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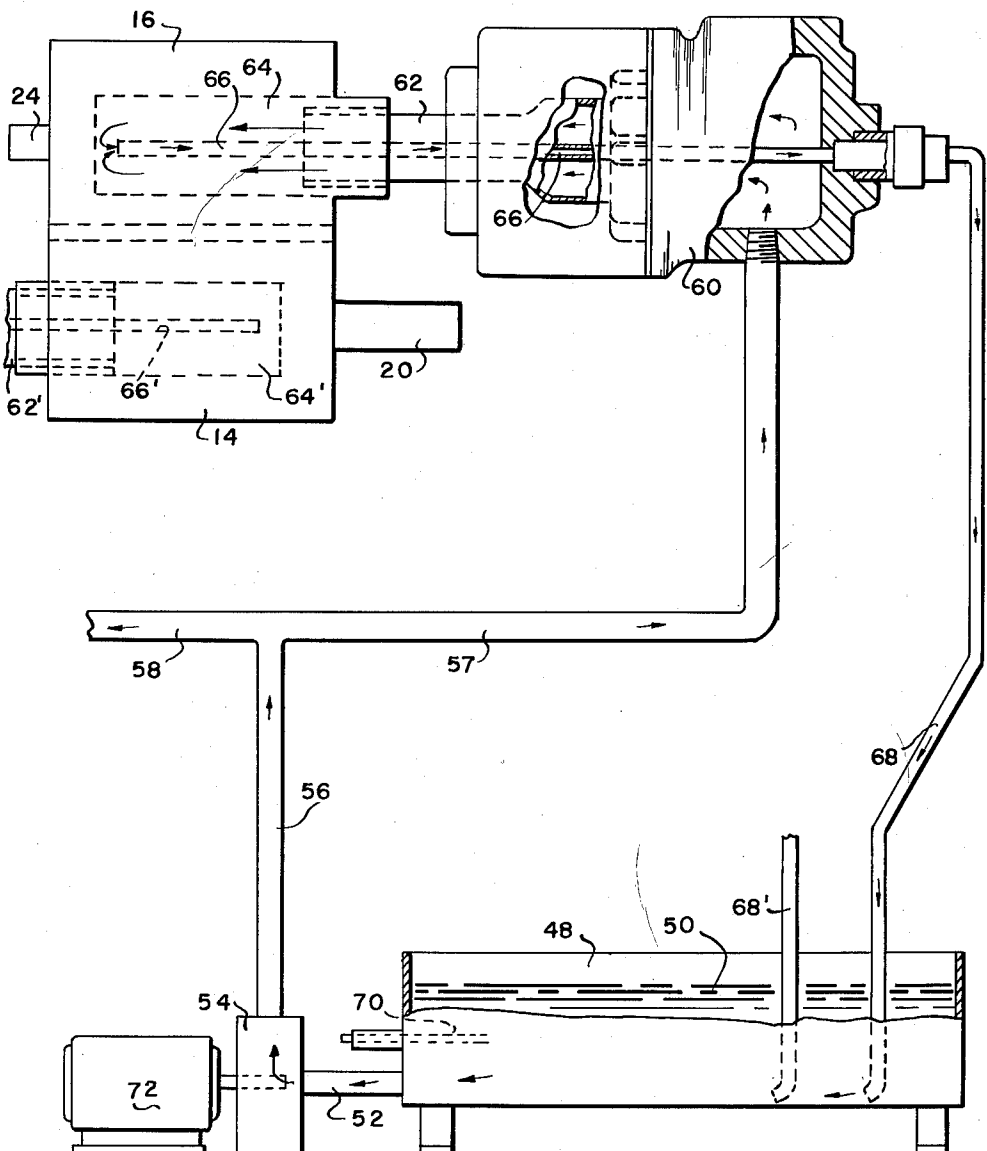
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PROCESS FOR TREATING YARNS, FILAMENTS AND FIBERS

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3 Sheets-Sheet 2

FIG.2.



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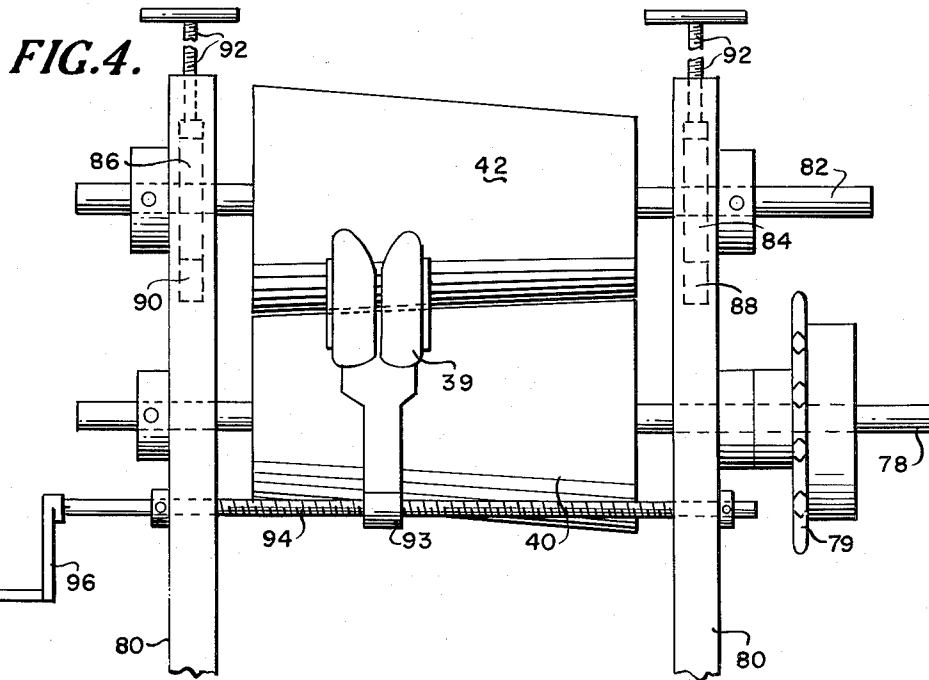
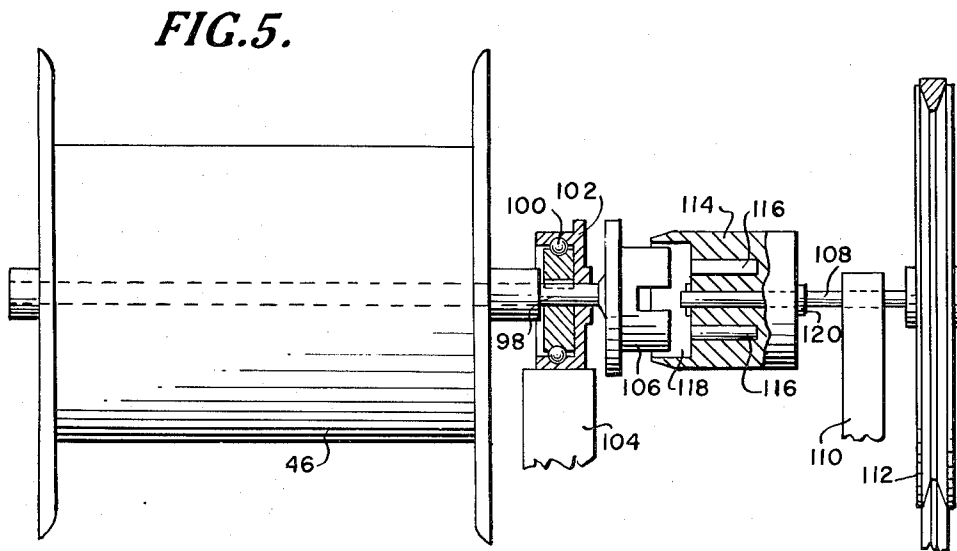
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**PROCESS FOR TREATING YARNS, FILAMENTS
AND FIBERS****Everett C. Atwell, Greensboro, N.C., assignor to Burlington Industries, Inc., Greensboro, N.C., a corporation of Delaware****Filed Sept. 24, 1956, Ser. No. 611,547
2 Claims. (Cl. 28—72)**

This invention relates to the crimping of filaments, yarns and fibers. More particularly, the invention is concerned with novel methods and apparatus for continuously imparting selected and uniform crimp patterns to filaments, yarns and fibers while simultaneously rendering the same heat set.

Filaments, yarns and fibers which may be processed according to the invention are those comprising synthetic, thermoplastic high molecular products of long chain molecular structure and capable of being heat set. Typical of such materials are the synthetic linear polyamides (nylon), acrylics and polyesters of the type shown in U.S. Patent 2,465,319 including the product known as "Dacron" (polymeric ethylene terephthalate).

Suitable synthetic linear polyamides are described in U.S. Patent 2,071,250, such as poly-hexamethylene adipamide, poly-decamethylene adipamide, and poly-hexamethylene sebacamide. Other polyamides suitable for use herein are the products obtained by self-condensation of 6 amino caproic acid or other omega-amino carboxylic acids, or the polymers obtained from lactams such as epsilon-caprolactam.

The term "heat set" as used herein is utilized in a generic sense and is intended to indicate a condition in which the yarns, filaments or fibers show no appreciable shrinkage after immersion in hot or boiling water and subsequent drying. For the purposes of the invention, heat set yarns, fibers and filaments measured under just sufficient load to straighten out the crimp, immersed fifteen minutes in water at, or close to, the boil, air dried in slack condition and remeasured under the same load as previously, will not shrink more than 1.0% in length.

It has previously been proposed (U.S. Patent 2,216,412) to produce crimped, low density bulk yarns or the like by a method involving the steps of (a) softening the yarn with water, steam or other softening agent; (b) subjecting the softened yarn, either subsequent to the softening treatment or simultaneously therewith, to lateral pressure exerted by the meshing together of suitable crimping rolls thus creating a temporary crimp; (c) immediately subjecting the yarn to a rubbing action in a transverse direction whereby the yarn assumes an open or low bulk condition; and (d) thereafter drawing the yarn over a heated plate under low tension to set the same in its open or low bulk condition.

According to another method, (U.S. Patent 2,575,833), the yarn or fibers are gripped between rollers, with or without teeth, and forced into a chamber where the material is positioned in a zig-zag pattern which forms sharp angular bends or crimps with longer intervening straight sections. The thus crimped yarn is then held compacted under constant pressure to retain the crimp and water, steam, superheated water vapor or the vapors of certain organic liquids introduced thereto for the purpose of softening the crimped material after which the material is removed from the treating chamber.

Other types of crimping procedures comprise highly twisting yarn or the like, setting the twist therein and then back twisting to obtain a product having a random crimp, low bulk and high elongation.

The present invention differs uniquely from the above-mentioned procedures in that it provides methods and

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means for heat setting and imparting a desired crimp pattern to synthetic thermoplastic polymeric yarns, filaments and fibers, uniformly and continuously in a single operation without the necessity of using softening agents such as water, steam or organic vapors prior to or during crimping and without the application of subsequent drying and/or heat setting operations.

As will be appreciated from the foregoing, the principal object of the present invention is the provision of improved methods and apparatus for crimping and heat setting synthetic thermoplastic yarns, filaments and fibers.

A more specific object is to provide means for continuously and simultaneously producing a uniformly heat set, crimped yarn, filament or fiber.

Another object of the invention is the provision of methods and apparatus for imparting a crimp of selected pattern to yarns, filaments or fibers of synthetic long chain, high molecular weight polymeric thermoplastics by subjecting the thermoplastic to controlled pressure of meshed crimping rolls at a temperature at least equal to the second transition step of the thermoplastic.

Other specific objects are to provide method and/or apparatus for:

- (a) supplying regulated, continuous and uniform heat to the crimping rolls;
- (b) positively controlling the tension on the crimped yarn or the like as it emerges from the crimping rolls and as it is taken up on a suitable bobbin or the equivalent;
- (c) retaining the crimped yarn in a compact form as it comes off the crimping rolls and, in the case of multifilament yarns, avoiding opening up of the yarn so that it is maintained as far as possible in a form resembling a monofilament yarn.

Other objects will also be apparent from the following detailed description of the invention and the accompanying drawings wherein:

FIGURE 1 is a diagrammatic view of an assembly for crimping and heat setting according to the invention;

FIGURE 2 is a horizontal sectional view of the means for heating the crimping rolls;

FIGURE 3 is a plan view of the crimping rolls;

FIGURE 4 is a horizontal sectional view of means utilized according to the invention to control tension on the crimped material as it leaves the crimping rolls; and

FIGURE 5 is a horizontal sectional view of means for winding up the crimped product in accordance with the present invention.

Referring more particularly to the drawings, FIGURE 1 shows a suitable supply package 2 having yarn of nylon or other synthetic polymeric thermoplastic material wound thereon. The yarn may be multifilament or monofilament yarn of any desired denier, e.g. 10-450 denier. As shown in FIGURE 1, the yarn 4 is drawn off the package 2 and passed through suitable guide means 6 and tension means 8, the tension on the yarn at this point generally ranging between 0.03 and 0.30 grams per denier. From tension means 8, the yarn is passed through further guides 10 and 12, the latter preferably being a comb guide, or the equivalent, to a pair of crimping rolls 14 and 16.

Rolls 14 and 16 comprise a pair of revolving, matching gears which are internally heated, in the manner described subsequently, to a temperature sufficient to heat set the yarn, i.e. one equal to or above the second transition point of the polymer comprising the yarn. Rolls 14 and 16 draw yarn 4 from the supply package 2 through the various guides and tension means referred to hereinabove and effect the desired simultaneous crimping and heat setting. Suitable screw means 18 are provided for adjusting the clearance between the meshed surfaces to give the desired lateral pressure on the yarn during the crimping and heat setting. Roll 14 may be revolvably

mounted on a suitable shaft 20 which is rotatable within bearing means 22 but fixed against lateral movement. As indicated, however, roll 16 is movable laterally with its supporting shaft 24 and bearing 26 by screw means 18. The lateral pressure exerted on the yarn by the crimping rolls simultaneously softens the thermoplastic material, forms the desired crimp therein and heat sets the same against loss of crimp pattern and dimensional loss during the short contact periods which are utilized. It will be appreciated that the lateral pressure exerted on the yarn can be widely varied depending upon other operating factors and the results desired.

On emergence of the yarn from the mesh of the rolls 14 and 16, the yarn is still hot and in a plastic state at the final point of roll contact. Therefore, any tension applied to the crimped yarn on the delivery side of the crimping rolls permanently reduces both the amplitude and crimp count. If enough tension is applied, all of the crimp will be removed and the yarn, being heat set under tension, also will not meet the "heat set" requirements, as defined heretofore. A most important aspect of the invention, therefore, relates to the manner in which the yarn is taken away from the hot crimp rolls under negligibly low tension thus permitting the crimped, hot plastic yarn to cool and set in the full crimped pattern imparted by the crimp rolls. To this end, the yarn is drawn, after it leaves the crimping rolls, over a ball bearing pulley 28 which is mounted at the inner end of an arm 30. The latter is pinioned at a fulcrum 32 and balanced by spring means 34 which are adjustable as to tension by control post 36. Pulley arm 30 serves to take up any slack in the yarn and at the same time prevents damage thereto due to excessive tension during periods of adjustment, e.g. when starting up. Arm 30 also indicates the relative tension and uniformity of tension during the period of operation.

After passing around a fixed pulley 38, the crimped yarn 4 is drawn through guide means 39 into the nip of a pair of tapered, rubber covered rolls, 40 and 42. These rolls are so arranged, as subsequently discussed in detail, that the takeup speed of yarn drawn therethrough can be exactly matched with the delivery of crimped yarn from crimping rolls 14 and 16.

The yarn leaving the nip of takeup rolls 40 and 42 is passed over a suitable reciprocating traverse guide 44 and wound up on a yarn carrier 46 of conventional type, e.g. an aluminum spool or the like. As discussed hereinafter, carrier 46 is arranged for rotation at various speeds so that the tension on the yarn as it is wound up can be adjusted over a wide range.

The foregoing describes in a general way the broad aspects of the present invention as exemplified by FIGURE 1. Certain important specific features of the invention are shown in FIGURES 2-5. For instance, FIGURE 2 illustrates preferred means for heating the geared rolls 14 and 16. According to FIGURE 2, a suitable reservoir 48 is provided for the heating fluid 50 which may be a chlorinated diphenyl. The preferred heating medium is any material of low vapor pressure at high temperature, which is fluid at room temperature as well as at elevated temperature and which does not readily oxidize or decompose during prolonged periods up to 500° F. As shown, by the arrows, the hot fluid is drawn out of the bottom of the reservoir through conduit 52 by suitable pump means 54 and forced through a header pipe 56. The latter is branched as shown to form two conduits 57 and 58. Conduit 57 leads into crimping roll 16 through a rotary union 60 while conduit 58 feeds to roll 14 in a similar manner. For simplicity, only the connection of branch 57 to roll 16 is shown although it will be understood that there is an identical connection between branch 58 and roll 14. As indicated in FIGURE 2, the heating fluid is forced from branch 57 and the rotary coupling 60 through a tubular conduit 62 from

whence it passes into an annular heating space or chamber 64 within crimping roll 16. From heating chamber 64, the fluid flows through a centrally located tube 66 which extends within roll 16 through conduit 62 and coupling 60. Tube 66 communicates with a suitable return conduit 68 which leads the fluid back to reservoir 48. The reference numerals 62', 64', 66' and 68' designate the elements corresponding with members 62, 64, 66 and 68 in the connection between branch conduit 58 and roll 14.

The fluid in reservoir 48 may be heated in any desirable manner, for example, by means of electrical heating coils or the like positioned adjacent the base of the reservoir. The temperature of the fluid may be widely varied as long as it is sufficient to heat the rolls to a temperature at least equal to the second transition point of the material being treated. Generally speaking, an operable temperature range for the crimping rolls runs from a minimum of about 250° F. for linear polyamides and polyesters (e.g. nylon and Dacron) up to the tack point of the material. The preferred temperature range is between about 360° F. and the tack point (e.g. about 400° F. for nylon).

The time of contact between the yarn or the like and the heated crimping rolls can be widely varied and depends upon the nature of the material being treated, denier and crimping temperature. In using monofilaments and multifilament yarns of the order of 15 to 30 denier at 400° F. a contact time in the order of $\frac{1}{15}$ second is ample to provide a good, fully heat set, crimped yarn. Generally speaking, from $\frac{1}{15}$ to 1 second, using the shorter lengths of time for higher temperatures gives satisfactory results.

A thermostat 70 may be provided in the reservoir for the purpose of operating the heating means and maintaining a desirably uniform temperature for the heating fluid. Preferably, the various conduits and other parts of the heating system hereinabove described are insulated in order to minimize heat losses. Motor 72 serves to operate pump means 54 and may comprise a small fractional horsepower motor directly coupled to the pump shaft. The speed of this motor may be controlled by a rheostat (not shown) in the power supply line to the motor.

The pipe connections 62 and 66 and 62' and 66' between the crimping rolls and the heating system are also shown in FIGURE 3. As illustrated therein, the rolls 14 and 16 each have two zones of meshing teeth, namely, a relatively wide band 74 and a narrower band 76, and are operated by suitably driven chain and sprocket means designated by the numeral 77. As indicated, the narrow band of teeth 76 on top roll 16 meshes with the corresponding band 76 in the lower roll 14. The top roll is turned by its drive shaft 24 through the sprocket and chain means 77. The lower roll 14 is driven by upper roll 16 through the meshing of the two narrow bands 76. The teeth in these narrow bands 76 are cut several thousandths of an inch in advance of the teeth in the crimping area 74, the purpose of such misalignment being to take the driving load off the fibers while they are at the interface of the meshed teeth.

FIGURE 4 shows another important feature of the invention, namely, the construction and mode of operation of the takeup rolls 40 and 42. These rolls and the means associated therewith, discussed hereinafter, are adapted to take the yarn up as the latter leaves the crimping rolls 14 and 16 at a sufficiently low tension to avoid removing the crimp which has been imparted thereto. To this end, the takeup rate of rolls 40 and 42 is adjustable to equal the rate at which the crimped yarn leaves crimping rolls 14 and 16. This rate can be widely varied and, as will be appreciated, is dependent upon other operating conditions such as the crimp roll diameters, yarn feed tensions, crimp roll speed and the like.

As shown in FIGURE 4, the bottom roll, roll 40, is

rotatably mounted upon an axle 78 and driven by a suitable chain and sprocket means 79. Except for its revoluble mounting on axle 78, roll 40 is supported in a fixed position by means of a supporting member 80. Roll 42, on the other hand, is mounted for vertical movement and is adjustable so as to regulate the interfacial pressure between the oppositely tapered, rubber covered surfaces of the rolls. Thus, as shown, roll 42 is provided with a shaft or axle 82 mounted in suitable block bearings 84 and 86, the latter being movable vertically in a pair of slots 88 and 90, respectively, formed in supporting frame 80. Threaded post means 92 are provided to permit adjustment of the interface pressure of rolls 40 and 42 by vertical positioning of the bearings 84 and 86 within their respective slots 88 and 90.

The sprocket 79 is selected as to diameter or number of teeth so that when yarn guide 39 is located midway between the ends of the tapered rolls on cylinders 40 and 42, the linear speed of the yarn is approximately equal to that of the fully crimped yarn being delivered from the crimping rolls 14 and 16. The desired positioning of guide 39 is effected by providing the same with a threaded end 93 which receives a threaded shaft 94. The latter is mounted in supporting frame 80 and is rotatable by handle means 96 to properly position guide 39.

The chain and sprocket means 77 and 79 associated with the crimping rolls 14 and 16, and rolls 40 and 42, respectively, as well as the traverse guide 44 and windup spool 46 may all be powered from a single motor through suitable gears or chains. Accordingly, there is generally no need for adjustment of guide 39 if this guide is properly positioned at the start of operations. If, however, the tension on the yarn changes, as indicated by the pivoted arm 30 of FIGURE 1 due, for example, to the accumulation of dirt or size from the yarn, or if the temperature of the crimping rolls should change appreciably, some readjustment of guide 39 by turning handle means 96 in a clockwise or counter-clockwise direction may be desirable. In this way, the tapered surfaces of the rolls 40 and 42 may be used to increase or decrease the takeup tension or speed as may be necessary. The motor used to drive the crimping and takeup rolls, traverse guide and spool may be a one horsepower unit with internal gear reduction. Alternatively, a large pump motor may be utilized.

A further advantage of the takeup rolls 40 and 42, as hereinabove described, is that they permit the crimped product to be subsequently wound up on the bobbin 46 of FIGURE 1 at any desired tension without taking out the crimp imparted by rolls 14 and 16. In other words, rolls 40 and 42 provide means for taking the yarn off crimping rolls 14 and 16 at speeds and/or tensions which are sufficiently low to have no significant effect upon the crimp after which the yarn can be wound up at significantly higher speeds or tensions on bobbin 46 in a conventional cross wind or the like by means of the traverse member 44. At this stage, the crimp has become permanently set in the yarn so that there is no danger of removing the same in the final winding operation.

Another significant aspect of the invention is the arrangement for winding the crimped product on bobbin or spool 46 as shown in FIGURE 5. More specifically, the bobbin 46 is supported upon a rotatably mounted shaft 98, one end of which is mounted on ball bearings 100 in a housing 102 fixed to a supporting frame indicated by the reference numeral 104. The end of shaft 98 carries a head 106 of steel or the equivalent for the purposes hereinafter apparent.

The means for driving bobbin or spool 46 for the purpose of winding the yarn thereon include a shaft 108 mounted for rotation in a supporting member 110 and driven by a suitable motor (not shown) through a belt and pulley arrangement 112 which is operatively associated with the shaft at the outer end thereof.

The inner end of shaft 108 carries a head 114 of

molded plastic or the like in which there are embedded a number of permanent magnets designated by the reference numeral 116. Two of these magnets are shown in FIGURE 5 although it will be appreciated that any number thereof, for example, four, positioned equidistant from the shaft 108, may be utilized.

The inner end of shaft head 114 is recessed as shown at 118 to expose the magnets 116 and receive the steel head 106 of shaft 98 in the manner shown. Screw means 120 are provided for the purpose of adjusting the clearance between head 106 and magnets 116 so as to change the magnetic coupling force exerted by these parts.

It will be appreciated from the foregoing description that, as the drive shaft 108 is rotated, the magnetic force created by magnets 116 overcomes the inertia of the spool 46 and causes the same to rotate. The linear speed of the spool barrel surface without a yarn load exceeds the linear speed of the yarn being delivered to the spool from the nip of the takeup rolls 40 and 42. The linear speed of the yarn as it is taken upon spool 46 can be widely varied and depends upon other operating factors such as the crimp roll diameter, crimp roll speed, crimp roll temperature and the denier of the yarn being processed. By adjusting the magnetic clearance between head 106 and the magnets 116 by means of screw 120, a wide range of tensions may be placed on the yarn as it is wound onto the spool. As indicated heretofore, the tension on the yarn at this point exceeds that on the yarn entering the takeup rolls 40 and 42 but even though these relatively high tensions are sufficient to pull the yarn out straight and free of crimp configuration, the crimp is not impaired, due to the low tensions used with rolls 40 and 42. Accordingly, when the yarn is taken from the spool in visually crimp-free condition, and put into water or steam, or the tension thereon relaxed, the crimp returns substantially instantaneously. Thus, yarn processed according to the invention, even though subjected to tensions in winding, warping, spooling or other operations necessary to weave or knit into fabric will regain its crimp in the boil-off and dyeing operations which normally follow.

From the foregoing, it will be recognized that the present invention provides uniquely improved methods for simultaneously heat setting and crimping yarns, filaments or fibers of nylon or other synthetic thermoplastic material by the steps of drawing the material through a pair of meshing and crimping rolls or gears shaped to give the desired crimp configuration, internally heating the rolls to a temperature sufficient to set the material, i.e. to a temperature at least equal to the second transition point of the material, maintaining the material in contact with the internally heated rolls for a time sufficient to heat set the same, thereafter taking up the yarn at a relatively low tension below the point at which the crimp would be removed from the material and then winding up the yarn thus taken up at a higher tension. Other aspects of the invention comprise taking up the crimped product from the meshing or crimping rolls at a rate of speed substantially equal to that of the product as it leaves the rolls and the invention includes novel means for accomplishing this. Unique magnetically operable means for winding up the crimped yarn or the like are also provided.

Various modifications may be made in the invention described herein without in any way deviating from the scope thereof as defined in the following claims wherein:

I claim:

1. A method of producing a uniformly crimped, heat set yarn of thermoplastic synthetic linear polymer which comprises providing a supply of said yarn in the uncrimped, non-heat set state, passing said yarn continuously from said supply into the nip of a pair of internally heated, driven crimping rolls maintained at a temperature sufficient to heat said yarn to a temperature at least equal to the second transition point of the polymer and

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below the tack point thereof, maintaining the yarn between said rolls for a period of time sufficient to simultaneously crimp and heat set the same, the heat set being such that the polymer, upon cooling, shows substantially no shrinkage after immersion in hot water followed by drying in the slack conditions; discharging said yarn from the crimping rolls in the hot plastic state and allowing the discharged yarn to cool and set into the crimped pattern of said rolls while said yarn is in a predominantly unsupported, essentially slack-free state and under negligible tension, taking up said cooled, set yarn at a rate equal to the rate at which it is discharged from the crimping rolls, measuring the tension on said yarn throughout the cooling and setting thereof between its point of discharge and takeup, adjusting the takeup path and the distance of takeup to compensate for any increase in tension on the yarn as it is being cooled and set, and thereafter collecting the cooled and crimped material from said takeup under tension, the heat setting treatment with said crimping rolls constituting the sole essential heating treatment between said crimping and cooling operations.

2. The method of claim 1 wherein the yarn is nylon,

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the yarn is maintained between said crimping rolls for a time within the range of $\frac{1}{15}$ to 1 second and the yarn is removed from said crimping rolls by passing the same into the nip of a pair of tapered takeup rolls, the rate of yarn takeup being maintained the same as the rate of yarn discharged from the crimping rolls by adjusting the point at which the yarn is passed into the nip of said tapered rolls.

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