

Dec. 29, 1942.

J. B. MILES

2,306,401

YARN PRODUCTION

Filed Oct. 4, 1941.

2 Sheets-Sheet 1

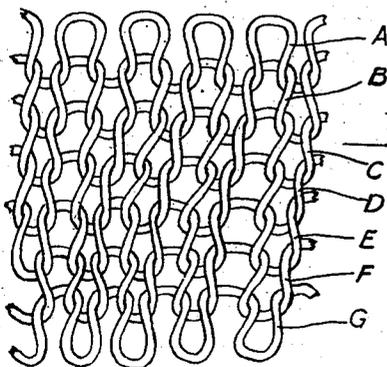
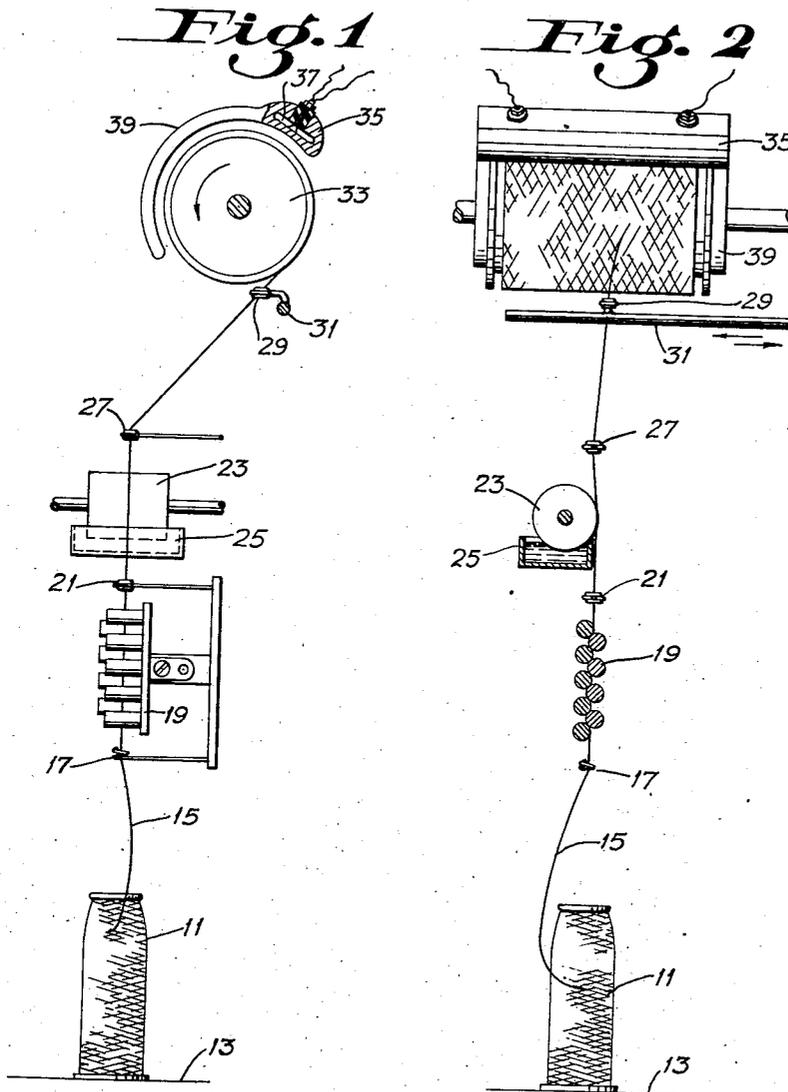


Fig. 3

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2 Sheets-Sheet 2

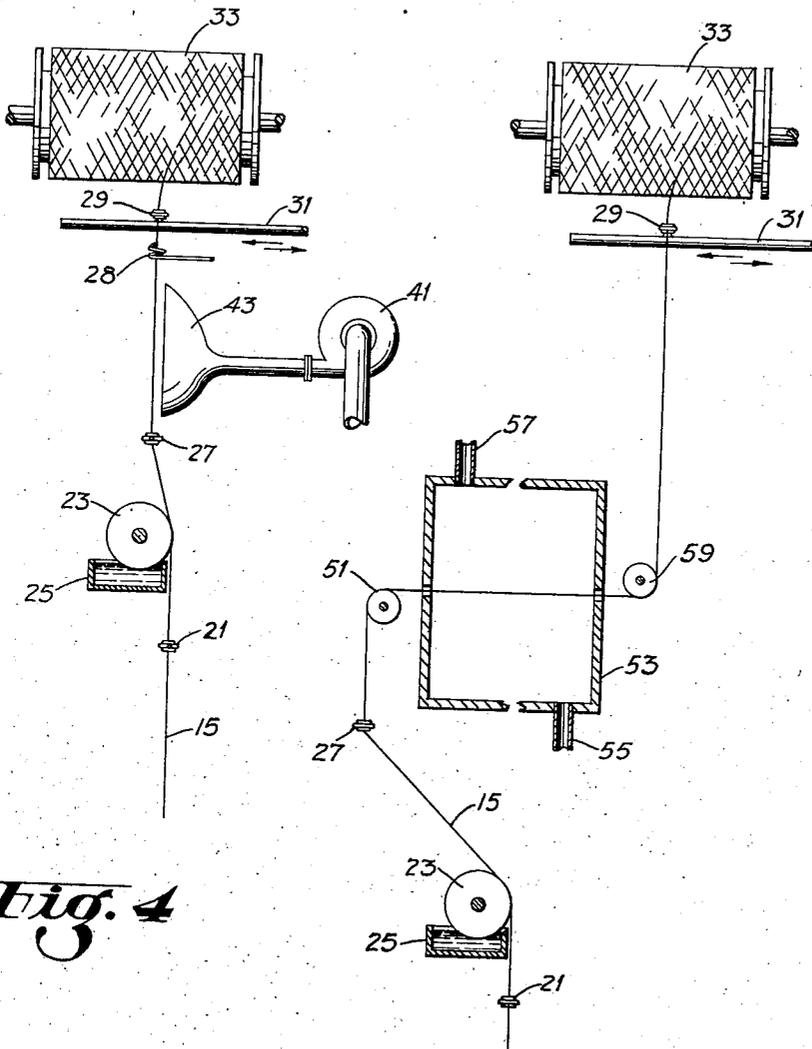


Fig. 4

Fig. 5

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2,306,401

YARN PRODUCTION

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Application October 4, 1941, Serial No. 413,606

7 Claims. (Cl. 57—140)

This invention relates to the production of a highly twisted and sized yarn comprising filaments of a synthetic linear polymer. The invention will be described with particular reference to Nylon yarns, i. e., yarns comprising filaments of synthetic linear polyamides as disclosed in Carothers United States Patent No. 2,130,948 and Carothers United States Patent No. 2,071,253. Since, however, the other synthetic linear polymers disclosed in Carothers United States Patent No. 2,071,250 are subject to the difficulties involved in the uniform sizing of Nylon, and since they may also be advantageously processed in accordance with the present invention, the present application, in its broad aspects, relates to the sizing of all synthetic linear polymers disclosed in Patent No. 2,071,250. The term "synthetic linear polymers" as used throughout the present specification and claims is limited and restricted in scope to the specific synthetic linear polymers disclosed in Patent No. 2,071,250.

The sizing of Nylon yarns has, heretofore, been carried out with great difficulty. Sizes and sizing processes suitable for use in the sizing of other yarns have, as a general rule, been unsuitable for use in sizing Nylon yarns. The term "sizing," as used throughout the present specification and claims, refers to and is specifically restricted to the application of an adhesive coating to a yarn to protect the many filaments thereof during the formation of a textile material from the yarn, and to protect the filaments during the subsequent handling of the textile. The term "sizing" does not refer to the application of other finishes, dressings, oil coatings, liquid treatments and the like.

The present invention is directed to the sizing of the yarn "on-the-run," that is, as the yarn passes from one package to another. The sizing of yarn in package form, or skein form, is generally considered to be inferior due to yarn degradation, waste of size, and non-uniformity of application. Furthermore, in skein sizing, it is difficult to apply a sufficient percentage of size to give adequate protection to the yarn filaments.

Heretofore, in the sizing of yarn on-the-run, two general methods of size application and yarn drying have been practiced. One of these methods comprises the application of size to the yarn and the passing of the yarn in contact with heating devices to completely dry the yarn before it is wound on to the package. By this method, the yarn is necessarily heated to temperatures in excess of 75° C. The other method comprises the application of size to the yarn and the winding of the yarn while it is still wet, as disclosed in the copending application of Edgar W. Spanagel, Serial No. 369,951, filed December 13, 1940.

Both of these two general methods of sizing have disadvantages when applied to the sizing

of Nylon yarn. In the first of the two above-mentioned processes, due to the high temperature used in drying the yarn, the yarn is subjected to setting conditions, which, due to probable slight non-uniformities in the size content of the yarn, impart non-uniform setting in successive short sections of the yarn. The resulting yarn has after twisting, in successive short lengths thereof, non-uniformity or irregularity in twist-liveliness, i. e., tendency of a twisted yarn to untwist. Yarn having short-length irregularity in twist-liveliness is unsuitable for use in the production of full-fashioned hosiery. Hosiery produced from said yarn has dye streaks and furrows coursewise of the fabric which are of sufficient severity to degrade the hosiery into irregulars. The streaks are particularly conspicuous when the stocking is illuminated from a glancing angle and viewed at a similar angle from the opposite edge of the fabric. The streaks seem to be associated with skewed stitches. This phenomenon will be referred to hereinafter as a "flash defect" and is different from so-called "rings" which may be easily observed from any angle and which show no furrows.

In the second of the two processes, the yarn forms a relatively dense package of wet yarn which takes an unduly long period of time to dry. Furthermore, in the drying of such a wet package of yarn, the size composition wicks out to the surface of the package, forming a shell of hardened yarn. This leads to some difficulty in unwinding the outer layers of yarn and promotes the non-uniformity of size content along the yarn. This disadvantage in the wet winding of sized yarn is particularly noticeable when the yarn has a low twist, i. e., a twist of less than 5 turns per inch. (The sizing of low twist yarn is particularly desirable, since the yarn consumer is better equipped to introduce a subsequent high twist, i. e., a twist in excess of 15 turns per inch, to the yarn than the producer, whereas the producer is better equipped to size the yarn than a yarn consumer.)

It is, therefore, an object of the present invention to provide an improved method of sizing, on-the-run, synthetic linear polymer yarn, particularly Nylon yarn, which has a low twist of less than 5 turns per inch, and subsequently unwinding the dry, sized yarn from the package and imparting a high twist in excess of 15 turns per inch twist.

It is another object of the present invention to size a low twist Nylon yarn and subsequently impart a high twist thereto, without imparting thereto objectionable non-uniformity of twist-liveliness.

It is another object of the present invention

to size, on-the-run, a low twist Nylon yarn without causing objectionable wicking of size composition on to the surface layers thereof.

Other objects of the invention will appear hereinafter.

The above-said objects may be accomplished, in general, by sizing and winding, in a continuous operation, a synthetic linear polymer yarn having a twist of less than 5 turns per inch, drying the sized yarn, during said continuous operation, between room temperature and 50° C. at a sufficiently high rate that the completely wound yarn package contains not to exceed 12% moisture, based on the weight of the dry yarn, and subsequently imparting a twist in excess of 15 turns per inch to the yarn.

The method of processing yarn in accordance with the present invention will be more clearly apparent by reference to the following detailed description when taken in connection with the accompanying drawings, in which:

Figure 1 is a diagrammatic side elevational view of one form of apparatus suitable for use in accordance with the present invention.

Figure 2 is a diagrammatic front elevational view of the apparatus shown in Figure 1.

Figure 3 is a greatly enlarged view of a portion of knit hosiery fabric showing "flash defects."

Figure 4 is a diagrammatic front elevational view of another modification of apparatus suitable for use in the present invention.

Figure 5 is a diagrammatic front elevational view of still another modified form of apparatus which may be used in carrying out the present invention.

Referring to Figures 1 and 2 of the drawings, reference numeral 11 designates a pirn of yarn positioned on a support 13. The yarn 15 is drawn from one end of the pirn and passed upwardly through pigtail guide 17, washboard tensioning device 19 and yarn guide 21. The yarn is then passed over size-applying roller 23 which is positioned within trough 25 containing a quantity of a suitable size. The yarn then passes through yarn guide 27, and then through traverse guide 29 positioned on traverse bar 31. The yarn is wound on to a bobbin 33 which may be driven in any desired manner. A strip heater 35 is positioned about the rotating yarn bobbin 33. The strip heater comprises a resistance heating element 37 and a shield 39 for maintaining the heated atmosphere in contact with the rotating yarn package.

The size-applying roller 23 is rotated in any desired manner and with a speed dependent upon the quantity of size desired to be applied to the yarn 15. Naturally, if the size-applying roller is rotated at a higher speed, relative to the linear speed of the yarn, a greater amount of size will be applied to the yarn. The yarn, which is moist with the size, is passed through the atmosphere to the wind-up bobbin 33 where continual heat is applied to the yarn. The strip heater must be adjusted in such a manner that the yarn will not be heated above a temperature of 50° C. so as to avoid imparting any setting action to the moist yarn. The linear speed of the yarn will, therefore, be adjusted so that the yarn, without heating the same above 50° C., will be wound into a completed package which will contain not to exceed 12% moisture. The yarn may, of course, be completely dried by the strip heater so long as the temperature of the yarn does not exceed 50° C.

Referring to Figure 3 of the drawings, the sev-

eral courses of the knit yarn indicate the effect of short length irregularities in twist-liveliness of the yarn. The yarn courses A, B, E, F, and G have the loops in substantially symmetrical form, whereas the loops in yarn courses C and D show the yarn to be slightly skewed, which is due to short length irregularities in twist-liveliness of the yarn. These short sections in the courses of the knit fabric are referred to in the art as "flash defects."

Referring to Figure 4 of the drawings, the yarn 15 is again passed through yarn guides 21 and 27 between which it is contacted with a size-applying roller 23. In this view, the tensioning device is not shown. The yarn passes from yarn guide 27 through yarn guide 28 and then through yarn traverse guide 29 positioned on traverse bar 31. Between yarn guides 27 and 28 a nozzle 43 is positioned adjacent the length of the yarn for the purpose of blowing air against the yarn to dry the same. This air may be directed through the nozzle by means of blower 41 or similar means. The air may be at room temperature or it may be heated to elevated temperatures which will heat the yarn to a temperature not to exceed 50° C. By this form of apparatus, the yarn may be dried more rapidly and the linear yarn speed increased accordingly. In this form of device, as in the device shown in Figures 1 and 2, it is necessary that the yarn is dried sufficiently that the completely wound package will contain not to exceed 12% moisture.

Figure 5 of the drawings illustrates another modification of the invention in which the yarn is dried on-the-run in such a manner that the linear speed of the yarn is unlimited. The yarn is passed under tension over the size-applying roller in the same manner as in Figures 1, 2 and 4. The yarn is then passed through a drying tunnel 53 which may be of any desired length. Warm air may be passed into the tunnel through conduit 55 and from the tunnel through the conduit 57. The temperature of the air may be between room temperature and that temperature which will heat the yarn to a temperature not to exceed 50° C. The yarn is passed from the tunnel over guide roller 59, then through yarn traverse guide 29 and on to the bobbin 33. Here again the yarn must be dried sufficiently that the completely wound package will contain not to exceed 12% moisture. If desired, the tunnel 53 may be positioned vertically about the vertically traveling yarn.

The following examples illustrate preferred methods of processing yarn in accordance with the present invention. The details set forth in the examples are not, of course, to be considered as limiting the invention thereto.

In all of the examples the yarn processed is 30-denier, 10-filament, 1½ turns per inch polyhexamethylene yarn, and the basic composition of the size used is as follows:

	Per cent
Partially hydrolyzed polyvinyl acetate *-----	68.5
Boric acid (based on the partially hydrolyzed polyvinyl acetate)-----	21.5
Polyethylene glycol of an average molecular weight of 4000 (based on the partially hydrolyzed polyvinyl acetate)-----	10.0

*The partially hydrolyzed polyvinyl acetate was of Saponification No. 140±10 and was within the viscosity range of 400 to 500 seconds (Universal Saybolt) at 78° F. in 14.5% solution in water.

Example I

The yarn was sized with the above mentioned basic size composition diluted with water to contain 91% water. The linear speed of the yarn passing over the size roll was 2,000 feet per minute with a size roll speed adjusted to deposit on the yarn 4.0% of solid size (based on the weight of the dry yarn). The yarn passing over the size roll was under a low tension of 0.1 gram per denier. The yarn was dried as it was wound on to a bobbin surrounded, as shown in Figures 1 and 2 of the drawings, with a 150 watt, 6½ inch strip heater, provided with a shield to hold the warm air on the bobbin in such a manner that the yarn on the bobbin was repeatedly exposed to the drying conditions until it was covered by the oncoming yarn. Determinations showed that the temperature imposed on the yarn was less than 50° C., the humidity was less than 50%, and the average moisture content of the yarn on the bobbin at the end of the winding was 10%. The package of yarn was free from wicking of size composition when subjected to a drying operation which will completely dry the same. The yarn was subsequently unwound from the dry package and twisted to 30 turns Z-twist, twist-set by subjecting the same for a period of 1.5 hours to an atmosphere having a dry bulb-wet bulb temperature ratio of 170° F./165° F., and then coned and oiled.

Ladies' full-fashioned hosiery made from this yarn was free from "flash defects," and the method of drying afforded greater speed of sizing. The uniformity of twisting was not excellent as a result of the low tension used. The twist analysis of 2.5 inch sections showed a twist count range of 58 to 87 with an average of 75.

Example II

The yarn was sized with the above mentioned basic size composition diluted with water to contain 88% water. The linear speed of the yarn passing over the size roll was 2,000 feet per minute with a size roll speed adjusted to deposit on the yarn 3.0% of solid size (based on the weight of the dry yarn). In the sizing step, the yarn was maintained under a tension of 0.33 gram per denier. The higher tension effectively prevented flutter and prevented the yarn from occasionally spreading out into a band and picking up large quantities of size as happens when the tension is lowered. As a result, the yarn has a better twist uniformity. As the yarn was wound on to a bobbin, it passed in the region of an infra-red heater, whereby the average moisture of the yarn on the bobbin at the end of winding was reduced to 12% since the yarn on the bobbin was repeatedly exposed to drying conditions until it was covered by the oncoming yarn. The package of yarn was free from wicking of size when dried. The sized yarn was subsequently unwound from the dry package and twisted to 30 turns Z-twist, twist set, coned and oiled.

Ladies' full-fashioned hosiery made from this yarn showed a very remarkable freedom from flash defects. It is interesting to note that twist analysis of consecutive 2.5 inch sections taken from the coned yarn over a 6-foot length showed a twist count range from 71 to 82 with an average twist count of 75. This very desirable twist uniformity is due to the high tension employed during sizing.

The method of determining twist count is as follows:

The yarn to be tested was carefully unwrapped without disturbing the twist with ½ inch wide Scotch tape strips every 2½ inches. The yarn was cut into 2½ inch sections by cutting through the middle of the tape. The sections were mounted in the usual twist counter and the twist determined in the customary way. By this technique, the twist in the section, as it was in the original sample, is carefully determined.

For convenience, the examples have been discussed in terms of 30-denier, 10-filament, 1.5 turns polyhexamethylene adipamide yarn. It will be understood that this was merely for convenience and that the invention is not limited either to filament denier, yarn denier, the particular degree of low twist, nor to the specific type of synthetic linear polymer yarn. The invention is generally applicable to all the synthetic linear polymer yarns above referred to.

The invention has been described in terms of sizing a low twist yarn and subsequently twisting. The examples have been concerned with sizing a 1½ turns per inch yarn and twisting to 30 turns per inch. It will be obvious that the main problem is to twist a sized yarn and that while the problem is more acute as the difference in preliminary twist and final twist increases, the twist in a yarn being sized may vary from 0 to 5 turns. Similarly, the final twist may vary from 15 turns to 50 turns.

Similarly, the invention has been discussed in terms of a specific size which consists of partially saponified polyvinyl acetate treated with boric acid and compounded with polyethylene oxide. It will be well understood that the principles of this invention can be equally employed with other satisfactory Nylon sizes.

An apparatus illustrated has been shown in order that the invention might be quite clear. It will be understood, of course, that several embodiments of apparatus are merely illustrative. The yarn may come from and go to any sort of spool or pirn or container. The yarn may have the size applied to it in any desired manner, such as by brushing, spraying or the like. The tension may be imposed on the yarn by any one of a large number of well-known tension devices.

Certain illustrative methods of drying the freshly sized yarn have been set forth. This invention generally comprehends a method of drying on-the-run wherein the temperature imposed on the yarn does not exceed 50° C., and wherein the average moisture content of the yarn, when the winding is completed, is 12% or less.

In the above mentioned examples, the advantage of tension in sizing was illustrated. In Example I, a tension on the yarn of 0.1 gram per denier resulted in a yarn having a twist count range of 58 to 87 in 2½ inch sections of the yarn. In Example II, using a tension of 0.33 gram per denier, the twist count range was 71 to 82. This difference is believed due to fluttering of the yarn, and a spreading of the filaments of the yarn, while in contact with a size roller and thereby picking up varying quantities of the size. The twist subsequently placed in the yarn will be greater at the thinner sections of the sized yarn.

Although it is not essential, it is highly desirable to carry out the process of the present invention by sizing under a relatively high tension. It has been found that flutter of the yarn on the size roller can be very materially reduced, if not eliminated, if the tension on the yarn exceeds 0.15 gram per denier.

One of the attributes of this invention is that

highly twisted, uniformly sized yarn, free from short length irregularity in twist-liveliness, is produced by a process in which the twist is added after the yarn has been sized. Another attribute is that the yarn produced according to this invention is capable of producing ladies' full-fashioned stockings remarkably free from flash defects.

By reason of this invention, there is now opened up the possibility for the producer of yarns, such as nylon yarns, of selling a low twist yarn, uniformly sized throughout, which the consuming trade can convert into a highly twisted yarn of such quality as is useful for the delicate operation such as full-fashioned stockings require.

More importantly, the yarn made in accordance with the examples produced ladies' full-fashioned stockings which passed the most critical tests for flash defects.

One of the unexpected results which accrued from this procedure was the discovery that the sized yarn ran much better in the final twisting operation with far less degradation of the yarn. This is a matter of considerable importance to commercial throwsters.

Since it is obvious that many changes and modifications can be made in the above described details without departing from the nature and spirit of the invention, it is to be understood that the invention is not to be limited to these details except as set forth in the appended claims.

I claim:

1. The method of producing a highly twisted and sized synthetic linear polymer yarn which comprises sizing and winding, in a continuous operation, a synthetic linear polymer yarn having less than five turns per inch twist, drying said sized yarn during said continuous operation, said drying carried out between normal working room temperature and 50° C. at a sufficiently high rate that the completely wound package contains not to exceed 12% moisture based on the weight of the dry yarn, and subsequently imparting a twist in excess of 15 turns per inch to the yarn.

2. The method of producing a highly twisted and sized nylon yarn which comprises sizing and

winding, in a continuous operation, a Nylon yarn having less than five turns per inch twist, drying said sized yarn during said continuous operation, said drying carried out between normal working room temperature and 50° C. at a sufficiently high rate that the completely wound package contains not to exceed 12% moisture based on the weight of the dry yarn, and subsequently imparting a twist in excess of 15 turns per inch to the yarn.

3. The method of producing a highly twisted and sized polyhexamethylene adipamide yarn which comprises sizing and winding, in a continuous operation, a polyhexamethylene adipamide yarn having less than five turns per inch twist, drying said sized yarn during said continuous operation, said drying carried out between normal working room temperature and 50° C. at a sufficiently high rate that the completely wound package contains not to exceed 12% moisture based on the weight of the dry yarn, and subsequently imparting a twist in excess of 15 turns per inch to the yarn.

4. The method of producing a highly twisted and sized nylon yarn which comprises sizing and winding, in a continuous operation, a Nylon yarn having less than 5 turns per inch twist, said sizing carried out with a tension on the yarn exceeding 0.15 gram per denier, drying said sized yarn during said continuous operation, said drying carried out between normal working room temperature and 50° C. at a sufficiently high rate that the completely wound package contains not to exceed 12% moisture based on the weight of the dry yarn, and subsequently imparting a twist in excess of 15 turns per inch to the yarn.

5. As a new article of manufacture, a package of dry, sized synthetic linear polymer yarn produced in accordance with the process of claim 1.

6. As a new article of manufacture, a package of dry, sized nylon yarn produced in accordance with the process of claim 1.

7. As a new article of manufacture, a package of dry, sized polyhexamethylene adipamide yarn produced in accordance with the process of claim 1.

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