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2,962,794

METHOD OF PRODUCING ELASTIC YARN AND PRODUCT

Filed March 29, 1954

FIG. 2

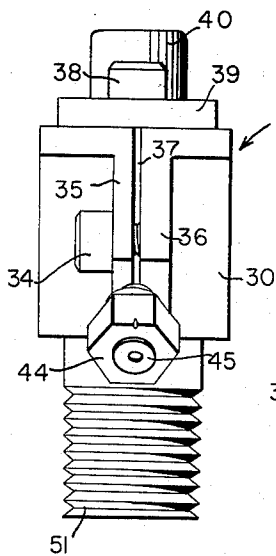


FIG. 3

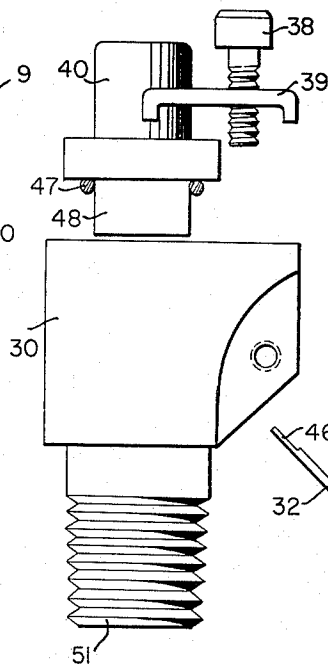


FIG. 4

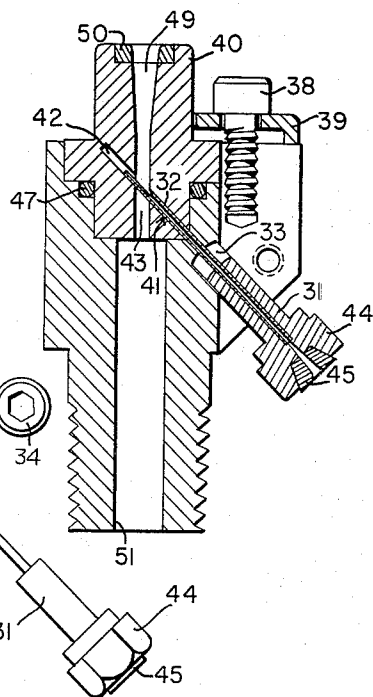


FIG. 1.

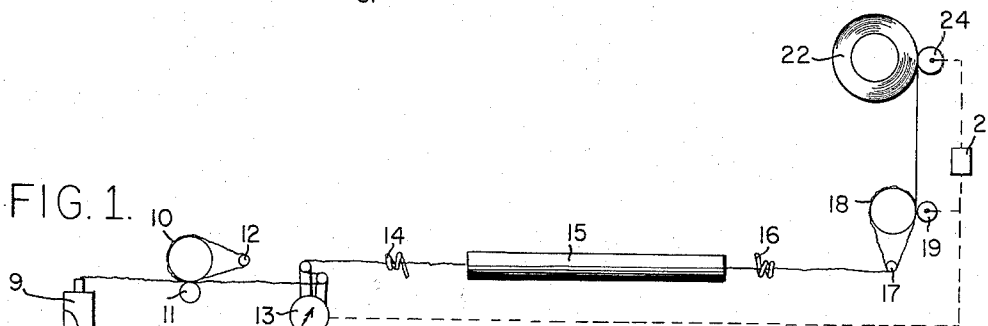


FIG. 6

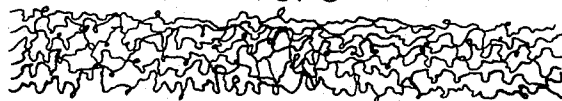
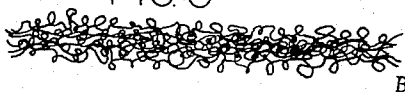


FIG. 5



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METHOD OF PRODUCING ELASTIC YARN AND PRODUCT

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This invention relates to treatment of continuous-filament yarn so as to provide improved bulkiness and other desirable properties in the yarn and in fabrics made therefrom.

Conventional yarns made of continuous filaments are notably deficient, as compared with staple yarns, in bulk, covering effectiveness, and insulating ability, all of which impairs their usefulness for apparel and other textile purposes. Breen patent applications S.N. 261,635 filed December 14, 1951 (now U.S. Patent 2,783,609) and S.N. 375,372 filed August 20, 1953, (now U.S. Patent 2,852,906) teach novel treatment of a bundle of continuous filaments to form bulky yarn characterized by loopiness produced in the individual filaments upon passage through a zone of turbulence. The present invention is dependent upon similar filament-convoluting means, but whereas Breen clearly prefers to form thereby a configuration of loopy yarn capable of resisting applied tensioning force, the present invention is directed toward formation of an intermediate yarn configuration thereby that, also loopy, is loose and open, incapable of resisting appreciable force applied to extend the yarn. Further modification of the yarn according to this invention completes the transformation to a highly desirable bulky yarn.

A primary object of the present invention is production of bulky continuous-filament yarn characterized by extreme extensibility under tension and recoverability after removal of the tensioning force. Another object is provision of yarn comprising continuous filaments containing non-helical loops removable temporarily by extension of the yarn. Other objects will be apparent from the following description and the accompanying diagrams.

Figure 1 is a schematic representation of apparatus useful according to the present invention. Figure 2 is a front view of a jet or nozzle element of the apparatus of Figure 1. Figure 3 is an exploded side view of the apparatus of Figure 2. Figure 4 is a cross-sectional side view of the apparatus of Figure 2. Figure 5 is an enlarged view of multifilament yarn after treatment by the apparatus of Figure 2. Figure 6 is a view of the yarn of Figure 5 after subsequent stabilization, extension, and relaxation.

In general, the objects of this invention are accomplished by passing continuous-filament yarn through a zone of turbulence to form along the length of each filament a multitude of loops susceptible to removal by extension of the filament, stabilizing the loops by exposure of the yarn to a setting treatment before extension, extending the yarn to distort the loops, and then relaxing the yarn.

As shown in Figure 1, yarn to be treated may be supplied from bobbin 1 through pigtail guide 2, tension guide 3, and pigtail 4, to pass successively over canted roll 5, driven roll 6, into the nip of the driven roll and drive roll 7, and back over the canted roll. After several passes over this three-roll combination, the yarn goes through slub cleaner 8 and through jet or nozzle 9 into the nip of driven roll 10 and drive roll 11, over canted

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roll 12, back through the roll nip, then over the rollers of tensiometer 13, through pigtail guide 14, setting tube 15, pigtail 16, over canted roll 17, and through the nip of driven roll 18 and drive roll 19. After several passes about this roll combination the yarn passes about windup roll 22 driven by roll 24 after entering the nip of the rolls. Adjusting mechanism 21 ensures that windup drive roll 24 rotates at a greater rate than drive roll 19 does, thus extending the yarn in this portion of its path.

Details of the jet or nozzle 9 appear in Figures 2, 3, and 4. Housing 30 holds casing 31 of tube 32 in bore 33 by means of screw 34 through side 35 into threaded side 36 separated from the other side of the housing by slit 37. Screw 38 threaded into the top of the housing fastens clamp 39 to hold venturi member 40 in place. Bore 41 through one side of this member is extended as recess 42 in the opposite side at venturi throat 43 to anchor the tube and permit adjustment to greater or less depth of insertion. Nut 44 at the entrance end of the tube casing carries ceramic insert 45, and for part of its length at the exit end 46 the tube is halved along the axis or slitted, as shown. The nut is notched on the face parallel to the edges of the slitted end to ensure proper assembly with the slit in the downstream direction. The venturi member has gasket 47 about neck 48, while mouth 49 has hardened insert 50 recessed in it. Air or similar fluid enters the housing at intake 51, which is externally threaded for connection to a suitable pressure source (not shown). The bulky or loopy form of continuous filament in the yarn persists from the mouth of the jet to the third three-roll combination, as suggested in the drawing by a jagged-line representation of the yarn between these two points, whereas a smooth line represents the yarn elsewhere in this schematic diagram.

Yarn place at the entrance of the tube is carried through the tube and out the slitted end into the throat of the venturi and out the mouth thereof by concurrent flow of fluid. Expansion of the fluid, usually air, separates the yarn components, and accompanying turbulence whips them about violently. While any staple component is subject to partial or complete separation from the body of the yarn, continuous filament components loop and may be otherwise convoluted. Sufficient entanglement of the loops to produce a relatively stable configuration that strongly resists tension applied to the yarn is favored by a large number of filaments, high yarn twist, high pressure at the jet, and only a modest excess of yarn supply rate over windup rate. However, all these features add to operating costs, and the present invention is adapted especially to production of a bulky yarn by jet processing of low-twist yarn having a relatively small number of filaments at low jet pressure and high net yarn overfeed.

In surface appearance a continuous-filament component of yarn processed through a jet according to this invention exhibits a multitude of rather large loops loosely intermingled and apparently randomly distributed along the lengths of separate filaments. Such loops appear in the multifilament yarn of Figure 5, which is distinguishable from yarn described in the above-mentioned Breen applications by greater abundance of loopiness, generally looser construction with corresponding interfilament spacing and relative absence of filamentary core in which loops present are not visible from the outside. In simplest form, one of these loops approximates a crunodal plane curve, differing drastically from a helical configuration such as may be formed by wrapping about a mandrel or by twisting. Depending upon the operating conditions, various distortions of the loops, undulations, and configurations in the form of protruding or twisted bights may appear. The last of these variations, strangling of one loop by another, and any other configuration that

resists removal by moderate tensioning of the yarn are undesirable in practice of the present invention. The easily removable loops of the type here considered may be denoted "metastable" because they persist at substantially zero tension but become progressively distorted as the filaments are tensioned, disappearing entirely as the filaments become realigned under light-to-moderate tension. Not only is this intermediate yarn containing a multitude of metastable loops characterized by a very low yield-point (i.e., tension at which extension to greater length is accounted for by slippage owing to distortion or removal of loops, rather than by elastic stretching), usually no more than a few hundredths gram per denier, but the tension required to extend the yarn to half again this intermediate length is only a few tenths gram per denier. Conceivably, even a simple monofilament could be formed into such a metastable configuration with sufficient overfeed of the filament and could be maintained at substantially zero tension.

According to the present invention, the filament loops formed by passage of the yarn through the zone of fluid turbulence are stabilized by appropriate treatment here termed generally "setting." Both type and intensity of setting treatment are determined by characteristics of the yarn to be treated and the conditions which it will be subjected in subsequent processing and in use as textile or other products. After completion of the setting treatment, the filament loops individually resist deformation, exhibiting no appreciable tendency to resume the straight linear form of a starting filament. Apparently the internal stresses induced in the filaments by the convolution have been relieved so that the loopy form now is stable rather than metastable. Even after being removed entirely by subsequent tensioning sufficient to realign the filaments, the loops tend to return more or less completely after removal of the tension.

Cellulose esters, such as acetate, propionate, or acetate-butyrate, which are relatively hydrophilic and thermoplastic, may be set satisfactorily by steaming for several seconds at a temperature of about 100° C., which relieves the stresses present in the convolutions sufficiently to render them stable. For cellulose esters and many other yarn compositions, the rate of loop recovery depends to a considerable extent upon humidity and temperature of the surroundings, and the amount or rate may be increased by relaxation of the yarn in boiling water for several minutes; as conventional textile finishing usually contains a boil-off step, these yarns (after stabilization of the loopy configuration) may be woven or knitted at their extended length into fabric that will acquire a greatly increased bulk or loft during finishing.

Most recently developed fiber constituents, even though relatively hydrophobic, may be set thermally. The temperature and time of treatment may be increased over those mentioned above so as to bring about the desired set or stabilization of the filament configuration. Among the materials that may be set thermally are glass, vinyl polymers, nylon, and polyesters (such as polyethylene terephthalate). Of course, steaming also may be helpful in setting nylon or other of the newer polymers. The setting zone is represented schematically in Figure 1 by tube 15 through which the yarn passes after being treated in jet 9. To avoid excessive length of tube for setting periods of more than a minute or so, the yarn may make several passes from end to end inside the tube over suitable rollers, or the yarn may be allowed to pile up in the tube so that it becomes set before being withdrawn at the other end, in which case the tube need not be straight but may be J-shaped, for example, to receive the yarn in the body of the J and emit it through the open leg of the J. Regenerated cellulose normally requires alkaline or similar treatment to acquire a satisfactory set, and analogous treatment may be useful in setting other kinds of fiber constituents. Other methods of setting some of these and other fiber constituents may be employed.

After being set, the yarn appears essentially as it does after emergence from the jet, exhibiting a multitude of loops in the continuous-filament component. The yarn then is extended to distort the set loops or to remove them entirely, as desired. This is accomplished conveniently by passing the yarn successively over a set of rolls rotating at a certain speed and then over a subsequent set of rolls rotating at greater speed. In Figure 1, these two sets of rolls are joined by dashed lines to element 21, which is a control mechanism of conventional design adapted to ensure the proper rate ratio and thus the desired degree of extension. In the set yarn the apparent yield-point, which is higher than the yield-point of the unstabilized intermediate, is more likely a measure of the bending modulus of a few loops as they begin to distort under tension. The yarn customarily is wound up at substantially the extended length because of the ease with which the extended yarn may be backwound later, so the second set of rolls may constitute the windup, as shown; however, a degree of recovery to shorter length may be permitted by interposing a separate set of extending rolls and then winding up at a slower rate than the yarn is forwarded by the extending rolls. The tension used to extend the yarn should not be excessive or the recoverability may be impaired. If desired, the tension employed may be such as to restore the yarn length to a value merely approaching the initial length to a chosen degree.

Recovery of the extended yarn to shorter length after removal of the extending tension apparently occurs because the set configuration is sufficiently elastic to prevent the extension from constituting the extended length an equilibrium or stable configuration, instead of the set configuration. In practice, complete recovery to the set length is not usually realized, the return being on the order of halfway or somewhat more. While appreciable recovery normally occurs at room temperature, recovery to an approximation of a thermally induced set is hastened by exposure to a temperature approaching but not exceeding the setting temperature. Swelling treatment for the yarn may be useful in accelerating recovery. The process of this invention is exemplified below using a multifilament yarn made of nylon (polyhexamethylene adipamide).

Example

Nylon yarn containing 34 filaments of approximately 2 denier per filament (d.p.f.) twisted one turn per inch is fed to a jet of the kind illustrated in the drawings at a speed of 85 yards per minute (y.p.m.). Air is supplied to the jet at gage pressure of 40 pounds per square inch. The resultant loopy yarn, which looks like that shown in Figure 5 and has a yield-point of about 0.01 gram per denier (g.p.d.) is forwarded away from the jet at a rate of 34 y.p.m. and a tension of less than 0.01 g.p.d.; the net overfeed of yarn thus is 250% or 2.5×, the difference in yarn length appearing as loopiness of the individual filaments. The yarn is passed through a chamber containing steam superheated at atmospheric pressure to a temperature of about 200° C., in which it remains for approximately five seconds. Unchanged in appearance by this setting treatment, the yarn then is extended 1.5× (based upon the stabilized length) by passage over draw rolls at a tension of 0.2 g.p.d. and is wound onto a bobbin at constant length. In subsequent immersion in boiling water after unwinding from the bobbin, the yarn recovers approximately 50% of the difference between the extended length and the stabilized unextended length. (Residual shrinkage of the yarn measured on an untreated sample in boiling water is only about 7%.) The relaxed yarn appears quite fluffy and bulky, exhibiting some crunodal loops and considerable irregular undulation, as shown in Figure 6. The yarn may be tensioned easily to the previous extended length (at least 20% over the recovered length), and upon being released it returns to substantially the re-

covered length. Socks knitted of the unrelaxed extended yarn become bulky and lofty during a hot aqueous finishing operation, losing about one third of their surface area (as knit). They are quite extensible, smooth and dry to the touch, and adapted to fit a wide range of foot sizes.

For best results the yarn is processed according to this invention at 100% or greater net overfeed; "net overfeed" is the difference between the rates of feeding yarn to the jet and of forwarding the set yarn as compared to the latter rate itself. Of course, the length difference is taken up in the loopiness induced by the jet. Overfeeds of several hundred percent and greater may be employed. Jet pressure should be as low as practicable to avoid stable loops instead of the metastable configuration discussed above. Twist in the yarn should be low, preferably one turn per inch or less (to zero twist) to produce the desired metastable intermediate yarn. With the illustrated type of jet, it normally is not necessary to exceed a supply pressure of about forty pounds per square inch (p.s.i.) gauge. When processing yarn at pressures above about 50 p.s.i., especially at reduced overfeed, the illustrated jet produces progressively more stable yarn configurations which are undesirable in the intermediate yarn of this invention. Usually, the quality of product is improved by concentrating overfeed downstream from the jet, thus minimizing windup tension. Instead of merely indicating the tension, which conveniently is sufficient to extend the stabilized yarn to the length at which it will be processed into fabric, the tensiometer may control that tension through appropriate servomechanism, as by adjusting the rate of drive roll 18 downstream from the tensiometer. Of course, the rate of windup is adjusted accordingly through mechanism 21, which also ensures the proper extension ratio between drive roll 18 and the windup.

A batch process may be used instead of the illustrated continuous flow; accordingly, the yarn may be wound up on a package soon after emergence from the jet (before stabilization) or may be placed loosely in a container, the package or container being used to support the yarn during the setting treatment, after which the yarn may be backwound, extended, and rewound or otherwise processed in analogous fashion. Packaging of the stabilized loopy yarn before extension may not be worthwhile because of the likelihood of entanglement of loops in adjacent wraps of yarn. Whether the process is continuous or discontinuous the equipment, except for the jet and possibly the setting tube, is conventional yarn-processing apparatus.

No configuration assumed by yarn processed according to this invention is dependent upon residual shrinkage in the yarn, as may be induced by stretching or other treatment. In fact, shrinkage is undesirable, particularly in the setting step, because tightening of the loops might render the set yarn difficult or impossible to extend as desired without breaking or other damage to the yarn. Nor does this processing involve any stretching or cold-drawing of the yarn; the extension step depends upon distortion of the loopy configuration to produce the increased length. Whereas the length of the intermediate yarn (downstream from the jet before extension) is at most half the initial length, preferably less, extension of the stabilized intermediate should bring the length to at least half again the intermediate length and preferably at least two thirds the initial length. After extension, the yarn should recover at least halfway to the intermediate length. Subsequent extension and recovery between these limits under moderate and very slight tensions, respectively, may be expected to be substantially complete. Of course, yarns of some thermoplastic materials exhibit appreciable "creep" or delayed recovery under ordinary room conditions, so measurement immediately after release of an extending force may not

reveal the full recoverability, whether of yarn or fabric produced therefrom. The processing conditions, such as air pressure, amount of overfeed, and setting treatment, can be varied to impart the desired characteristics to the yarn.

Although perhaps at their best in knit fabrics, such as sweaters and socks, in which the yarns are less confined than in most woven fabrics, the yarns (and fabrics) of this invention are also useful in the manufacture of form-fitting woven apparel, such as swim-suits and various undergarments. Fabrics comprising these yarns should recover to three quarters or less of their extended length. The bulk and covering power of fabrics consisting entirely of continuous filaments are enhanced greatly by processing of the yarns according to this invention, and the slick handle often associated with such fabrics is replaced by a pleasantly soft and dry feel. Many advantages of practicing the invention upon yarns of all kinds are apparent. Notably, yarns treated according to this invention do not have to be plied, as do yarns relying upon helical twist for their extensibility and recoverability.

What is claimed:

1. Process comprising passing thermoplastic continuous filament yarn having a twist of less than about one turn per inch at a fixed rate into a zone of fluid turbulence sufficient only to convolute the filaments individually into a multitude of crunodal loops along the lengths of filaments, whereby internal stresses are induced in the filaments, said loops being only loosely intermingled such that the yarn has a yield point of less than 0.05 gram per denier; removing the filaments in a bundle as a self-supporting yarn from the zone of fluid turbulence at substantially zero tension and at a rate of less than half the fixed feeding rate; stabilizing the loops by exposing the yarn to a stress-relieving treatment; tensioning the yarn to remove a substantial number of the loops; and relaxing the yarn to provide an elastic yarn characterized by extensibility under very slight tension.

2. The process of claim 1 in which the yarn is a nylon yarn.

3. Yarn comprising continuous thermoplastic filaments exhibiting crunodal loops along the lengths of filament, said loops being loosely intermingled so that the yarn is characterized by extensibility under very slight loop-distorting tension to at least one fifth again the unextended yarn length and by recoverability to substantially the unextended length upon removal of the tension.

4. Yarn comprising continuous thermoplastic filaments exhibiting a multitude of internally relieved crunodal loops along the lengths of filament, said loops being only loosely intermingled so that the yarn is characterized by extensibility under very slight tension to a yarn length at least half again the unextended length and by recoverability to a length at most the arithmetic mean of the extended and unextended lengths.

5. The product of claim 4 in which the yarn is a nylon yarn.

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