

Dec. 7, 1965

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3,221,385

STRAND TREATMENT

Filed May 24, 1961

3 Sheets-Sheet 1

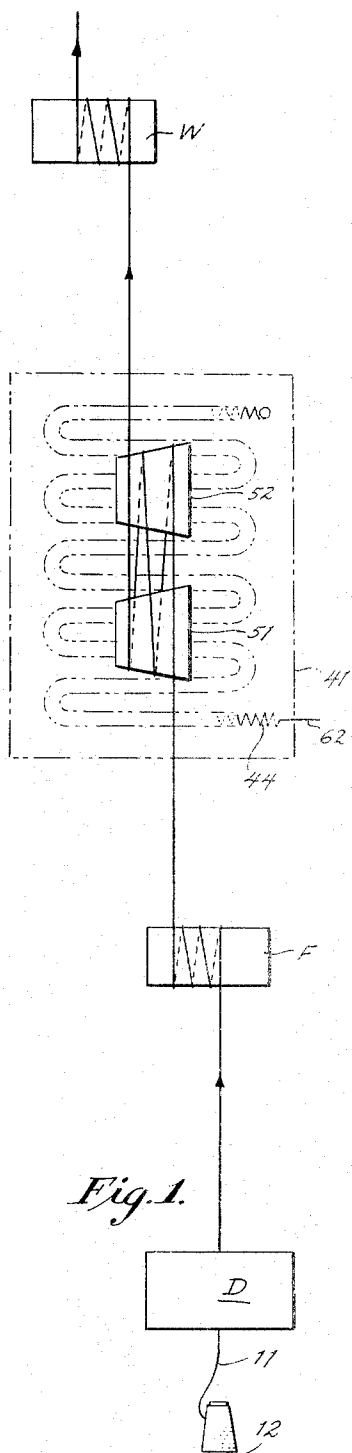


Fig. 1.

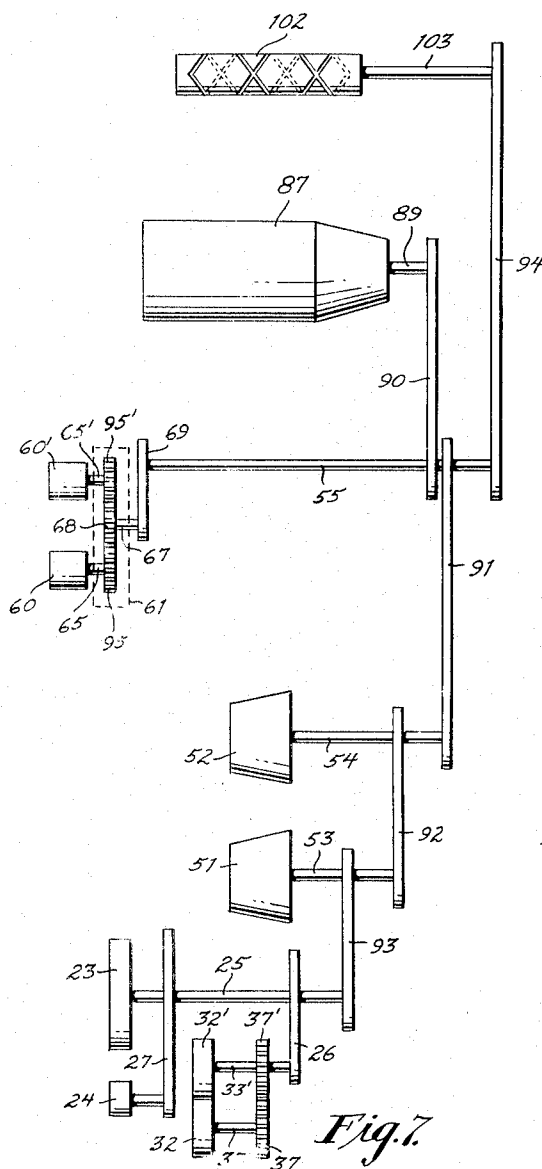


Fig. 7.

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3 Sheets-Sheet 2

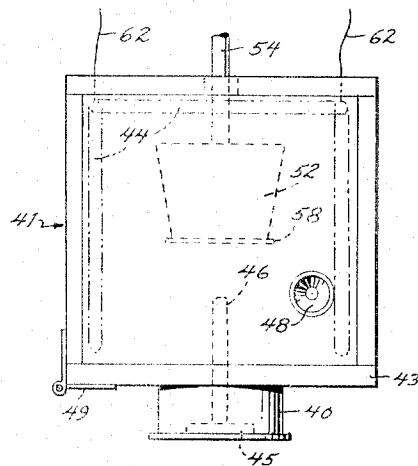


Fig. 1.

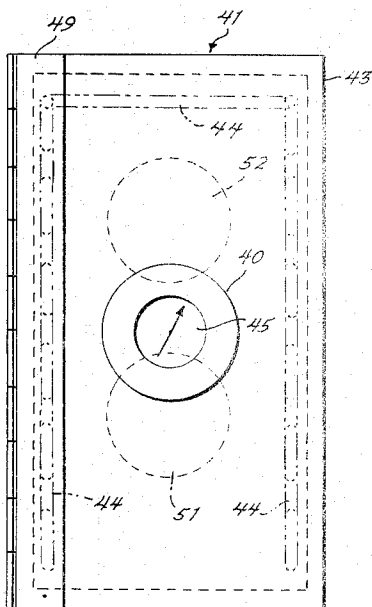


Fig. 3.

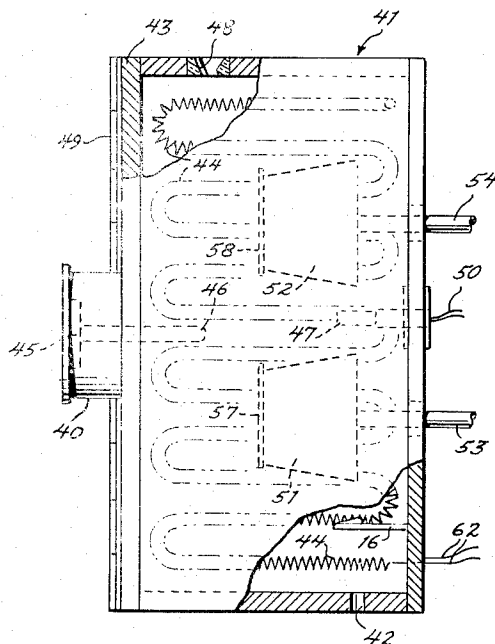


Fig. 2.

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3 Sheets-Sheet 3

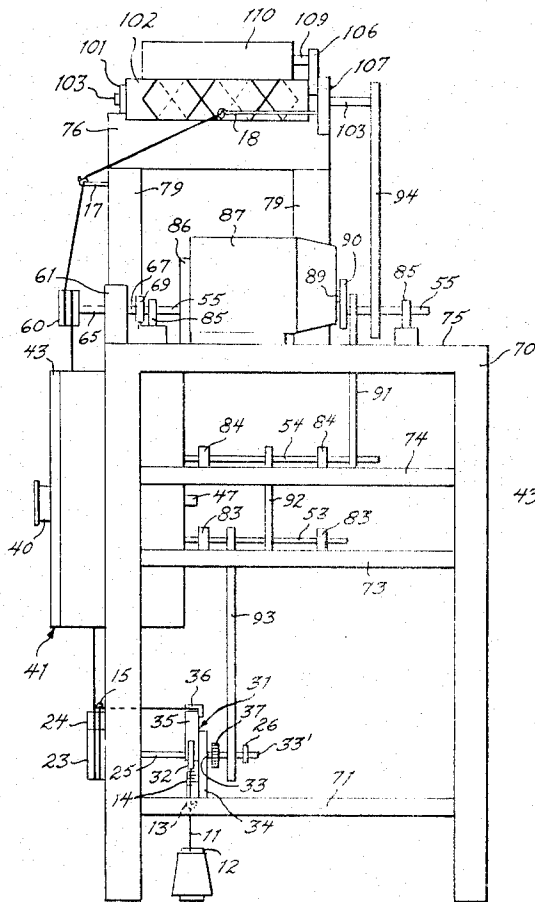


Fig. 5.

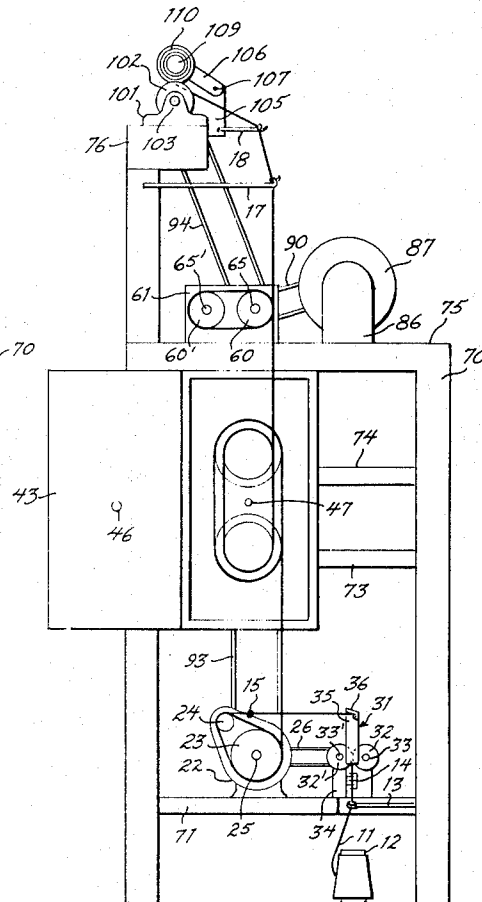


Fig. 6.

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3,221,385

STRAND TREATMENT

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Filed May 24, 1961, Ser. No. 112,374

2 Claims. (Cl. 28—72)

This invention relates to strand processing, especially the heat-setting 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.

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

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.

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.

Yet another object is stabilization of the configuration of a strand by heating without "ironing" of the strand.

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;

FIG. 2 is a side elevation, partly broken away, of apparatus of this invention;

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;

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; and

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

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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, and removing the strand from the heating zone at a lesser rate. The invention comprehends particularly a heat-setting treatment for a crimped textile strand adapted to assume a stable shortened end-to-end configuration when heated, comprising passing such strand through a radiant heating zone and permitting the strand to shorten progressively at a controlled rate while in the zone, and contemplates also apparatus or machinery adapted to perform such a process.

FIG. 1 shows, in schematic form, passage of strand 11 from bobbin 12 into and 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 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 about windup roll system W.

FIG. 2 shows heating chamber 41 in side elevation, partly broken away to reveal portions of the interior. Pigtail guide 16 is located above entrance aperture 42 in the bottom of the chamber, at the lower right. The exit aperture in the roof of the chamber, at the upper left, is provided by 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. 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) on 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 belt 26, and to shaft 53 by belt 93.

Also shown in FIG. 5 are the supporting and driving means for shafts 53 and 54 of the frustoconical rolls. Intermediate and top shelves 73 and 74 support respective pairs of pillow blocks 83 and 84 for these shafts, which are interconnected by belt 92. 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 heating chamber, 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 is open, thereby revealing the interior. The strand is shown wrapped about the frustoconical rolls between its entrance into and exit from the 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.

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.

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 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 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 surface speed of the windup rolls approximates the speed of the small end of the frustoconical rolls. No slack develops in the strand as it gradually undergoes this speed reduction, 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.

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 selected 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.

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. The 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. The controlled end-to-end shortening of the strand as provided by this invention is essential to such stabilization, and the particular method herein described and claimed is optimum for this purpose.

The claimed invention:

1. 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, 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 at successive increments of its travel through the zone, and 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.

2. Strand treatment comprising passing a crimped textile strand, 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 removing the strand from the zone at a rate approximating the slowest rate of travel of the strand in the zone.

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