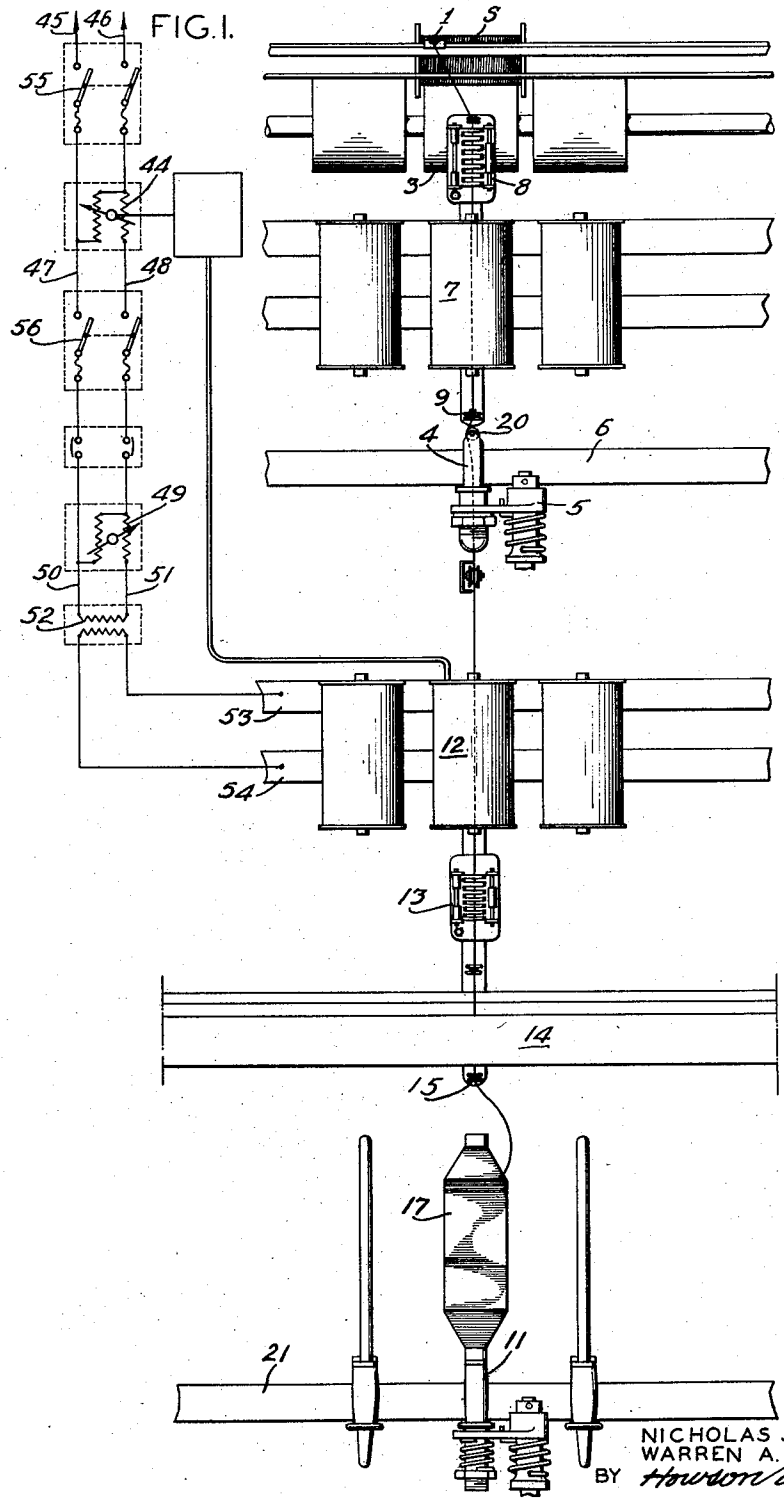
June 23, 1959 N. J. STODDARD ET AL 2,891,376

METHOD OF PROCESSING YARN

Filed Sept. 22, 1955 3 Sheets-Sheet 1

FIG. 1.



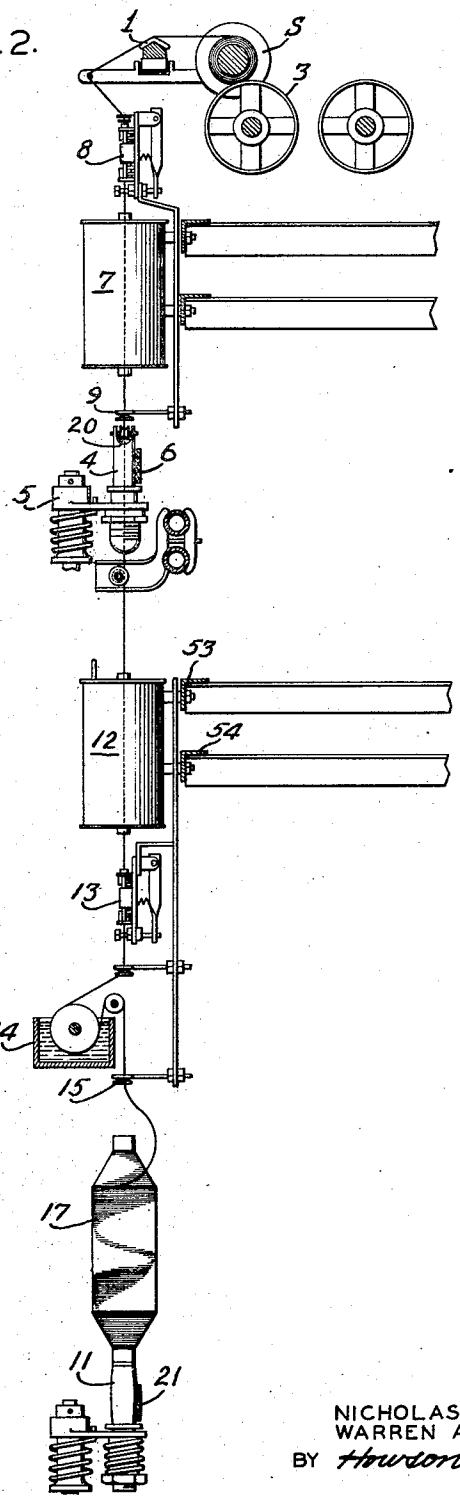
INVENTORS:
NICHOLAS J. STODDARD
WARREN A. SEEM
BY Howson & Howson
ATTYS.

June 23, 1959 N. J. STODDARD ET AL 2,891,376

METHOD OF PROCESSING YARN

Filed Sept. 22, 1955 3 Sheets-Sheet 2

FIG. 2.



INVENTORS:
NICHOLAS J. STODDARD
WARREN A. SEEM
BY Howson & Howson
ATTYS.

June 23, 1959 N. J. STODDARD ET AL 2,891,376

METHOD OF PROCESSING YARN

Filed Sept. 22, 1955 3 Sheets-Sheet 3

FIG. 3.

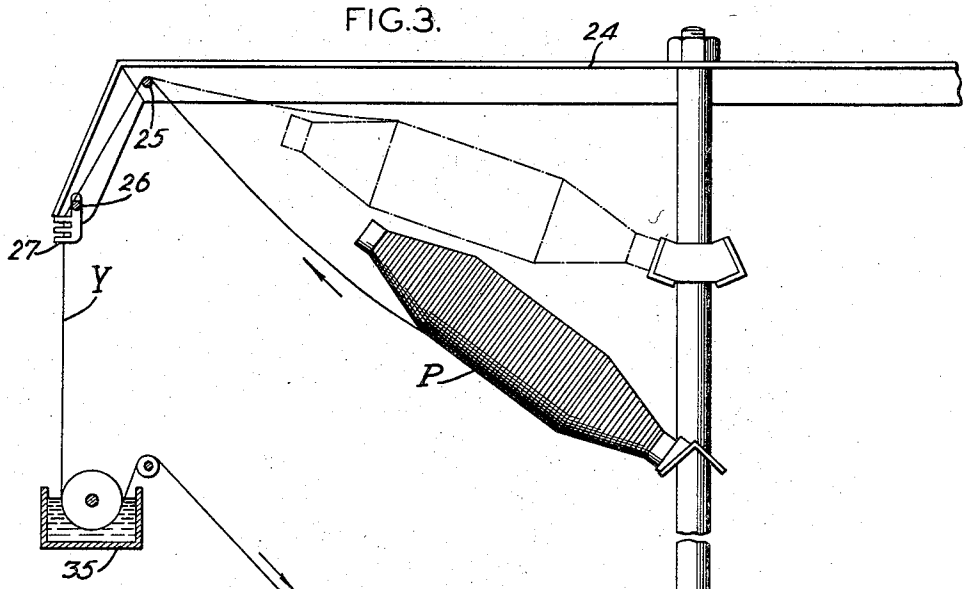
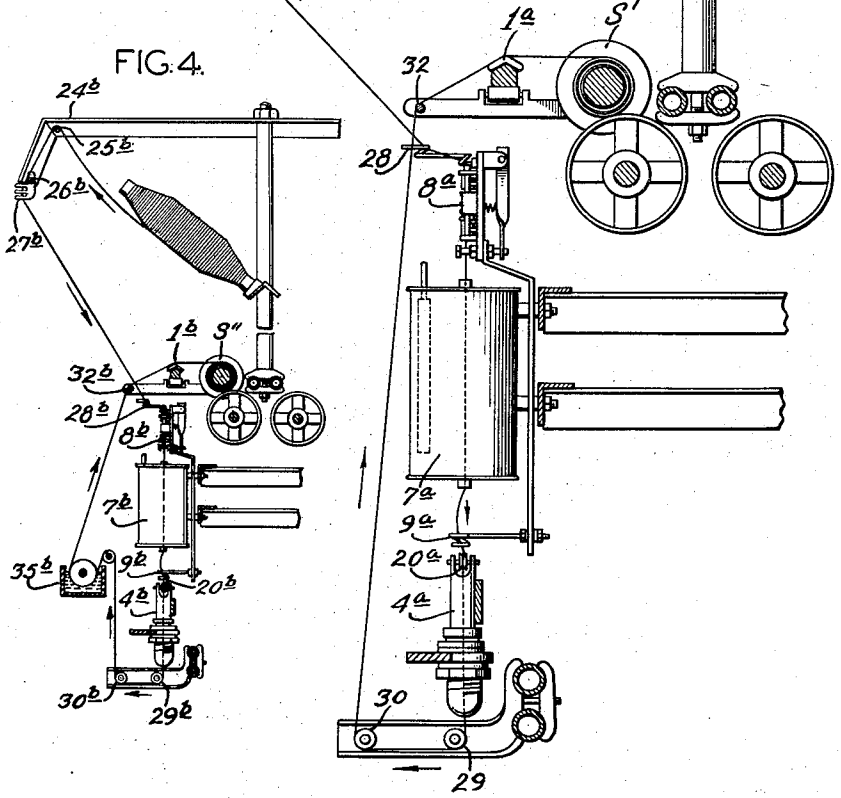


FIG. 4.



INVENTORS:
NICHOLAS J. STODDARD
WARREN A. SEEM
BY Howson & Howson
ATTYS.

United States Patent Office 2,891,376 Patented June 23, 1959

2,891,376

METHOD OF PROCESSING YARN

Nicholas J. Stoddard, Philadelphia, and Warren A. Seem, Gwynedd, Pa., assignors to Universal Winding Company, Cranston, R.I., a corporation of Massachusetts

Application September 22, 1955, Serial No. 535,968

11 Claims. (Cl. 57—157)

The present invention relates to methods and apparatus for producing mono-filament, multi-filament and spun staple fibre yarns having substantial torque throughout their length.

More particularly, the invention is concerned with methods of imparting perceptible or latent torque to yarns, without creating crimped, wavy or fluffed yarns, which methods involve the use of hollow twisting-untwisting spindles which insert and remove the identical amount of twist.

The object of the invention is the more economical production of improved yarns for textile fabrics whose appearance and utility are primarily dependent upon substantial torque in the yarn from which they are fabricated. An outstanding example of such fabrics is the recent development of women's nylon stretch hosiery, the stretchability of which is caused by the loops of one or more courses being biased in one direction and the loops of one or more alternate courses of loops being biased in the opposite direction, with said opposed bias formation of the different courses of loops being the result of the opposed torque in two or more separate yarns comprising the stocking fabric. Similar yarns are now coming into general use in other knitted fabrics and in woven fabrics and the need is great for more uniformity and permanency of torque and more economical methods and means of producing such yarns.

It is to be understood that in the following specification and claims, "torque" is intended to mean that force which produces or tends to produce rotation or torsion of the yarn about its axis, irrespective of the degree of actual twist, if any, in the yarn. The tendency of the yarn to recover from the actual twist may add to or detract from the torque otherwise inherent in the yarn processed by the methods and apparatus of the invention.

A preferred method of imparting torque to yarn consists of twisting the yarn a given number of turns, and then untwisting the same number of turns. Since no textile yarns are perfectly elastic, any twisting of a yarn causes a degree of permanent spiraled deformation and causes torque if the twist is all or partly removed from the yarn. The greater the degree of permanent spiraled deformation resulting from the twisting, the greater will be the torque in the yarn after untwisting, and therefore, thermoplastic yarns are twisted while heated and non-thermoplastic yarns are twisted while wet-out so as to reduce the yield value and increase the plastic flow to thereby increase the degree of permanent spiraled deformation. In accordance with the invention, both thermoplastic and non-thermoplastic yarns are also twisted under tension to further increase the plastic flow and resultant permanent deformation. It is important that the temperature be correlated with tension upon the yarn while it is twisted, so as to preclude ductility from the finished yarn, which otherwise would produce less resilience in the finished yarn and less permanent torque.

In one type of prior art yarns used to produce women's

stretch hosiery, 15 denier mono-filament nylon is up-twisted 30 turns per inch S, the twisted yarn on take-up packages is then thoroughly set by steam under pressure, the yarn is then redrawn from take-up packages to spinner bobbins wound for Z twisting and then the yarn is up-twisted 23 turns per inch Z, thereby creating torque resulting from the Z twisting. Of course, a companion yarn, first twisted 30 turns per inch Z and reverse twisted 23 turns per inch S is used in one carrier of the knitting machine and the opposite torque yarn is used in a second carrier. When knitting, one or more courses of the one yarn are alternated with a like number of courses of the companion yarn. By the present invention, the above four separate operations are more uniformly carried out in one economical continuous operation.

In our co-pending application, S.N. 489,693, filed February 21, 1955, there are disclosed methods and apparatus for producing yarns having substantial torque, without containing any real or actual twist. While this yarn is highly desirable for certain applications, it has been found that for other uses, it is desirable to produce a yarn having a certain degree of actual residual twist in addition to a high degree of torque. For example, when employing multi-filament yarns, a certain degree of actual twist is desirable to produce a yarn having high torque yet possessing non-bulking qualities or characteristics.

With the foregoing in mind, a primary object of the present invention is to provide methods and apparatus for producing yarn having non-bulking qualities or characteristics and which is possessed of substantial torsional forces.

More specifically, the invention contemplates methods and apparatus of this type in which the yarn is processed continuously without interrupting the travel of the yarn.

More particularly, the invention contemplates the production of yarns of the type described which are characterized by their lengthwise uniformity and have a uniform helical set producing a permanent torque in the yarn.

These and other objects of the present invention and the various features and details of the construction of the apparatus and operation of the method are more fully set forth hereinafter with reference to the accompanying drawings in which:

Fig. 1 is a fragmentary front elevational view of apparatus suitable for carrying out our improved method of producing thermoplastic yarns having various improved physical characteristics;

Fig. 2 is a fragmentary view of the apparatus of Fig. 1 in cross section;

Fig. 3 is a fragmentary view in cross section similar to Fig. 2 showing another apparatus suitable for processing yarns in accordance with the improved method of the present invention; and

Fig. 4 is a view similar to Fig. 3 but at reduced scale showing a modification within the scope of the present invention.

The one operation of the invention to replace four conventional operations is made possible by equipping the top deck of a conventional double deck up-twister as shown in Figs. 1 and 2 and previously disclosed in our co-pending application, Serial No. 489,693 filed February 21, 1955 and further mounting a heating device and tensioning device between the top of the conventional spindle on the lower deck and the bottom of the twisting-untwisting spindle on the top deck as shown in Fig. 2.

In one method of carrying out the present invention, a 15 denier nylon on a pirn is twisted 7 turns per inch on the lower deck on conventional spindles revolving about 7000 r.p.m. and then instead of being wound upon

a take-up package as is the usual practice, the 7 turns per inch twisted yarn is passed through the tensioning and heating devices, through the twisting-untwisting spindle revolving in the opposite direction at about 23,000 r.p.m., through the top deck heating device which is not in operation, through the top deck tension device and finally to the take-up package regulated to take up the yarn at the rate of about 1000 inches per minute. The result of the above is that the yarn is twisted 7 turns per inch on the lower deck of the machine. Subsequently, on the top deck of the machine, the yarn is twisted an additional 23 turns per inch under tension while heated sufficiently to increase the plastic flow and set the yarn. Then, the yarn is reverse twisted 23 turns per inch, leaving the yarn with 7 turns of actual twist per inch and a substantial active torque or liveliness due to the reverse twisting operation.

The economy of performing in one continuous operation, what would by conventional methods require four operations, is of importance, but of greater importance is the improvement in the uniformity of torque and the permanency of the torque since the prime function of the yarns involved is to create by the use of torque, special effects in fabrics made therefrom. By the invention, every inch of the entire length of yarn is uniformly heated and uniform tensile stress is applied while twisting so as to preclude ductility. This is not possible by conventional methods.

Since the invention pertains to yarns having torsion without bulkiness, it is of importance when processing multi-filament yarns by the invention, to have sufficient actual twist in the finished yarn to hold the plurality of filaments into one compact bundle, if the twisting, setting and reverse twisting is of such magnitude as would otherwise cause the filaments to separate and the yarn to bulk. The apparatus of Fig. 1 is ideal for this purpose since any twist inserted into the yarn on the conventional spindle on the lower deck of the machine remains in the yarn after the subsequent twisting-untwisting is performed on the top deck of the same machine.

Referring to Figs. 1 and 2 of the drawings, the top deck of a conventional double deck up-twister is equipped with apparatus as disclosed in our co-pending application, Serial No. 489,693.

The apparatus is basically a conventional up-twister having a take-up spool S driven by a roll 3. A conventional guide 1 distributes the yarn evenly on the take-up spool S. A twisting-untwisting spindle 4 is mounted on the spindle bracket 5 of the upper deck and is operable to be rotatably driven by the spindle driving belt 6. A specially constructed heating device 7, as described in detail in the above-identified application, is positioned between the twisting-untwisting spindle 4 and the guide 1 to pass the yarn. A special tension device is provided at 8 to insure proper tension on the yarn as it is wound on the spool S. Ballooning of the yarn from the twisting-untwisting spindle 4 is controlled by a pigtail guide 9 positioned intermediate the heater 7 and the spindle 4. In the present embodiment of the invention, the heater 7 is rendered inoperative, it being retained in the apparatus to provide easy conversion from the method of the present invention shown in Fig. 1 to the method disclosed in our co-pending application above-identified, or the method of the present invention described in connection with Fig. 3.

On the bottom deck of the same double deck up-twister there is mounted between the top of the conventional spindle 11 of the lower deck and bracket arm 5, a heating device 12 and a tensioning device 13. An emulsion trough 14 is mounted between the thread guide 15 associated with the spindle 11 and tensioning device 13, and is used when liquids are to be applied to the yarn.

The liquid supplied by the emulsion trough 14 may be a dye solution to permanently dye the yarn, the dye being developed and set by the elevated temperature of the restricted heating zone. Likewise, a suitable sizing or other treating liquid may be employed as desired or required, and passage of the treated yarn through the heating zone will operate to dry the sizing or other material. When treating non-thermoplastic yarn, the non-thermoplastic yarn may be passed through the emulsion trough which may contain a thermal setting material, such for example as a solution of urea formaldehyde resin. The yarn passing through and trough is coated with the resin and the heat applied to the yarn so coated, imparts the desired set to the yarn.

When nylon yarn is to be processed by twisting 30 turns per inch in one direction and 23 turns per inch in the opposite direction by the use of the apparatus of Figs. 1 and 2, a pirn 17 of nylon is placed upon conventional spindle 11 and the yarn is twisted 7 turns per inch between the pirn 17 and the tensioning device 13 (or emulsion trough 14 when utilized), the yarn then travels through the tensioning device 13 where sufficient tension is applied in relation to the temperature to which the yarn is thereafter heated to preclude ductility in the yarn. The yarn is then heated while being twisted an additional 23 turns per inch while traveling through the heating device 12. The yarn is then cooled while traveling from the heating device 12 to the reverse twisting roller 20 of the twisting-untwisting spindle 4. The yarn then travels through the balloon control thread guide 9 and then through the heating device 7 (inoperative in this embodiment of the invention) and tensioning device 8 on to the take-up spool S. It is to be noted that in this embodiment of the invention, the supply creel shown in our co-pending application above the top deck of the machine is inoperative since the yarn is supplied from the pirn 17 on the conventional spindle 11 of the lower deck.

As explained in detail in our co-pending application, above-identified, the tension in the yarn, and the heat applied thereto, are closely regulated to provide uniform heat and uniform tensile stress while twisting, to preclude ductility. Thus, in practicing the methods of the present invention by controlling the supply of heat energy to the restricted zone in the heating device 12 through which the yarn is passed to heat the yarn uniformly to a prescribed temperature to reorient the molecules of the yarns to the twisted yarn, thereby to yarn-set the same, and by correlating the tension in the yarn to the prescribed temperature and linear speed thereof to maintain the yarn at a selected uniform tension relative to the contractual force of the yarn, it is possible to produce commercially satisfactory yarn having desirable though different physical properties, which in each instance, are characterized by their permanency and high degree of uniformity.

The required degree of heat is uniformly maintained in a device by current at a constant voltage (not exceeding 24 volts for personal safety) through an automatic voltage induction regulator 44 from a power line 45, 46, said regulator being connected by conductors 47, 48 to a manually adjustable induction voltage regulator 49 connected in turn by conductors 50, 51 to the primary of a step-down transformer 52 which maintains a voltage across the bus bars 53, 54 supplying energy to the heating device 12. The output voltage of the induction voltage regulator 44 is automatically governed by a thermally responsive sensing means incorporated in the heating device 12. The automatic and manual induction voltage regulators 44 and 49 and the thermostatic sensing means may all be of any approved standard commercially available types which function cooperatively to control the temperature in the heating device 12 compensatively according to changes in the ambient or room temperature and the rate of heat transfer to the yarn, so that the restricted zone of the heater through which the yarn passes is heated uniformly to a temperature to reorient the yarn molecules to the twisted formation of the yarn, and yarn-set the same. Manually operable hand switches 55 and 56 are included in the lines 45 and 46, and 47 and 48 respectively, as shown in Fig. 1. Thus, the yarn passing

through the heater is subject to a constant prescribed uniform heat transfer.

The tensioning means 8 and 13 exert a uniform predetermined tension on the yarn passing therethrough. As described in detail in our co-pending application, above-identified, the tensioning device comprises two comb-like vanes between the alternating times of which the yarn is passed. One of the vanes is fixed, whereas the other vane is swingable about a hinge pin. The swingable vane is connected by a spring to an adjusting lever which may be accurately regulated to impart a predetermined drag or tension to the yarn. According to the method of the invention, the tensioning device is adjusted to accurately correlate the tension in the yarn undergoing processing to the temperature to which the yarn is heated and the linear speed of travel of the yarn to maintain the latter at a selected uniform tension relative to the contractual force of the yarn which results from heating and twisting it.

It will be clear to those familiar with the art that in the practice of the invention, using the apparatus shown in Figs. 1 and 2, any desired amount of twist in the same or opposite direction as the reverse twisting may be inserted and retained in the yarn and any amount of reverse twisting may be carried out, merely by conventionally regulating the speed and direction of rotation of the spindles shown on both decks of the machine and the speed of yarn take-up. The actual twist in the finished yarn is controlled by the speed of the drive belt 21 for the conventional spindle 11; and the amount of reverse twisting by the speed of the belt 6, both in relation to the speed of the roll 3. It will also be clear to those familiar with the art that any mono-filament, multi-filament or spun staple fibre yarns may be similarly processed and that instead of pirn 17, a spinner bobbin wound with any yarn may be substituted on the same spindle.

In the practice of the invention, it is sometimes desirable to twist, set the yarn and reverse twist, without changing the amount of actual twist (if any) in the yarn as received from the producer. This may be done by using the top deck only of the apparatus shown in Figures 1 and 2 or each deck of a double deck up-twister whose top and bottom decks have been modified the same as the top deck modification shown in Figures 1 and 2.

Fig. 3 is a fragmentary view, in section, of an apparatus for practicing another embodiment of the invention. Referring to Fig. 3 of the drawings, a pirn or other supply package P is placed upon an overhead creel 24 which is capable of holding supply packages for both decks of the machine, the yarn Y is drawn continuously endwise from the package P, passed over guide rods 25, 26 and through a drag tension 27 also on the creel, then downwardly to a pigtail guide 28 attached to a tensioning device 8*a*, then down between the wings of the tensioning device 8*a* and through a heating device 7*a*, then through the pigtail guide 9*a*, then twice around the reverse twisting roller 20*a*, then through the spindle 4*a*, then horizontally under a pair of spaced rolls 29 and 30, then upwardly over guide rod 32 to the traverse guide 1*a*, and finally to the driven take-up spool S'. When liquids are to be applied, the yarn is passed through an emulsion trough 35 intermediate the drag tension 27 and the pigtail 28.

In accordance with the present invention, the apparatus of Fig. 3 is used to impart torque to yarns by twisting, setting the yarn and reverse twisting exactly as many turns per inch as twisted. If a multi-filament zero twist or very low twist yarn is so processed and the twisting, setting and reverse twisting is of sufficient magnitude, the finished yarn will tend to shrink and bulk and exhibit relatively little of the essential torque, as set forth in our co-pending application, above-identified. Therefore, the apparatus of Fig. 3 is used primarily for mono-filament yarns, spun yarns, or any other yarns where bulking will not result when the necessary twisting, setting and reverse twisting to produce the required torque is performed. However, many multi-filament yarns may be processed by the use of the apparatus of Fig. 3, as for example 40 denier 13 filament nylon may be twisted 20 turns per inch while heated and under tension and reverse twisted 20 turns per inch and such a yarn will exhibit adequate torsion to cause a desired bias of the loops of knitted fabric. In this example, the magnitude of the twisting, setting and reverse twisting was not sufficient to cause shrinking and bulking of the thirteen individual filaments comprising the yarn.

When twisting and untwisting is carried out on a twisting-untwisting spindle, sometimes referred to as a false twist spindle, it is possible to twist and untwist more than one end of yarn at the same time and thereafter separate the ends for use as individual ends. In the practice of the present invention, for example, more than one end of 15 denier mono-filament may be twisted at one time under tension while heated, then reverse twisted and then separated and each individual 15 denier yarn will have torque depending upon the degree of twisting, heating, tension and untwisting.

When processing thermoplastic yarns by the present invention, the heat in correlation with tension insures permanency of torque. In order to obtain a high degree of permanency of torque in non-thermoplastic yarns, the yarn is coated or impregnated with thermoplastic or thermal setting materials prior to the travel of the yarn through the heated zone. This causes the normally non-thermoplastic yarn to have thermoplastic characteristics as it is twisted, heat set, and untwisted, as described above.

An example of a modification of the present invention to produce non-bulking yarns which have latent torsion is the application of chemicals, or sizing materials to the yarn after imparting torque thereto to reduce the normal liveliness of the yarn. The chemicals or sizing materials are capable of being removed after the yarns have been converted to knitted or woven fabrics to thereby release the yarn torsion to enable it to cause the desired fabric effect. The apparatus for carrying out this modified method may consist of the apparatus of either Figs. 1 and 3, modified to locate the trough between the false twist spindle and the take-up spool. The modification of the apparatus of Fig. 3 is shown in Fig. 4. In carrying a modified method on the apparatus shown in Fig. 4, the yarn is supplied from a creel 24*b* over guide rods 25*b* and 26*b*, through a drag tension device 27*b*, pigtail guide 28*b*, tension device 8*b* and a heating device 7*b* to the false twist spindle 4*b*. The yarn is wrapped twice around the roller 20*b* of the false twist spindle around guide rollers 29*b* and 30*b* through an emulsion or sizing trough 35*b* over the guide rod 32*b* and the traverse guide 1*b* to the take-up spool S''. The spindle 4*b* and the heating device 7*b* operate to insert substantial torque in the yarn, and the trough 35*b* coats the processed yarn with a suitable sizing material to reduce the liveliness of the yarn on the package, or take-up spool S''.

For example, when treating 40 denier 13 filament nylon yarn, the yarn is advanced through the equipment at a rate of 1500 inches per minute, the spindle revolving at about 30,000 r.p.m. The sizing trough 35*b* should contain a water solution of polyvinyl alcohol and boric acid and approximately 5% of sizing (dry weight) would be applied to the yarn. The moisture would be dried from the take-up package while winding and during storage. Of course, the apparatus of Fig. 2, modified by the relocation of the sizing trough 14 would accomplish the same purpose.

Another example of a modification of the present invention is the insertion of torque into a yarn capable of being cold drawn. With such a yarn, adequate tension upon the yarn while twisting without increasing the temperature of the yarn, causes sufficient permanent spiraled deformation to leave the yarn with substantial torque after reverse twisting the identical amount. Any of the appa-

ratus shown in the drawings may be employed to effect this processing of the yarn, the heating elements being deenergized or energized to provide only minimum heat transfer to the yarn.

A yarn suitable for cold drawing is a 15 denier monofilament undrawn nylon. In processing this yarn, the yarn is traveled through the machine at a rate of 1,000 inches per minute with a spindle speed of 30,000 r.p.m. The tension device is set to apply sufficient tension to draw the nylon yarn to approximately three times its undrawn length. The yarn exhibits a substantial amount of torque and liveliness. Of course, other yarns capable of being cold drawn may be processed in this manner.

It is not uncommon in the prior art to use yarns having substantial latent torque for release after fabrication to produce desired fabric effects but such yarns are normally well set and exhibit little active torsion or liveliness prior to fabrication. There has been a recent departure from established procedure in respect to lively yarns. The recognition of the varied functional uses for lively yarns has brought about the development of new apparatus and techniques to facilitate their conversion to fabrics and these new techniques and apparatus are in turn making possible more and more new uses.

The present invention is directed to yarns requiring non-bulking qualities or to methods of inserting torque in the yarn which involve, in part, the continuous steps (without interrupting the travel of the yarn) of (*a*) twisting the yarn under tension and (*b*) the reverse twisting the identical amount and it is intended in the specifications and appended claims, that the requirement of the identical amount of reverse twisting be such as is possible by false twist spindles.

However, while only selected embodiments of the present invention have been herein illustrated and described, it should be apparent that many variations are possible within the scope of the present invention. Thus, the invention is not limited to the illustrated and described embodiments, but changes and modifications may be made therein and thereto within the scope of the following claims.

We claim:

1. A method of continuously inserting torque forces in a running strand of thermoplastic yarn which comprises continually drawing thermoplastic yarn from a source of supply, continually twisting the yarn, continually passing the twisted yarn at a selected linear speed under uniform tension through a restricted thermally isolated uniformly heated zone to uniformly heat the yarn to a prescribed temperature to reorient the molecules of the yarn to the twisted formation of the yarn and yarn-set the same, controlling the supply of heat energy to said zone to thereby maintain said heated zone uniformly at the temperature required to uniformly heat said yarn to said prescribed temperature, continually cooling the yarn to stabilize the same after passage under tension through said heated zone, continually untwisting the yarn to remove the twist inserted in said twisting step, winding the processed yarn, and correlating the tension in said yarn to said prescribed temperature and linear speed of travel of the yarn to maintain the yarn at a uniform tension relative to the contractile force and thermal characteristics of the yarn resulting from the heating, twisting, and untwisting of the same, said twisting and untwisting being of insufficient magnitude to cause bulking of said strand of yarn.

2. A method according to claim 1 including the step of applying a sizing material to said yarn immediately prior to the step of winding the processed yarn to provide a compact non-bulking yarn having latent torque capable of being activated upon subsequent removal of said sizing material.

3. A method of continuously inserting torque forces in a running strand of thermoplastic yarn which comprises continually drawing thermoplastic yarn from a source of supply, continually twisting the yarn, continually passing the twisted yarn at a selected linear speed under uniform tension through a restricted thermally isolated uniformly heated zone to uniformly heat the yarn to a prescribed temperature to reorient the molecules of the yarn to the twisted formation of the yarn and yarn-set the same, controlling a supply of heat energy to said zone compensatively according to the ambient temperature and rate of transfer of heat to the yarn to thereby maintain said heated zone uniformly at the temperature required to uniformly heat said yarn to said prescribed temperature, continually cooling the yarn to stabilize the same after passage under tension through said heated zone, continually untwisting the yarn to remove the twist inserted in said twisting step, winding the processed yarn, and correlating the tension in said yarn to said prescribed temperature and linear speed of travel of the yarn to maintain the yarn at a uniform tension relative to the contractile force and thermal characteristics of the yarn resulting from the heating, twisting, and untwisting of the same to preclude ductility in the final yarn, said twisting and untwisting being of insufficient magnitude to cause bulking of said strand of yarn.

4. A method according to claim 3 including the step of applying a sizing material to said yarn immediately prior to the step of winding the processed yarn to provide a compact non-bulking yarn having latent torque capable of being activated upon subsequent removal of said sizing material.

5. A method of continuously inserting torque forces in a running strand of yarn which comprises continually supplying yarn from a source of supply, continually applying a thermally responsive liquid treating agent to said yarn, continually twisting said treated yarn, continually passing the treated and twisted yarn at a selected linear speed under uniform tension through a restricted thermally isolated and uniformly heated zone to uniformly heat the treated yarn to a prescribed temperature to set the treating agent and yarn-set the strand of yarn, controlling the supply of heat energy to said zone compensatively according to the ambient temperature and rate of transfer of heat to the yarn to thereby maintain said heated zone uniformly at the temperature required to uniformly heat said yarn to said prescribed temperature, continually cooling the yarn to stabilize the same after passage under tension through said heated zone, continually removing the twist by untwisting the yarn, winding the processed yarn, and correlating the tension in said yarn to said prescribed temperature and linear speed of travel of the yarn to maintain the yarn at a uniform tension relative to the contractile force and thermal characteristics of the yarn resulting from heating the same, said twisting and untwisting being of insufficient magnitude to cause bulking of said strand of yarn.

6. A method of thermally processing yarn which comprises continually drawing multifilament thermoplastic yarn having a twist greater than producer twist from a source of supply, continually additionally twisting the twisted yarn, continually passing the yarn at a selected linear speed under uniform tension through a restricted thermally isolated uniformly heated zone to uniformly heat the yarn to a prescribed temperature to reorient the molecules of the yarn to the twisted formation of the yarn and yarn-set the same, controlling a supply of heat energy to said zone compensatively according to the rate of transfer of heat to the yarn to thereby maintain said heated zone uniformly at the temperature required to uniformly heat said yarn to said prescribed temperature, continually cooling the yarn to stabilize the same after passage under tension through said heated zone, continually untwisting the yarn to remove the additional twist inserted in said twisting step, winding the processed yarn having the original twist therein, said twist being of sufficient magnitude to prevent substantial bulking of said multifilament yarn, and correlating the ten-

sion in said yarn to said prescribed temperature and linear speed of travel of the yarn to maintain the yarn at a uniform tension relative to the contractual force and thermal characteristics of the yarn resulting from the heating, twisting, and untwisting of the same.

7. A method of thermally processing yarn which comprises continually supplying multifilament thermoplastic yarn having a twist greater than producer twist from a source of supply, continually applying a liquid treating agent to said yarn, continually additionally twisting said twisted and treated yarn, continually passing the treated yarn at a selected linear speed under uniform tension through a restricted thermally isolated and uniformly heated zone to uniformly heat the yarn to a prescribed temperature to yarn-set the same, controlling the supply of heat energy to said zone compensatively according to the rate of transfer of heat to the yarn to thereby maintain said heated zone uniformly at the temperature required to uniformly heat said yarn to said prescribed temperature, continually cooling the yarn to stabilize the same after passage under tension through said heated zone, continually removing the additional twist by untwisting the yarn, winding the processed yarn having the original twist therein, said twist being of sufficient magnitude to prevent substantial bulking of said multifilament yarn, and correlating the tension in said yarn to said prescribed temperature and linear speed of travel of the yarn to maintain the yarn at a uniform tension relative to the contractile force and thermal characteristics of the yarn resulting from heating the same.

8. A method of thermally processing multifilament thermoplastic yarn which comprises continually drawing the yarn from a source of supply and imparting a twist thereto greater than producer twist and of sufficient magnitude to prevent substantial bulking of said yarn, continually imparting additional twist to the yarn, continually passing the yarn at a selected linear speed under uniform tension through a restricted thermally isolated uniformly heated zone to uniformly heat the yarn to a prescribed temperature to reorient the molecules of the yarn to the twisted formation of the yarn and yarn-set the same, controlling the supply of heat energy to said zone to thereby maintain said heated zone uniformly at the temperature required to uniformly heat said yarn to said prescribed temperature, correlating the tension in said yarn to said prescribed temperature and linear speed of travel of the yarn to maintain the yarn at a uniform tension, continually cooling the yarn to stabilize the same after passage thereof under tension through said heated zone, continually untwisting the yarn after cooling the same to remove no more than the twist imparted by said additional twisting step, and finally continually collecting the processed yarn with at least the originally imparted twist therein.

9. A method according to claim 8 in which said untwisting step removes entirely the twist imparted by said additional twisting step.

10. A method of continuously inserting torque forces in a running strand of yarn which comprises continually advancing multifilament yarn having thermoplastic qualities so as to be capable of being thermally set, continually twisting said advancing yarn, continually passing the twisted yarn at a selected linear speed under uniform tension through a restricted thermally isolated and uniformly heated zone to uniformly heat the yarn to a prescribed temperature to set the yarn, controlling the supply of heat energy to said zone to thereby maintain said heated zone uniformly at the temperature required to uniformly heat said yarn to said prescribed temperature, continually cooling the yarn to stabilize the same after passage under tension through said heated zone, continually removing the twist by untwisting the yarn, winding the processed yarn, and correlating the tension in said yarn to said prescribed temperature and linear speed of travel of the yarn to maintain the yarn at a uniform tension relative to the contractile force and thermal characteristics of the yarn resulting from heating the same, said twisting and untwisting being of insufficient magnitude to cause bulking of said strand of yarn.

11. A method of thermally processing yarn which comprises continually drawing twisted thermoplastic multifilament yarn from a source of supply, continually additionally twisting the twisted yarn, continually passing the yarn at a selected linear speed under uniform tension through a restricted thermally isolated uniformly heated zone to uniformly heat the yarn to a prescribed temperature to reorient the molecules of the yarn to the twisted formation of the yarn and yarn-set the same, controlling a supply of heat energy to said zone compensatively according to the rate of transfer of heat to the yarn to thereby maintain said heated zone uniformly at the temperature required to uniformly heat said yarn to said prescribed temperature, continually cooling the yarn to stabilize the same after passage under tension to said heated zone, continually untwisting the yarn to remove the additional twist inserted in said twisting step, applying a sizing material to said yarn to provide a compact non-bulking yarn having latent torque capable of being activated upon subsequent removal of said sizing material, winding the processed yarn, and correlating the tension in said yarn to said prescribed temperature and linear speed of travel of yarn to maintain the yarn at a uniform tension relative to the contractile force and thermal characteristics of the yarn resulting from the heating, twisting, and untwisting of the same.

References Cited in the file of this patent

UNITED STATES PATENTS

2,087,467	Byron	July 20, 1937
2,130,948	Carothers	Sept. 20, 1938
2,202,031	Smith	May 28, 1940
2,295,593	Miles	Sept. 15, 1942
2,353,666	Hathorne et al.	July 18, 1944
2,463,618	Heberlein et al.	Mar. 8, 1949
2,556,919	Hardacre et al.	June 12, 1951
2,743,572	Hiensch	May 1, 1956