

Feb. 9, 1971

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3,561,082

METHOD OF CRIMPING AND/OR STABILIZING TEXTILE STRANDS

Filed Sept. 12, 1967

4 Sheets-Sheet 1

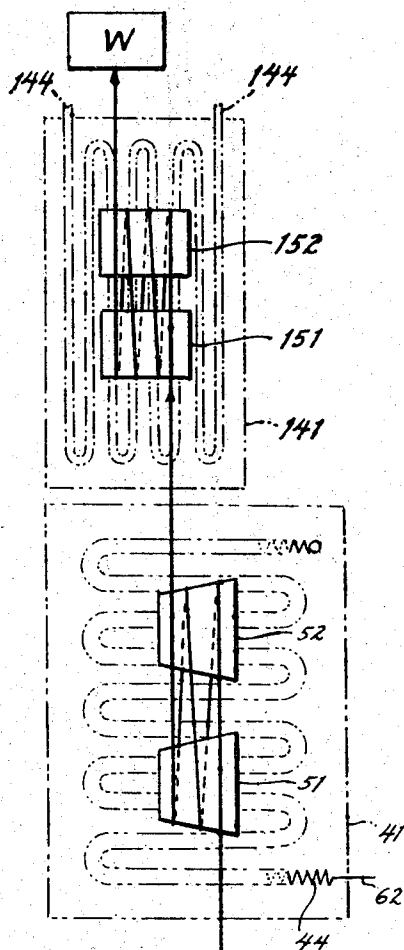


Fig. 1.

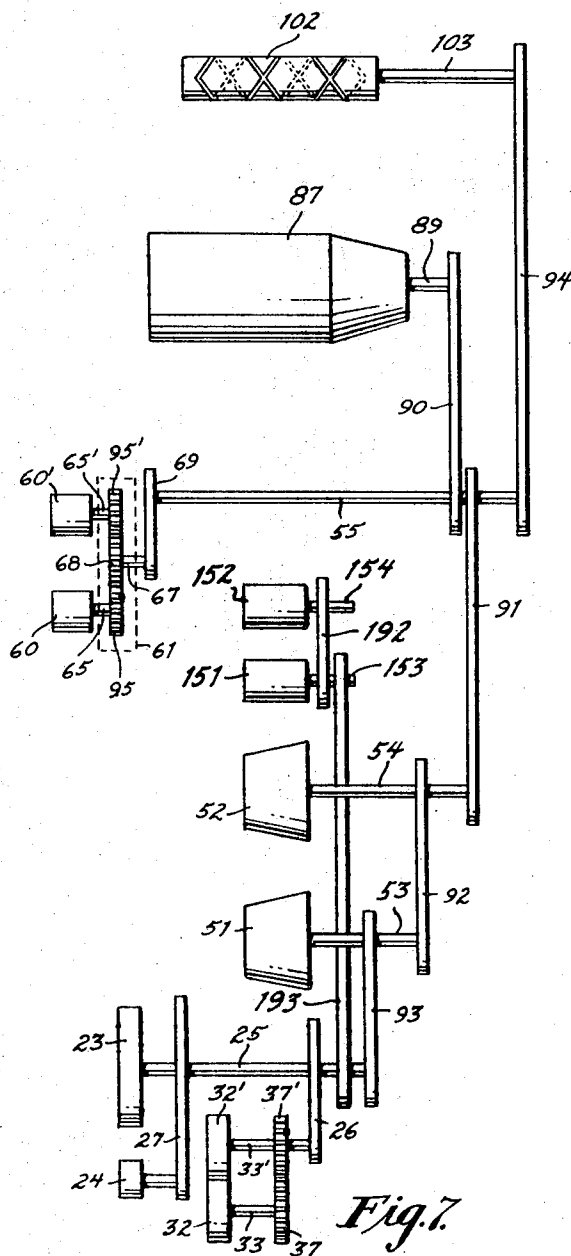


Fig. 7.

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4 Sheets-Sheet 2

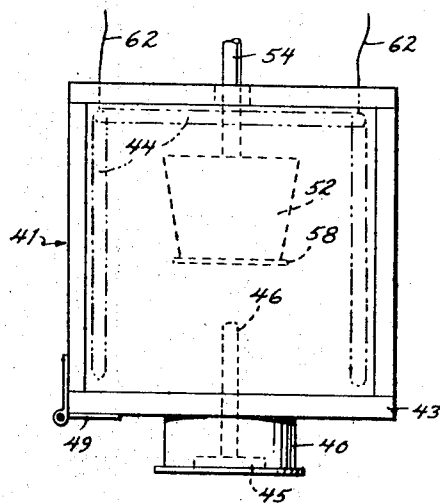


Fig. 4.

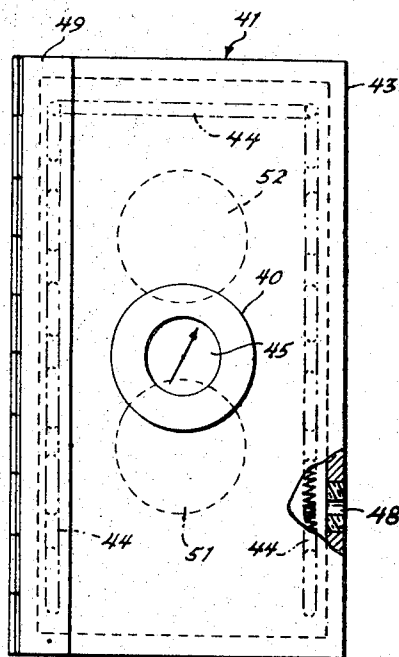


Fig. 3.

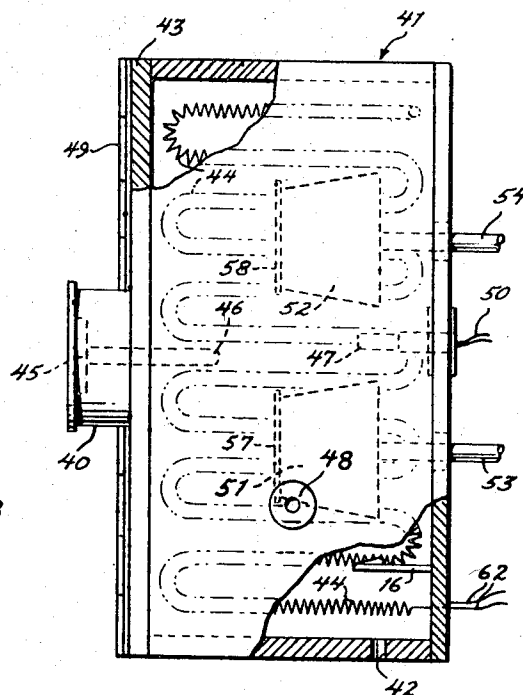


Fig. 2.

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4 Sheets-Sheet 3

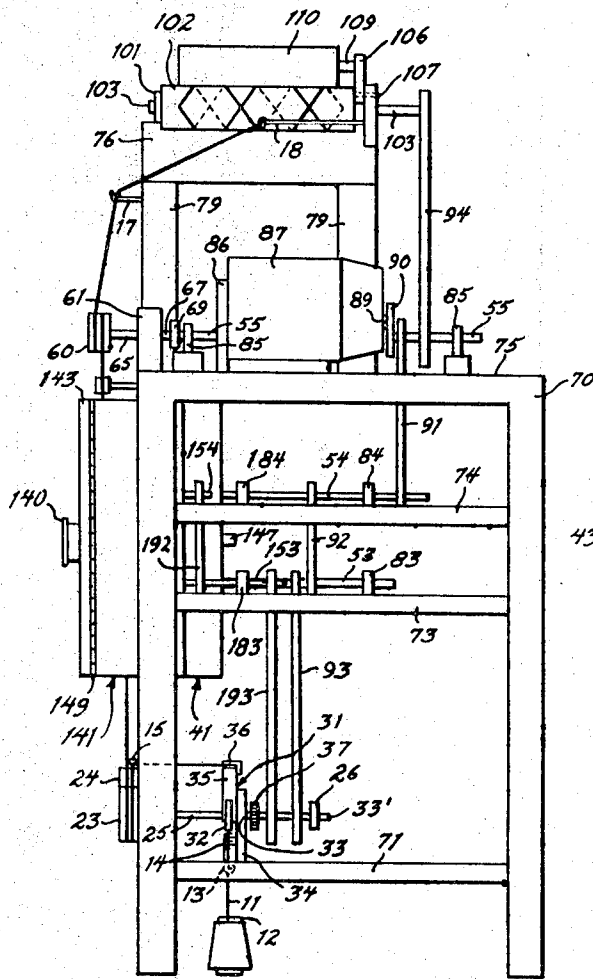


Fig. 5.

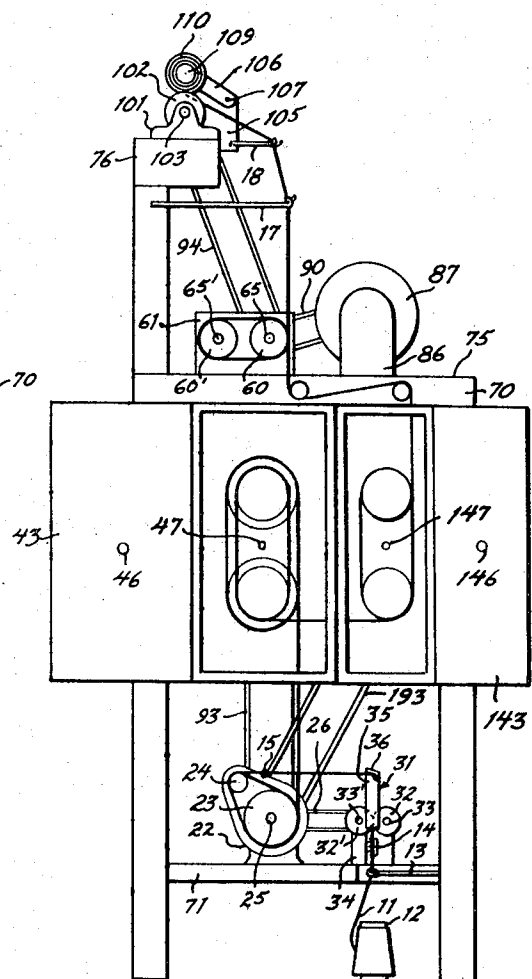


Fig. 6.

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4 Sheets-Sheet 4

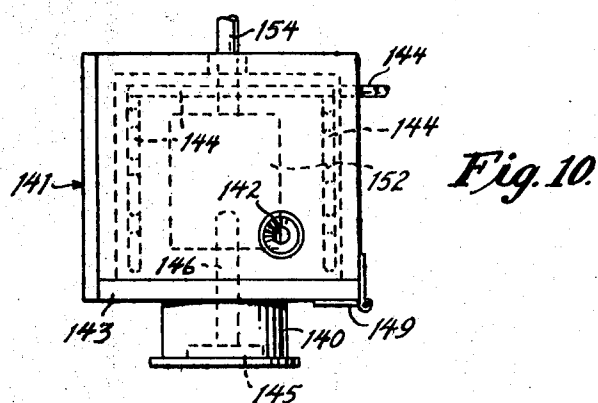


Fig. 10.

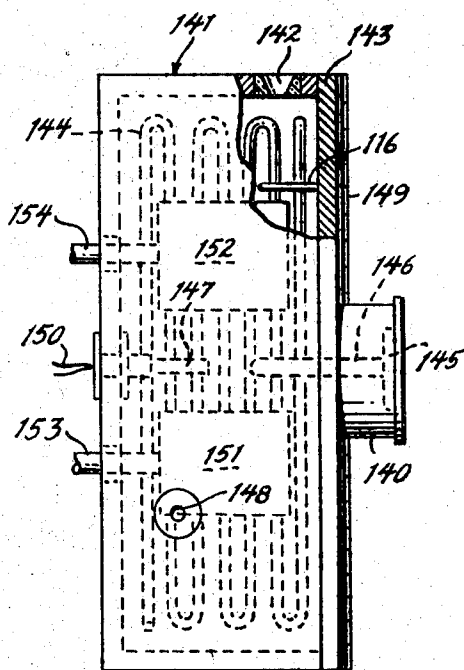


Fig. 8.

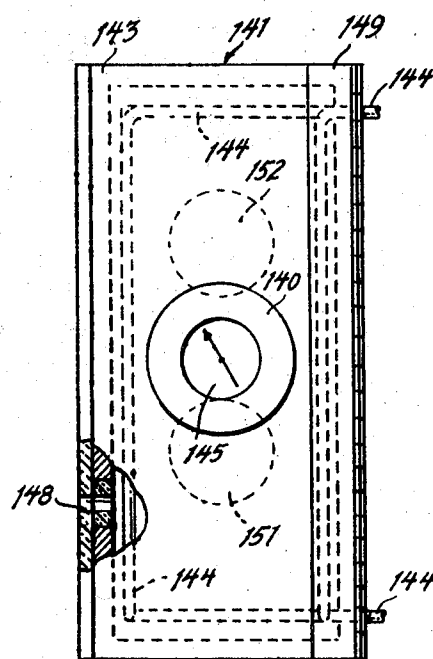


Fig. 9.

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1

3,561,082

METHOD OF CRIMPING AND/OR STABILIZING TEXTILE STRANDS

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Continuation-in-part of applications Ser. No. 112,374, May 24, 1961, and Ser. No. 415,068, Dec. 1, 1964.
This application Sept. 12, 1967, Ser. No. 667,294
The portion of the term of the patent subsequent to Dec. 7, 1982, has been disclaimed

Int. Cl. D02g 1/00

U.S. Cl. 28—72.1

13 Claims

ABSTRACT OF THE DISCLOSURE

A textile strand which has been subjected to crimping distortion strains is stabilized in configuration in an apparatus and by a process which includes heating the strand in a heating zone where its rate of travel through the zone is reduced in successive increments and cooling the strand in a cooling zone under processing conditions provided to avoid storage distortion of wound strand.

This is a continuation-in-part application of Ser. No. 415,068, filed Dec. 1, 1964 for Strand Treatment and now abandoned, and of application Ser. No. 112,374, filed May 24, 1961 and now U.S. Pat. 3,221,385, granted Dec. 7, 1965 for Strand Treatment.

This invention relates to strand processing, especially the heat-setting and cooling of synthetic textile strands following crimping thereof.

Textile strands (hereinafter usually referred to simply as "strands") of synthetic compositions, which are generally thermoplastic, may be stabilized, at least to a considerable degree, in length and other configuration by heating under such conditions that the heated strands assume or do not deviate from the desired configuration. Length and cross-sectional area of a rectilinear strand are inversely related, of course. A non-rectilinear strand, especially a multifilament strand, may have an effective cross section greater than the space actually occupied by the filamentary composition, i.e., the strand being "spread out" transversely by virtue of a configurational modification, usually called crimping. Crimped strands stand in especial need of structural stabilization, as by heat-setting. Heating a strand facilitates relief of internal strains set up by crimping or other previous distorting stresses.

Heat-setting of a crimped strand to maintain desired bulk at appropriate elasticity may be accomplished before the strand is withdrawn from the crimping apparatus or from a zone in which the strand has accumulated in the crimped condition. Stabilization of strand configuration may be effected in similar manner during subsequent winding or forwarding of the strand in lengthwise fashion. However, as is well known, the crimp may be reduced significantly, or the strand actually may be stretched, minimizing the retained crimp, if it is under too great tension in the setting zone. Also, insufficient stabilization may occur if the strand is not in the zone long enough or not otherwise properly treated while therein.

Following the heat-setting of the crimped strand, it is customary to cool the strand in the course of rewinding it. It has now been found that the strand should be promptly cooled after the heat-setting thereof in order to prevent subsequent distortion of the crimps into different, unwanted forms which detract from the uniformity of the heat-set crimped strand.

A primary object of the present invention is controlled contraction of a strand adapted to shrink or shorten when heated under appropriate tension.

2

An object is improved control of time, temperature, and tension for a strand in a heat-setting zone.

A particular object is stabilization of the configuration of a running strand.

5 Another object is reduction in tension variations in a running strand by controlled stabilization of the strand.

A further object is improvement in uniformity or reduction of residual strains throughout the length of a crimped or otherwise distorted strand.

10 Yet another object is stabilization of the configuration of a strand by cooling of the strand at constant length, as soon as the heat-setting has been completed.

Other objects of this invention, together with means and methods of attaining the various objects, will be apparent from the following description and the accompanying diagrams.

FIG. 1 is a schematic diagram of the processing of a strand according to the present invention;

15 FIG. 2 is a side elevation, partly broken away, of apparatus of this invention, showing the heat-setting portion thereof;

FIG. 3 is a front elevation of the apparatus of FIG. 2.

FIG. 4 is a plan view of the apparatus of FIGS. 2 and 3;

25 FIG. 5 is a side elevation of a machine embodying the apparatus of the preceding views;

FIG. 6 is a front elevation of the machine of FIG. 5, with the access door of the heating chamber opened to reveal the interior;

30 FIG. 7 is a schematic representation of the drive layout of the machine of FIGS. 5 and 6;

FIG. 8 is a side elevation, partly broken away, of apparatus of this invention, showing the cooling portion thereof;

35 FIG. 9 is a front elevation of the apparatus of FIG. 8; and

FIG. 10 is a plan view of the apparatus of FIGS. 8 and 9.

In general, the objects of the present invention are accomplished, in a crimped textile strand, by passing the strand at a given rate into a heating zone, progressively decreasing the rate of travel of the strand as it travels through the heating zone, to heat-set the strand, and immediately passing the strand from the heating zone at a lesser constant rate into and through a cooling zone at that rate. The invention comprehends particularly a heat-setting and cooling stabilization treatment for a crimped textile strand adapted to assume a stable shortened end-to-end configuration when heated and to retain said configuration when cooled below distortion temperature, comprising passing such strand through a radiant heating zone and permitting the strand to shorten progressively at a controlled rate while in the zone, passing the shortened strand through a cooling zone and permitting the strand to cool below a distortion temperature to prevent distortion of said configuration, and contemplating also apparatus or machinery adapted to perform such a process.

FIG. 1 shows, in schematic form, passage of strand 11 from bobbin 12 into a through distortion-producing zone D (shown in block form), which may be occupied by a crimper or twister (or combination thereof) or equivalent, and into heating chamber 41 (indicated in broken lines) with the aid of forwarding roll system F and related elements, which appear in greater detail in subsequent views. Inside the chamber, which has internal heating element 44 of electrical resistance type (shown partly in broken lines), the strand passes about pair of frustoconical rolls 51, 52, beginning at or near the larger end of the first roll, continuing to and about the larger end of the second roll, and then from roll to roll (two complete wraps shown), progressing toward the smaller

3

ends thereof, and finally leaving from at or near the smaller end of the second roll. The strand then exits from the chamber and passes into cooling chamber 141, which appears in greater detail in subsequent views. Inside chamber 141, which has coolant conducting tube 144 (shown partly in broken lines) through which a cooling fluid (not shown) may be circulated, the strand passes about a pair of cylindrical rolls 151, 152, beginning at or near one end of roll 151, continuing to and about the corresponding end of roll 152, and then from roll to roll (three complete wraps shown), progressing to the other ends of the rolls, and finally leaving from at or near the end of roll 152. The strand then exits from chamber 141 and passes about windup roll system W shown in block form.

FIG. 2 shows heating chamber 41 in side elevation, partly broken away to reveal portions of the interior. Pigtail guide 16 is located above the entrance aperture 42 in the bottom of the chamber, at the lower right. The exit aperture in the side of the chamber, at the lower portion, is provided by outlet inserted eye guide 48. Door 43, located (closed) on hinge 49 along the left edge in this view, supports thermometer 40, which has dial 45 on the exterior and stem 46 extending through the door and into the chamber. Thermocouple 47, with pair of leads 50, extends similarly into the chamber through the opposite (rear) wall, located at the right in this view. Frustoconical rolls 51, 52, with rims 57, 58 at their smaller ends (to aid retention of the strand during string-up), are mounted on respective shafts 53, 54 and appear largely in broken lines, being hidden by the rear (right) wall of the chamber. Resistance heating element 44 is indicated similarly, being hidden except where the wall is broken away at the upper left and lower right. Pair of electrical leads 62 to the heating element are visible at the lower rear (right) of the chamber.

FIG. 3 shows the heating chamber in front elevation. Heating element 44 (indicated in broken lines) lines the chamber at opposite (right and left) sides and crosses from side to side at the top rear. Outlet 48 is shown in the partly broken away section at the lower right of this view. Upper conical roll 52 and lower conical roll 51, also represented in broken lines behind door 43, are centered above and below the level of thermometer dial 45 (with indicating arrow), which protrudes from the front of the door. FIG. 4 shows the heating chamber in plan, viewed from above, the interior elements being shown in broken lines. The yarn itself is omitted from FIGS. 2, 3, and 4 in the interest of clarity, as are the conventional supporting spacers for the heating element.

FIG. 5 shows the apparatus of the preceding views in side elevation. Table frame 70 supports all the apparatus elements, either directly or indirectly. Bobbin 12, from which the yarn unwinds, is located on the floor or other supporting surface for the frame. Lowest shelf 71 supports pigtail guide 13 directly above the bobbin and, above the level of the guide, gate tensioner 14 and stuffer-crimper 31, the latter corresponding to distorting component D of FIG. 1. The stuffer-crimper comprises pair of nip rolls 32, 32' (only 32 visible in this view) in respective shafts 33, 33' supported in pillow block 34 mounted on the shelf. Stuffing chamber 35 is juxtaposed to the rolls from above, and it terminates in pivoted cap 36, which impedes the exiting of crimped strand from the chamber. The emergent yarn passes through pigtail guide 15 supported on a capstan frame (hidden in this view) which is mounted on the shelf. The yarn passes down behind small and large rolls 24 and 23, respectively, of the capstan and about the same (two wraps shown) before proceeding to the heating chamber. The capstan arrangement corresponds to forwarding roll system F of FIG. 1. Shaft 25 of the large capstan roll is linked to shaft 33' of one of the crimper nip rolls by

4

belt 26, and to shaft 53 by belt 93. Shaft 25 is also linked to shaft 153 by belt 193.

Also shown in FIG. 5 are the supporting and driving means for shafts 53 and 54 of the frustoconical rolls, and of shafts 153 and 154 of the cylindrical rolls of cooling chamber 141. Intermediate and top shelves 73 and 74 support respective pairs of pillow blocks 83, 84, 183, and 184 for these shafts, which are interconnected by belt 92 between shafts 83 and 84 and belt 192 between shafts 183 and 184. Motor 87 is mounted on bracket 86 on top surface 75 of the table frame. Shaft 89 of the motor is connected by belt 90 to intermediate shaft 55, which is mounted in pillow blocks 85 on the top surface. Belt 91 interconnects the intermediate shaft to upper frustoconical roll shaft 54. Belt 69 at the opposite end of the intermediate shaft connects it to gear shaft 67, which enters gearbox 61. Shaft 65 of windup roll 60 is visible leaving the opposite face of the gearbox. Concealed behind this windup roll in this view is similar windup roll 60' mounted on shaft 65' protruding from the gearbox, inside which the shafts are geared together (as subsequently shown) for like rotation. The windup rolls, which receive the strand from the cooling chamber 141, correspond to windup roll system W of FIG. 1.

Located on superstructure comprising pair of uprights 79 and overhanging shelf 76 mounted in pillow blocks 101 (only one being clearly visible) at its opposite ends is shaft 103 of grooved traversing drive roll 102. This shaft is interconnected by belt 94 to intermediate shaft 55. Flange 105 affixed to the right edge of the shelf supports swing arm 106 on pivot pin 107. Spindle 109 rotatably mounted on the swing arm has windup bobbin 110 on it and in contact with the grooved face of the traversing drive roll. Also supported by the flange is pigtail guide 18, which terminates in front of the traversing drive roll to receive the strand from pigtail guide 17 supported above the windup rolls by left upright 79. The bobbin is rotated on its spindle by contact with the face of drive roll 102. The strand from the pigtail guides winds onto the bobbin through the grooves in the drive roll, patterned to traverse the strand back and forth along the bobbin. Of course, as the treated strand accumulates on the bobbin, the swing arm permits the spindle to pivot away from the roll axis.

FIG. 6 shows the apparatus of FIG. 5 in front elevation. Certain of the machinery elements mentioned as not visible in FIG. 5 are visible in this view. In this view, moreover, access door 43 of the heating chamber and access door of the cooling chamber are open, thereby revealing the interiors. The strand is shown wrapped about the frustoconical rolls between its entrance into and exit from the heating chamber, passing through the adjoined walls of the heating and cooling chambers, and wrapped around the cylindrical rolls between its entrance and exit from the cooling chamber.

FIG. 7 shows the various shafts and interconnecting belts and gears in a schematic layout to clarify the interrelationships in a way not permitted by the elevational views. This view also shows the contents of gearbox 61, which has drive gear 68 on previously shown shaft 67 in mesh with gears 95, 95' on respective shafts 65, 65' for windup rolls 60, 60'. The driving of all the shafts and the elements carried by them from motor 87 is readily apparent. As in the preceding mechanical views the shaft pulleys about which the various belts pass are not shown.

FIG. 8 shows cooling chamber 141 in side elevation, partly broken away to reveal portions of the interior. The entrance aperture in the side of the chamber, at the lower left, is provided by inserted eye guide 148. Pigtail guide 116 is located below exit aperture 142 in the top of the chamber, at the upper right. Door 143, located (closed) on hinge 149 along the left edge in this view, supports thermometer 140, which has dial 145 on the exterior and

5

stem 146 extending through the door and into the chamber. Thermocouple 147, with pair of leads 150, extends similarly into the chamber through the opposite (rear) wall, located at the left in this view. Cylindrical rolls 151, 152 are mounted on respective shafts 153, 154 (slightly skewed to advance yarn along the rolls, as is conventional) and appear largely in broken lines, being hidden by the rear left wall of the chamber. Coolant conducting tube 144 is indicated similarly, being hidden except where the wall is broken away at the upper right.

FIG. 9 shows the cooling chamber in front elevation. Coolant conducting tube 144 (indicated in broken lines) lines the chamber at opposite (right and left) sides and crosses from side to side at the top rear. Upper cylindrical roll 152 and lower cylindrical roll 151, also represented in broken lines behind door 143, are centered above and below the level of thermometer dial 145 (with indicating arrow), which protrudes from the front of the door. FIG. 10 shows the cooling chamber in plan, viewed from above, the interior elements being shown in broken lines. The yarn itself is omitted from FIGS. 8, 9, and 10 in the interest of clarity, as are the conventional supporting spacers from the coolant conducting tube.

Suitable construction of the mechanical elements of the invention will be readily apparent to a person having ordinary skill in the art, after consideration of this specification. Of course, all guides are of suitably smooth, hard material, preferably ceramic. The size, spacing, and taper of the frustoconical rolls are discussed below. The various winding and drive means are only exemplary and may be replaced by any equivalent means and may be supplemented by suitable synchronization devices, as may be desired. The heating element in the heating chamber is made of conventional high-resistance wire supported on small ceramic spacers (not shown) carried by the inside walls of the chamber. Equivalent radiant heating means, such as infra-red lamps, may be substituted, with appropriate redesign of the chamber. The electrical circuit for the heating means is not illustrated, but it contains, and is controlled in conventional manner by, the bimetal thermostat supported by the rear wall of the chamber.

The coolant conducting tube in the cooling chamber is made of corrosion resistant material used for refrigeration cooling coils, preferably metal, such as stainless steel or aluminum. It may be supported on ceramic or plastic hangers or on corrosion resistance metal hangers. The coolant may be any fluid suitable for cooling the strand in the chamber from its heat-setting temperature, e.g., 290° F., to its sub-distortion temperature, e.g., 120° F. or less, and as low as 32° F. Water; a refrigerant material such as dichlorodifluoromethane or ammonia, or other vaporizable liquid; or a brine solution may be used as a coolant. Cooled water will usually be adequate to provide sufficient cooling capacity in the tube to cool the chamber and the strand passing through it. The coolant can be circulated in a known way. The temperature in the cooling chamber is controlled in the conventional way by means of the bimetal thermostat 150 supported by the rear wall of the chamber 141.

Operation of the apparatus of this invention to perform the mentioned process is readily understood. Strand in the form of yarn or the like is unwound from the lower bobbin and treated by the crimper or other strand-distorting means and is forwarded to the frustoconical rolls in the heating chamber where it is heat-set; it is then immediately cooled, and finally wound up onto the upper bobbin. The strand passes first onto the large end of the frustoconical rolls and progresses in successive wraps about the pair of rolls as a unit to the smaller end, from which it is withdrawn by the pull of the cylindrical rolls in the cooling chamber and then withdrawn from the cooling chamber by the windup rolls about which it then passes. The surface speed of the forwarding rolls approximates the speed of the large end of the frustoconical rolls (both of which turn at the same speed), while the

6

surface speed of the windup rolls approximates the speed of the small end of the frustoconical rolls and the speed of each cylindrical roll. No slack develops in the strand as it gradually undergoes the speed reduction on the frustoconical rolls, and any slippage between the strand and the various roll surfaces is minimal. Because of the substantially non-slipping contact between the strands and the rolls in its repeated passage thereabout, the strand is not 'ironed' by its contact with the rolls in either the heating or cooling chamber.

As the strand is heated in the chamber it shortens or shrinks as permitted by the taper of the frustoconical rolls, remaining under some tension all the time. The time, temperature, and tension of the strand in the chamber depend in large part upon the strand composition, of course. Also important are the conditions of distortion to which the strand was subjected previously. Unless otherwise indicated, the data set forth herein relate chiefly to nylon strands. In general, tension at which the strand is forwarded to the chamber is purposely low, as on the order of tenths of a gram per denier (e.g., from about 0.1 to 0.5 g.p.d.). The preferred angle of roll taper (i.e., the apex or included angle), which is conveniently constant from one end of the rolls to the opposite end, is on the order of a small fraction (e.g., $\frac{1}{20}$ of a circle. At these relatively small angles the yarn changes in overall length by an amount that, expressed as a percentage, approximates the taper angle expressed in degrees. The roll size, spacing, and speed, as well as the number of wraps of the strand about the rolls, are selected to provide the desired holdup time for a given strand in the chamber; this time usually is on the order of a second or so. Principal limiting factors in the rise of the strand temperature are the heat absorption and transmission properties of the strand composition. The actual time during which the entire cross-section of the strand need be at the stabilizing temperature is only about $\frac{1}{10}$ of the total holdup time. The ambient temperature elected usually will be at least about 200° F. and, of course, below the temperature at which the particular strand composition softens excessively, colors, or otherwise degrades to an undesired extent. The rolls in the chamber will assume a slightly lower equilibrium temperature.

In processing stuffer-crimped nylon multifilament (e.g., 200-68 count), the following conditions have proved eminently satisfactory: 6 wraps about rolls slightly wider than 3", having respective large and small end diameters of 4" and 3", spaced 6" on centers at an average speed of 30 y.p.m., at an ambient temperature of 230° F. in the chamber. The overall reduction in strand length (by shrinkage and other end-to-end shortening) was about 15%. Tension on the strand entering the chamber was 60±30 gms., while the exiting strand tension was 20±4 gms. Nylon is only one example (actually more than one, both 6 nylon and 66 nylon having been used successfully) of strand composition amenable to the practice of this invention, and the data recited above constitute only one example of suitable conditions (being taken from results for 66 nylon).

The moisture content of the strand may affect the desired holdup time by varying the speed with which the strand reaches a stable condition. In general, for this and other reasons, the strand should not be wet, the preferable content of water (and/or any lubricant or softening, swelling, or plasticizing agent or solvent, all of which may be collectively referred to as "moisture") being less than about 10%. A strand at such low moisture content may be considered as essentially dry or moisture-free for the purposes of the present invention. The relative humidity in the heating chamber should not exceed about 20% for usual textile strand compositions, varying according to the moisture sensitivity of the composition. Excessive humidity or moisture content in the strand can be expected to be conducive to slackening of the strand and to loss of

any desired distortion (such as crimp) present therein and may increase holdup requirements significantly.

It is noteworthy that, according to the present invention, change is permitted in the strand configuration within the heating zone only at a controlled rate and to a controlled extent. Thus, the strand becomes adapted to its reduced length and undergoes other less obvious changes, such as internal strain relief, incrementally, i.e., in a succession of relatively short, closely spaced steps. The strand entering and leaving the zone is under less extreme conditions than the strand in the zone so that the effect of the treatment upon the strand is so concentrated as to prevent the strand from relaxing irregularly or to an extreme extent as it might if it were forwarded on the run through a simple heating or steaming zone or over a heating block or through a heating tube or the like, where there is no similar incremental focusing of the treating conditions and where the strand consequently is subject to wide and deleterious tension fluctuations.

As described above, the crimped strand has undergone a reduction of about 15% in strand length and is at an ambient temperature of about 230° F. in the heating chamber at the time it is ready to leave the chamber. After such heat treatment, it is known to pass the heat-set crimped strand through a cooling zone, which may be a predetermined distance of passage through air at ambient temperature, before winding it on the windup bobbin. When the ambient temperature is low enough to provide a sizable temperature differential between the heating chamber and the atmosphere outside the chamber, little or no problem arises. However, because of variations in the ambient room temperature, the differential can vary considerably and the strand-winding temperature will vary accordingly. Therefore, particularly at high rates of winding speed, the strand may reach the bobbin at an excessively high temperature. The portion of the strand which is first wound on the bobbin will, in such a case, continue to hold its heat on being covered with subsequently wound outer layers of strand. Due to the insulating properties of the nylon strand, this heat can be retained in the bobbin for a considerable period of time. During winding, the strand usually is extended sufficiently to straighten the crimp at least partially and may even be placed under sufficient tension to elongate the strand somewhat. When hot strand is held in such extended wound configuration for a prolonged period of time, some of the crimp may be removed. The result is that strand at the innermost part of the bobbin may have a different crimp configuration than that at the outermost part of the bobbin. This variation in configuration is undesirable, particularly as non-uniformity may cause barre in woven fabric or puckering in knitted fabric, or dyeing non-uniformity, regardless of type of fabric construction. Furthermore, the possibility of differences in configuration between strand wound under conditions of high humidity and that wound under conditions of low humidity can be similarly serious.

To overcome the above problem, the present invention provides a cooling chamber immediately adjacent to the heating chamber for cooling crimped, stress-relieved strand to a "storage distortion temperature," herein defined to mean a temperature at and above which a significant storage distortion problem may be expected to occur with the wound strand and below which essentially no significant distortion normally occurs. The hot strand enters the cooling chamber substantially at the temperature of the heating chamber, for example, in the range of about 200° to 300° F. In the cooling chamber, the strand passes over the outer surfaces of the pair of cylindrical rolls substantially as shown in FIG. 6 and is quickly cooled to a temperature below the storage distortion temperature. This storage distortion temperature for the nylon of the exemplary description above is about 125° F. The temperature in the chamber may vary above or below this temperature depending on the chemical and

physical characteristics of the filament or strand being treated. The temperature of the cooling chamber, i.e., the temperature at which cooling is carried out will in some cases be the same as room temperature, and in other cases higher, and in many cases will advantageously be lower than room temperature. Accordingly, uniform cooling of the strand in the chamber to a strand temperature in the range of from about 30° F. to about 125° F. may be used with 6 nylon to achieve the advantages and benefits of the invention.

When the storage distortion temperature in the cooling chamber is significantly, e.g., 20 to 30 degrees, above the ambient room temperature, the strand can be further cooled in the customary way by passage through an air cooling zone in which residual heat in the strand can be dissipated. While this step has but only a slight added benefit, it may be desirable with some heavy strands which retain significant amounts of heat.

The cooling is done at substantially constant length, since the shrinkage during cooling is relatively insignificant. The size of the cooling chamber and the number of wraps around the rolls can be readily determined so that the strand is held in the chamber for at least the minimum time necessary to cool it below the storage distortion temperature. The following conditions have proved successful: 6 wraps around a pair of rolls, each having a 3" diameter, corresponding to the smaller diameter of the frustoconical rolls, spaced on 6" centers, and turning at the same speed as the frustoconical rolls at a chamber temperature of $110 \pm 5^\circ$ F. in the cooling chamber provided by cooling water circulated in the coolant circulating tube. The hot strand thus is cooled to uniform temperature suitable for storage purposes before it leaves the chamber. On leaving the chamber, the cooled strand is wound directly on the windup bobbin. By means of the invention, strand is provided uniform in temperature at the bobbin and the resulting wound-up strand is itself uniform in temperature from its core to its outer winding.

The distortion which occurs during storage takes at least two forms. The first of these is a reduction in crimping effectiveness and is evidenced by a decrease in the stretch and recovery of the crimped strand. For example, when the strand has been cooled below its storage distortion temperature of 115° F., crimped 6 nylon strand having 68 filaments of 16 denier each has an elongation of 35% of its original crimped length under a 10 gram weight and a recovery to 90% of its original crimped length. In contrast, similar crimped strand cut from the first few wraps of strand which had been wound on a bobbin when the strand was above its storage distortion temperature, e.g., at a windup temperature of about 200° F., was found to have an elongation of 20% of its original crimped length and a recovery to 85% of its original crimped length.

The second distortion is in the nature of a helical distortion of the strand from the core wrappings to the exterior wrapping of the bobbin. The difference in the helices becomes noticeable when the tail end of one bobbin, where the helix is small, is tied to the beginning of a second bobbin, where the helix is large. The result of this distortion is that a stronger tension must be exerted on the smaller helix to straighten the strand than is required to straighten the larger helix and causes a variation in elongation and recovery of the crimping in the corresponding portions of the joined strands.

A strand treated according to the present invention is stabilized to retain an optimum amount of the desired distortion, whether crimp, twist, or other, previously induced. This distortion-induced strains that previously existed to bias the strand to reduce the distortion are reduced to a sufficient extent as to render the strand configuration desirably stable, and the uniform cooling of the stress-relieved strand renders the strand more capable of retaining this stability in woundup form. The controlled

end-to-end shortening of the strand as provided by this invention is essential to such stabilization, and the controlled cooling of the strand is advantageous to its retention. The particular method and means herein described and claimed are optimum for these purposes.

What is claimed is:

1. In a textile strand treatment for a distorted strand having distortion-induced strains therein effective to bias the strand so as to reduce the distortion thereof, such strains being adapted to be relieved by heating, wherein such strand is supported within a heating zone for travel through the zone, and is traveled through the zone, and the rate of travel of the strand is reduced at successive increments of its travel through the zone, and wherein the strand is heated sufficiently throughout its travel through the zone to relieve such strains to a desired extent, the improvement comprising travelling the textile strand from the heating zone into a cooling zone and cooling it at substantially constant length during its travel through the cooling zone below the distortion temperature to prevent distortion thereof.

2. The strand treatment according to claim 1 wherein the cooling is carried out throughout the travel of the strand through the cooling zone.

3. The strand treatment according to claim 1 wherein the cooling is carried out at a temperature higher than room temperature.

4. The strand treatment according to claim 1 wherein the cooling is carried out at a temperature about the same as room temperature.

5. The strand treatment according to claim 1 wherein the cooling is carried out at a temperature lower than room temperature.

6. In a strand textile treatment wherein a crimped textile strand is passed under tension sufficient to prevent slack but insufficient to straighten the crimp, into a heating zone wherein the strand is passed in essentially non-slipping contact with a succession of solid surfaces moving at progressively slower speeds, the speed of each surface remaining essentially constant, thereby progressively slowing the strand during its passage through the zone while maintaining it free from slack, and wherein the strand is removed from the zone at a rate approximating the slowest rate of travel of the strand in the zone, the improvement comprising passing the strand immediately from the heating zone into a cooling zone wherein the strand is cooled at substantially constant length below the distortion temperature to prevent distortion thereof, and withdrawing the strand therefrom at said constant length.

7. The strand treatment according to claim 6 wherein the temperature of the cooling zone does not exceed the storage distortion temperature.

8. The strand treatment according to claim 6 wherein the strand removed from the heating zone is cooled in the cooling zone to a temperature not exceeding storage distortion temperature.

9. Strand treatment, for a distorted textile strand containing less than about 10% moisture and having distortion-induced strains therein effective to bias the strand so as to reduce the distortion thereof, such strains being adapted to be relieved by heating, comprising supporting such strand within a heating zone for travel through the zone, travelling the strand through the zone, and reducing the rate of travel of the strand progressively at selected successive increments of its travel path through

the zone, heating the strand sufficiently throughout its travel through the zone to relieve such strains to a desired extent, as evidenced by resultant reduction in the bias of the strand toward a distortion-free condition, then passing the strand into a cooling zone maintained at a constant temperature not exceeding storage distortion temperature, and cooling the strand at least to storage distortion temperature therein to prevent distortion thereof.

10. Strand treatment comprising passing a heat-shrinkable distorted textile strand essentially moisture-free along a path through a heating zone, heating the strand therein throughout a plurality of incrementally shorter portions of the path to shrink it, then passing the strand along a path through a cooling zone, maintaining the temperature in the cooling zone substantially constant at a temperature not exceeding storage distortion temperature, and cooling the strand therein to said temperature to prevent distortion thereof.

11. The strand treatment according to claim 10 wherein there are more than two incrementally shorter path portions of the strand in the heating zone.

12. Strand treatment comprising passing a distorted textile strand in essentially moisture-free condition at a plurality of incrementally slower speeds through a heating zone, the speed of the strand into the zone being substantially constant and at all times exceeding each of the plurality of incrementally slower speeds, heating the strand throughout its passage through the zone to relieve strains therein then passing the strand into a cooling zone maintained at a constant temperature not exceeding storage distortion temperature, and cooling the strand at least to storage distortion temperature therein to prevent distortion thereof.

13. In a process for strand treatment which comprises crimping an essentially dry textile strand, passing the crimped strand at a given rate into a heating zone, reducing the rate of travel of the strand progressively at selected successive increments of its travel path through the zone, and heating the strand sufficiently throughout its travel through the zone to relieve strains induced in the strand by said crimping, the improvement which comprises passing the heated strand from the heating zone into a cooling zone maintained at a temperature not exceeding storage distortion temperature, and cooling the strand at such temperature therein prior to winding the strand on storage means to prevent distortion thereof.

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