Method and Apparatus for Production of Bulked Yarn

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19 Claims. (Cl. 28—1)

Co-pending patent application No. 726,328, filed April 7, 1958, describes a method and apparatus for processing thermoplastic yarns to give them "stretch" properties by imparting a crimp thereto. The method in essentials comprises stretching a thermoplastic filament, heating it while stretched in such a manner that a temperature gradient is set up across the filament, cooling it and permitting it to relax. More specifically a thermoplastic yarn consisting of a single filament or a plurality of filaments is first stretched by at least 10% in length by passing it progressively around grooves formed in the peripheries of a conical stretching roller (which is driven) and a conical jockey pulley. The yarn while being maintained in its stretched condition is then passed through the nip between two plain rollers relatively biased together. One of these rollers is heated and is power driven and the other is cooled and is driven by contact with the yarn which it helps to wind around the hot roller. Since the yarn is nipped between the hot and cold rollers it is prevented from rotating about its own axis and a temperature gradient is established across its cross-section. From the nip between the hot and cold rollers the yarn, still in its stretched condition, passes round a final grooved cylindrical take-off roller, and a grooved jockey pulley, from which it is delivered ready to be wound into a package. In passing round these last mentioned rollers and on delivery by them the yarn cools, and on delivery by them relaxes, and it then possesses a helical crimp. This crimp can be further developed by submitting the yarn to a further heat treatment either before or after it has been made into fabric. Such further heat treatment shrinks the yarn and tightens up the helix.

Such yarn, either in single filament or plural filament form, is excellent for the construction of stockings and like articles of footwear, having a very pronounced capacity for being stretched. For example when the yarn is knitted into a woman's stockings and as part of the finishing process the stockings are subsequently heated while immersed in a liquid, a latent capacity for additional crimp is fully developed and the fabric of the stockings contracts to a fraction of its original knitted size. Such stockings are highly extensible, recover rapidly from distortion and stretching and by reason of these properties give cling and accurate fitting to the contours of the legs of the wearer, however varied those contours may be.

However yarns made in this way are not entirely suitable for other purposes such as for example as the manufacture of underwear and outerwear and some half-hose where bulk and "fluffiness" are more important than high extensibility and rapid recovery. Plural filament yarns made in accordance with the method described exhibit a tendency for the coils in the individual filaments to remain in phase and while this gives sheerness and elasticity to the resultant fabric these properties, although desirable in the case of women's stockings, are not of primary value in the other garments mentioned above in which softness of handle and good heat insulation by virtue of the trapping of air pockets in the fabric are important desiderata.

It has now been found that yarn processed according to the aforesaid patent application can be given a softer handle and improved heat insulating properties if at least some of the latent crimp is developed by heating the yarn under substantially no tension and allowing it to contract by a predetermined amount before it is knitted into fabric.

The invention therefore provides a method of bulking a plural-filament yarn consisting of a plurality of thermoplastic filaments that have been subjected to a crimping treatment, which comprises traversing the yarn through a zone in which it is permitted to contract lengthwise to a predetermined extent while subjecting it to substantially uniform heating.

The invention further provides a method of bulking a plural-filament yarn consisting of a plurality of thermoplastic filaments that have been subjected to a crimping treatment, which comprises forwarding the yarn at a predetermined input speed to the periphery of a roller which rotates at a higher peripheral speed than the input speed and tends to speed up the yarn, passing the yarn through a zone in which it is permitted to contract lengthwise to a predetermined extent while subjecting it to substantially uniform heating, and delivering the yarn, by a let-off device, at a linear speed less than the input speed.

This bulking may be carried out immediately after the yarn has been treated in accordance with the aforesaid co-pending application so that the two form a continuous process. Alternatively the bulking can be carried out as a separate operation.

This invention further includes apparatus for bulking a plural-filament yarn consisting of a plurality of thermoplastic filaments that have been subjected to a crimping treatment, which apparatus is constructed and arranged to permit lengthwise contraction of the running yarn to a predetermined extent while subjecting it to substantially uniform heating and comprises yarn input means for passing the yarn into the apparatus at a predetermined speed, let-off means for delivering the yarn from the apparatus at a less linear speed than the input speed, and heating means for subjecting the yarn to substantially uniform heating while running between said input and let-off means. The heating means is preferably a yarn-engaging roller, drum, or the like.

The foregoing and other features of the invention set out in the appended claims are incorporated in the method and apparatus which will now be described with reference to the accompanying drawings which is largely diagrammatic and in which FIGURE 1 is a side elevation and FIGURE 2 a front elevation of the bulking apparatus.

The plural yarn is delivered from the roller 2 (which is the grooved let-off roller 14 of the co-pending patent application) at a predetermined input speed. It then passes over a small arc of the periphery of a smooth roller 3 or the like which is driven to rotate at a higher peripheral speed than the input speed. Roller 3 therefore tends to speed up the yarn and its purpose is to prevent the yarn in its relaxed condition from wrapping back on the roller 2. It exerts a slight scrubbing action on the yarn, which may tend to shift the convolutions of the yarn out-of-phase. It has been found advantageous to give the periphery of roller 3 a fine "satin" finish by fine sand blasting followed by light polishing. This reduces the area of contact of the yarn with the roller and avoids the yarn sticking to the roller. The yarn is then finally delivered through the nip between smooth let-off rollers 4, 5. Roller 4 is power driven and roller 5 is free running and the two rollers are biased together by an air piston, spring, weight loading, or any other convenient means. The peripheral speed of rollers 4 and 5 is slower than that of roller 2 by a predetermined amount. 30% slower has been found to be suitable but other amounts depending on the characteristics required in the final yarn can be used.
3. The fact that yarn is forwarded into the apparatus by roller 2 at a linear speed greater than that at which it is delivered from the apparatus by let-off rollers 4, 5 would normally cause a surplus of yarn to be built up within the apparatus. However after leaving roller 3 the yarn is heated substantially uniformly. It therefore contracts to an extent (30%) governed by the speed difference. The effect of the heating apparatus is to develop the latent crimp in the yarn so that the latter remains taut in its passage through the apparatus. The individual filaments are not allowed to take up their helical form but assume a simple wave form which is close to a sine wave. The helical formation which would tend to pull the individual filaments into phase is absent and the wavy filaments are able to separate somewhat, giving the yarn a bulky, fluffy character.

The substantially uniform heating is preferably achieved by passing the yarn, between roller 3 and rollers 4, 5, over a considerable arc of the periphery of a large roller 6, within a deep groove 6' therein, this roller 6 being maintained at a substantially constant elevated temperature. The use of a deep groove ensures that the yarn is heated uniformly during its passage over roller 6 and also ensures that it is protected from draughts. The peripheral speed of the bottom of groove 6' in roller 6 is arranged to be the same as the peripheral speeds of rollers 4 and 5.

It will be appreciated that the temperature at which roller 6 must be maintained in order to heat the yarn up to the temperature required to cause crimp development will be governed by the conditions of processing; obviously the speed at which the yarn travels and the length of the arc of contact which the yarn makes with roller 6 are important factors. It has been found that with roller 2 delivering yarn at the rate of 200 yards per minute, the arc of contact with roller 6 being approximately 60' (being about one quarter of the roller circumference), the temperature of roller 6 should be a little above the melting point of the material of the yarn being processed.

There are a number of ways in which roller 6 can be heated, for example it can be constructed as a hollow shell rotating around a stationary electric heating element. The heating element may be carried by a stationary hollow shaft through which its leads extend. The roller 6 may be supported on this hollow shaft or on a rotating shaft, for example on a hollow rotating shaft housing the stationary shaft.

After emerging from the nip between rollers 4, 5 the yarn is wound onto a package in known manner, a down-twister being suitable. The down-twister will apply sufficient tension to the yarn to straighten out the developed crimp in the filaments and these will subsequently reappear when the yarn is allowed to hang slack and after a subsequent relaxing treatment.

Since roller 6 must be held at an elevated temperature, it is not possible to thread up the equipment and to permit the yarn to remain stationary and in contact with the roller while the latter is being heated up. It is therefore convenient to heat up the roller and to hold the thread-up yarn out of contact with it until the apparatus is brought into operation. For this purpose means are provided for engaging the yarn between rollers 3 and rollers 4 and 5 and for holding the yarn out of contact with roller 6. In the illustrated construction there is a freely running groove 8 on the end of arm 7 pivoted at 9. Before starting the run, roller 6 is brought to its correct temperature and the arm 7 with its pulley 8 are in the position shown in dotted lines in FIG. 1. It will be seen that the yarn, also shown in dotted lines, extends over the displaced pulley 8 and is withdrawn from contact with roller 6. The arm 7 may then be moved to the right in FIG. 1 into its full line position so that it carries the yarn into the groove in roller 6 and roller 8 passes out of contact with the yarn.

When commencing processing operations in accordance with patent application No. 726,928 and the present invention, roller 6 is already hot as is also roller 13 of said application. Arm 7 is in the dotted line position and the nip rollers 4 and 5 are open. Cold roller 26 of said application is moved to nip the yarn with hard pressure against the hot roller 13. The running yarn treated in accordance with the said application is delivered by roller 2 into the present apparatus and after passing over fast-rolling roller 3 and the displaced pulley 8, without making contact with hot roller 6, travels down through an open gap between rollers 4 and 5. Arm 7 is then swung to its full line position so that the yarn is carried into the groove of roller 6, and the nip between rollers 4 and 5 is closed. Therefore the yarn emerging from between rollers 4 and 5 is fully processed and may be wound onto a suitable package.

The displaceable arm 7 permits the apparatus of the present invention to be brought into and out of operation as required and therefore permits stretch yarn produced according to the said co-pending application to pass through the present apparatus without further treatment or to be bulked in the present apparatus as required. Preferably when the arm 7 is displaced to its dotted line position the rollers 4 and 5 are opened, and they are closed when it is brought to its full line position. Appropriate connections are provided between arm 7 and rollers 4 and 5 to produce the movements just referred to. The arm may be moved, and the rollers opened or closed, manually. Any suitable means for driving 3, 4, and 6 from a power source may be provided.

The present invention is applicable, not only to "stretch" yarn produced according to patent application No. 726,928 but also to "stretcher" yarns produced by other processes especially those produced by twisting and untwisting.

What I claim is:

1. A method of bulking a previously only partially crimped plural-filament thermoplastic yarn which comprises feeding the yarn at a predetermined input speed, forwarding said yarn at an increased speed prior to entrance into and through a treating zone, decreasing the speed of the yarn in said zone to substantially completely untension said yarn and subjecting said yarn to substantially uniform heating, the subheating the completely untensioned condition thereof resulting in lengthwise contraction of said yarn to a predetermined extent as said yarn passes out of said zone at the same decreased speed, and delivering said yarn at a predetermined exit speed which is substantially equal to the decreased speed of said yarn in said zone.

2. A method according to claim 1 in which the forwarding speed is greater than the exiting speed and the amount of lengthwise contraction of the yarn is about 30% depending on the difference between the forwarding speed and the exiting speed.

3. Apparatus for bulking a previously treated plural-filament thermoplastic yarn in which the tendency to crimp is developed by the establishment of a heat gradient across the yarn, which comprises means for feeding the yarn under sufficient tension to suppress the crimp and at a predetermined input speed into a treating zone including means for forwarding said yarn at an increased speed into said treating zone, means for decreasing the speed of said yarn to such an extent that said yarn is in the substantially completely untensioned condition and for treating substantially uniformly said yarn with heat within said zone so that a predetermined amount of lengthwise contraction occurs on the part of said yarn while in the substantially completely untensioned condition thereof whereby a bulking effect is achieved by producing a shrinkage in the yarn along the side exposed to the relatively cooler temperature while leaving sub-
stantially unaffected the side exposed to the relatively hotter temperatures of the gradient, and means for withdrawing said contracted yarn substantially at the same decreased speed.

4. Apparatus according to claim 3, wherein said means forwarding said yarn at an increased speed includes a roller having a fine satin finish.

5. Apparatus according to claim 4, further comprising means for selectively holding said yarn, while threaded in said apparatus, out of contact with the means for treating the yarn with heat.

6. Apparatus according to claim 3, further comprising means for selectively holding said yarn, while threaded in said apparatus, out of contact with the means for treating the yarn with heat.

7. A method of bulking a plural filament yarn to which there has been applied a crimping treatment in which the travelling plural-filament yarn is stretched to a predetermined extent, its filaments heated on one side while in the stretched condition to establish a temperature gradient across each filament between relatively hot and relatively cool sides thereof, and thereafter cooled, whereby the relatively hot side retains a greater proportion of the applied elongation than does the relatively cool side and each filament assumes a cramped formation, comprising the steps of:

traversing the thus-crimped yarn in the substantially completely untensioned condition thereof through a zone in which the relatively cool side of the yarn is shrunk by subjecting the yarn to substantially uniform heating thereby accentuating the cramped formation, and thereafter cooling said yarn whereby the accentuated cramped formation is confirmed in said yarn.

8. A method of bulking a plural filament yarn to which there has been applied a crimping treatment in which the travelling plural-filament yarn is stretched to a predetermined extent, its filaments heated on one side while in the stretched condition to establish a temperature gradient across each filament between relatively hot and relatively cool sides thereof, and thereafter cooled, whereby the relatively hot side retains a greater proportion of the applied elongation than does the relatively cool side and each filament assumes a cramped formation, comprising the steps of:

traversing the thus-crimped yarn in the substantially completely untensioned condition thereof through a zone in which the relatively cool side of the yarn is shrunk by subjecting the yarn to substantially uniform heating at such temperature as to leave substantially unaffected the pre-set elongation in the relatively hot side of the yarn thereby accentuating the cramped formation, and thereafter cooling said yarn whereby the accentuated cramped formation is confirmed in said yarn.

9. A method for accentuating the crimp in a cramped yarn in which the crimp is only partially developed, and in which the partially developed crimp is the result of a temperature gradient established across each filament in the tensioned condition thereof so that the relatively hot side retains a greater proportion of the applied elongation than the relatively cool side, thereby resulting in a cramped formation, comprising the steps of:

feeding the yarn at a first linear speed, thereafter heating said yarn within a treating zone in the substantially completely untensioned condition thereof while travelling at a reduced linear speed to enable shrinkage of the relatively cool side and therewith accentuate the crimp development thereof; and delivering the thus-crimped yarn at a linear speed substantially equal to the linear speed within said treating zone.

10. A method of bulking a plural filament yarn to which there has been applied a crimping treatment in which the travelling plural-filament yarn is stretched to a predetermined extent, its filaments heated on one side while in the stretched condition to establish a temperature gradient across each filament between relatively hot and relatively cool sides thereof, and thereafter cooled, whereby the relatively hot side retains a greater proportion of the applied elongation than does the relatively cool side and each filament assumes a cramped formation, comprising the steps of:

feeding the yarn at a predetermined linear input speed; forwarding said yarn at an increased linear speed prior to entrance into a treating zone; decreasing the speed of the yarn and treating the same with heat within said treating zone to thereby enable shrinkage, in the substantially completely untensioned condition of said yarn, of the relatively cool side of the filament thereby accentuating the cramped formation; and thereafter cooling said yarn during delivery thereof at a linear speed substantially equal to the linear speed thereof within said treating zone to thereby confirm the accentuated cramped formation within said yarn.

11. A method of bulking a yarn comprised of a plurality of thermo-plastic filaments having a cramped configuration, the cramped configuration of each individual filament being substantially in phase with adjacent filaments, characterized by:

feeding the yarn to a treating zone, subjecting said yarn in the treating zone to a scrubbing action to shift the individual filaments relative to each other,

heating said yarn under substantially tensionless conditions to obtain a lengthwise contraction thereof, and

withdrawing the contracted yarn from said treating zone.

12. A method of bulking yarn comprised of a plurality of thermo-plastic filaments having a cramped configuration produced by a temperature gradient set up there across, the cramped configuration of each individual filament being substantially in phase with adjacent filaments, characterized by:

feeding the yarn to a treating zone, contacting said yarn in the treating zone with a roller operating at a greater speed than the input speed of the yarn to the treating zone whereby the individual filaments are shifted relative to each other,

heating said yarn under substantially tensionless conditions to obtain a lengthwise contraction thereof, and

withdrawing the contracted yarn from said treating zone.

13. Apparatus according to claim 3, wherein the plural-filament thermoplastic yarn is delivered to said feeding means immediately following the crimping treatment.

14. A method of bulking a plural-filament thermoplastic yarn, which has been previously treated to impart thereto a permanent tendency to crimp, which comprises:

feeding the previously crimp-treated yarn to a treating zone in such tensioned condition as to prevent the formation of the crimps that would otherwise form, subjecting said yarn in a substantially untensioned condition thereof within said treating zone to a substantially uniform heating before in phase crimps can form in the untensioned yarn thereby resulting in out-of-phase formation of the crimps, and delivering the thus bulked yarn with the out-of-phase crimps thereof.

15. A method of bulking a plural-filament thermoplastic yarn, which has been previously treated to impart thereto a permanent tendency to crimp, which comprises:

feeding the previously crimp-treated yarn to a treating zone at a first speed and in such tensioned condition as to prevent the formation of the crimps
that would otherwise form, subjecting said yarn in a substantially untensioned condition thereof within said treating zone to a substantially uniform heating before in phase crimps can form in the untensioned yarn whereby resulting in out-of-phase formation of the crimps, and delivering the thus bulked yarn with the out-of-phase crimps thereof at a second speed which is less than said first speed by an amount substantially proportional to the lengthwise contraction of the yarn in the treating zone.

16. A method of producing in a continuous process a bulked yarn from a travelling plural filament thermoplastic yarn, wherein the travelling plural filament yarn is first subjected to a crimping treatment by stretching it, as it travels, to a predetermined extent and rendering permanent a greater proportion of the stretch at one side of each filament than at the other side by establishing a temperature gradient across each filament between a relatively hot and a relatively cool side thereof, whereby the relatively hot side retains a greater proportion of the applied elongation than does the relatively cool side, and each filament tends to assume a helically-crimped formation, comprising the steps of immediately following said treatment accentuating the length difference between the two sides of each filament of the travelling yarn and imparting to the yarn an enhanced bulk by shrinking the relatively cool side of each filament by traversing the still-travelling yarn, under substantially no tension, through a zone in which it is heated uniformly.

17. A method according to claim 16, wherein immediately following the said treatment, the travelling yarn is brought into contact with the surface of a roller travelling at a higher speed than the yarn.

18. Apparatus for bulking a previously treated plural-filament thermoplastic yarn in which the tendency to crimp is developed by the establishment of a heat gradient across the yarn, which comprises means for feeding the yarn under sufficient tension to suppress the crimps and at a predetermined input speed into a treating zone including means for forwarding said yarn at an increased speed into said treating zone, means for decreasing the speed of said yarn to such an extent that said yarn is in the substantially completely untensioned condition and for treating substantially uniformly said yarn within said heating zone so that a predetermined amount of lengthwise contraction occurs on the part of said yarn while in the substantially completely untensioned condition thereof whereby a bulking effect is achieved by producing a shrinkage in the yarn along the side exposed to the relatively cooler temperature while leaving substantially unaffected the side exposed to the relatively hotter temperatures of the gradient, and means for withdrawing said contracted yarn substantially at the same decreased speed, the means for treating the yarn with heat including a roller having a deep groove to ensure uniform heating of the yarn and protection thereof from draughts.

19. Apparatus according to claim 18 wherein said means forwarding said yarn at an increased speed includes a roller having a fine satin finish.

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