches the roller. Each of the rollers **42, 43** and **44** is mounted (by means not shown) to be fully adjustable as to angular and elevational positions.

Heater **30** is an elongated arcuate compact heater which may preferably consist of an arcuate tube through which steam is passed. The outer forward surface of the elongated tube is provided with at least one lengthwise groove **31.** The yarn ends **12** and **13,** after passing through the twist barrier device B, are pulled upwardly as a two-ply helically twisted yarn through the groove **31** of the heater. The groove **31,** through which the twisted two-ply yarn is passed, tends to restrain the yarn from migrating laterally relative to the linear yarn path. When the yarn ends are in twisted condition, as represented by the two-ply yarn **12, 13,** shown in the groove **31,** the individual yarn filaments follow a helical path.

The heated two-ply helically twisted yarn **12, 13** is set in the cooling zone C, which extends from the upper end of heater **30** to the separation device S. In FIG. **1,** the cooling zone C is formed by direct exposure of the twisted yarns to the air of the room in which the texturizing apparatus is installed. This has been found to be entirely adequate in actual practice, even for high-speed operations.

In the illustrated apparatus in FIG. **1,** the yarn is pulled through the texturing apparatus by two pairs of conical nip rolls **65** and **66** driven by a variable speed drive **67.** The rolls **65** and **66,** the drive means **67,** the takeup rolls **73** and **74,** the reciprocating traversing guide means **71** and **72,** and the separating device S, may, if desired, be similar to prior art equipments, such, for example, as are shown in U.S. Pat. No. 3,327,462, issued June 27, 1967 to William Kirk Wyatt, entitled "Yarn Separating Means."

If the system of FIG. **1,** is used in the texturing of a single end of yarn, either monofilament or multifilament, as distinguished from the texturing of two ends plied together as described hereinabove, the false twist would be inserted into the yarn at a point downstream from the corner roller **44** rather than by the pretwist device **14.** Such a device is normally referred to as a false-twist spindle and is indicated in the drawing by the dot-and-dash rectangle **121.** Use of a separation device S is then not necessary and only one pair of delivery rolls is required. Other forms of false twist device may also be used in lieu of a false-twist spindle.

To return now to a description of FIG. **1** when used to texture two ends of yarn — the yarns **12** and **13** are separated at the separation point S. Each of the separated yarns in the regions between the separation point S and the nip of the withdrawing rolls **65** and **66** is pulled substantially straight, that is to say, while the helical twist imparted to the yarn ends in the texturing zone is latent in the yarn, and while the yarn when relaxed will return to its helical condition, during the operation of the texturing machine of FIG. **1,** the tension on the yarn between the nips of the rolls **65** and **66** and the separation point S is sufficient to pull the yarn into a straightened condition.

When a very high number of turns of twist per inch is applied to such yarn and the yarn is processed in conventional knitting or other fabricating machines, it tends to be "torque lively" and to twist upon itself, as indicated in FIG. **3,** and to snarl when straightened, as indicated in FIG. **5,** as when processed in a conventional knitting or other fabricating machine. The effect is particularly pronounced in low-denier monofilament yarns, such as a **15**-denier nylon, for example. I have discovered, however, that this tendency of the helical yarn to snarl, as indicated in FIG. **5,** can be substantially completely eliminated by cold drawing the helical yarn after texturizing and before processing it in the knitting or other fabricating machine. As previously indicated, the term "cold drawing" is used in this specification to mean drawing the yarn at a temperature which is lower than the temperature at which the twist was heat-set into the yarn. Ordinarily, the "cold drawing" temperature is approximately equal to, or slightly above the ambient temperature of the room in which the cold drawing equipment is located.

In FIG. **1,** I have illustrated one form of apparatus for providing the cold drawing necessary to achieve the surprising result referred to above. In FIG. **1,** I have provided pairs of draw rolls **95** and **96** and I drive these draw rolls, as by variable speed drive **97,** at such rotational speed that the surface speed of rolls **95, 96** is somewhat higher than the surface speed of the upper pairs of rolls **65** and **66.** In one case, for example, **15** denier monofilament Nylon **66** yarn, textured on the apparatus shown in FIG. **1**, was subjected to drawing between the nips of rolls **95** and **65** and the nips of rolls **96** and **66** with a draft ratio of 1.3 to one. This provided an elongation of the yarn of the order of about five percent. The resulting yarn had, surprisingly, a substantially complete elimination of any tendency to snarl when used at the usual minimal tension in the feed of conventional hosiery knitting machines. The same yarn, when not cold drawn, snarled so badly and so frequently that breakages occurred so often that it was utterly impracticable to mass-produce hosiery on the same machine.

The extent of cold drawing, expressed as the percentage of elongation based upon the original straight length of torque yarn, may be within the range of about three percent to about 20 percent for best results in accordance with this invention.

In summary, by cold drawing the yarn in the region between the nips of rolls **95, 65,** and **96, 66,** the apparatus and method of FIG. **1** provides a means for the continuous production of substantially zero-snarl textured stretch yarn which, when relieved of longitudinal tension after the cold drawing operation, will assume a form illustrated schematically in FIG. **4.** Although it does appear that this yarn has much smaller kinks and perhaps a few long kinks, (one being illustrated in FIG. **4**), the important and surprising difference is that the kinks are of a different kind. All the kinks, even the long kinks, have been found to untangle when they are subjected to the application of tension, and they do not snarl when processed in conventional knitting machinery, even when fed at the minimum tension.

In the modification of FIG. **2,** the apparatus is similar to that of FIG. **1** except that in FIG. **2** the textured yarn ends **12** and **13** are run over adjustable pairs of tension-adjusting pins **133, 134** and **135, 136** which may be similar in material, shape and mounting to twist-barrier pins **33** and **34** shown in FIG. **1** and previously described herein. The tension-adjusting pins **133, 134,** and **135, 136,** may be preferably of ceramic material and may preferably be hour-glass shaped. Each of the pins of a pair is mounted on the enlarged head of a threaded stud, equidistant from the center axis of the stud. This is seen best in the enlarged view of FIG. **6.** Thus, adjustment of the position of the pins of the pairs is made by rotating the studs to rotate the heads **137, 138.** The yarns **12, 13** are separated, and each of the separated yarns is trained under an inner pin (**134** or **135**), then over the outer pin (**133** or **136**), then over a guide pin **141** or **142,** and then down through the nips of the pairs of draw rolls **165** and **166** to the take up rolls **73** and **74.**

FIG. **6** is an enlarged view of one of the pair of tension-adjusting pins, namely, pins **133, 134** mounted on stud head **137**, supported in support arm **143.** In FIG. **6**, the stud is shown provided with a wing nut.

In FIG. **2,** cold drawing occurs between the tension-adjusting pins and the nips of the rolls **165, 166** which now function as draw rolls. The draw tension is provided by the frictional drag contributed by the pins **133, 134.** The amount of this tension, and thus the extent of the draw, may be regulated by adjustably turning each disc **137, 138** and securing it in its adjusted position, thus causing the yarn to travel through an adjustably tortuous path with correspondingly adjustable friction drag.

In one specific run, in the case of the 15 denier Nylon 66 monofilament yarn referred to above, it required approximately 30 grams to cold draw the yarn sufficiently to eliminate for practical purposes the tendency to snarl. This amounts to about 2 grams per denier for the cold drawing operation. This compares to about 1/2 gram per denier which is the normal tension applied for the texturing operation.

In summary, I have discovered that when textured yarn is "cold drawn" as described, it may be processed in conventional knitting or other textile fabrication machines without snarling, thereby substantially eliminating yarn breaks from this cause. Yet when the resulting fabrics are subsequently subjected to a filament relaxing step at a temperature above the cold-drawing temperature, as by heat relaxing in an autocalve, or by passing of the fabrics through a dye bath or a hosiery boarding or setting procedure, the yarn in the fabric recovers all or a substantial part of its initial bulk and stretchiness, and the fabric product has superior stretch properties as compared to stretch fabrics heretofore produced.

It is believed that, after such heat-relaxing, the yarn in the fabric also recovers all or some of its tendency to snarl, but this is academic in the fabric stage because it is no longer necessary to run the yarn through the fabricating machine.

FIG. **7** is a flow diagram which illustrates a method of the present invention. A supply of non-textured yarn is pulled through a texturing apparatus where the torque is heat-set into the yarn at a temperature of $a°$, which in a typical case may be of the order of 400° F. The textured torque-lively yarn is then cold drawn at a temperature of $c°$ which is much less than $a°$. In a typical case, $c°$ may be room temperature of the order of 70° F. The cold drawn yarn is then stored, or shipped, in package form, or may be subjected to direct fabrication as in a knitting machine, for example. The fabric product is then subjected to conventional processing which may involve tumbling in an autoclave at temperature $b°$. Temperature $b°$ is substantially higher than $c°$ but less than $a°$. In a typical case, temperature $b°$ may be of the order of 180°–200° F. The yarn in the resulting knitted or other fabric has surprising stretch. For example, actual articles of ladies' hosiery, made of 15-denier Nylon subjected to 10 percent cold drawing showed a body elongation of about 250 to 290 percent when tested four layers thick. These tests were conducted at the leg portion of the hosiery, doubled over to present four layers, and by stretching all four layers longitudinally in unison, and by comparing the stretched length with the original length. This is an exceedingly large amount of stretch as compared to presently available stretch hosiery.

This invention is not limited to torque lively yarn produced by helical wrapping, but also applies to yarn that has been twisted about its own axis by means of a false twist spindle, for example.

What is claimed is:

1. In a continuous method of making a novel yarn product, the steps which comprise:

a. continuously twisting heat-settable synthetic thermoplastic yarn,

b. heat-setting the yarn at a predetermined temperature while in a twisted condition,

c. continuously cooling the yarn, and

d. after cooling continuously drawing the cooled yarn sufficiently to elongate the yarn at a temperature substantially below the heat-setting temperature.

2. The method defined in claim **1,** wherein the drawing temperature is substantially ambient temperature.

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