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Smith et al.

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[45] **Dec. 10, 1974**

[54] **BULK YARN**

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[73] Assignee: **Celanese Corporation,** New York, N.Y.

[22] Filed: **Nov. 12, 1970**

[21] Appl. No.: **89,024**

Related U.S. Application Data

[60] Continuation of Ser. No. 687,077, July 10, 1967, abandoned, which is a continuation of Ser. No. 425,372, Dec. 24, 1964, abandoned, which is a division of Ser. No. 812,718, May 12, 1959, abandoned.

[52] **U.S. Cl.** ..... **57/140 R,** 57/157 TS, 57/157 F

[51] **Int. Cl.** **D02g 1/02,** D02g 1/16, D02g 3/24

[58] **Field of Search** ..... 57/34 B, 140 R, 140 BY, 57/157 F; 28/1.4, 72.12

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Attorney, Agent, or Firm—Thomas J. Morgan; Robert J. Blanke

[57] **ABSTRACT**

A thermally-set bulked yarn comprising at least two yarn ends each of which contain a plurality of helically crimped filaments, wherein the crimps are out of registry with one another, and wherein the helically crimped filaments have varying helix angles.

9 Claims, 7 Drawing Figures

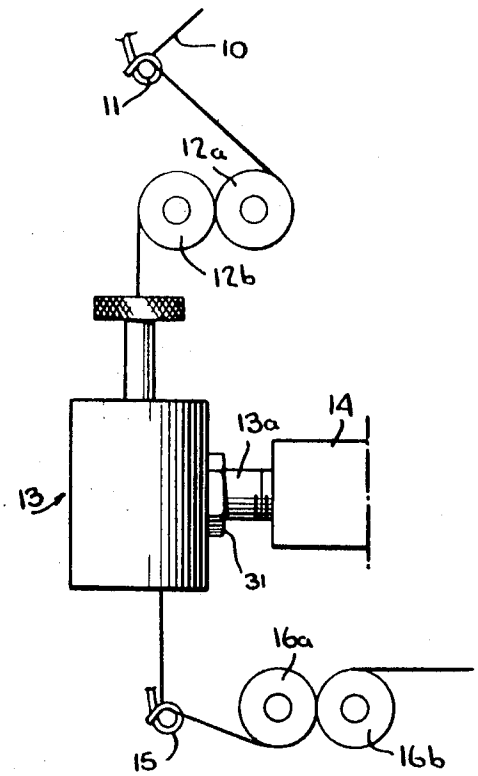


Fig. 1.

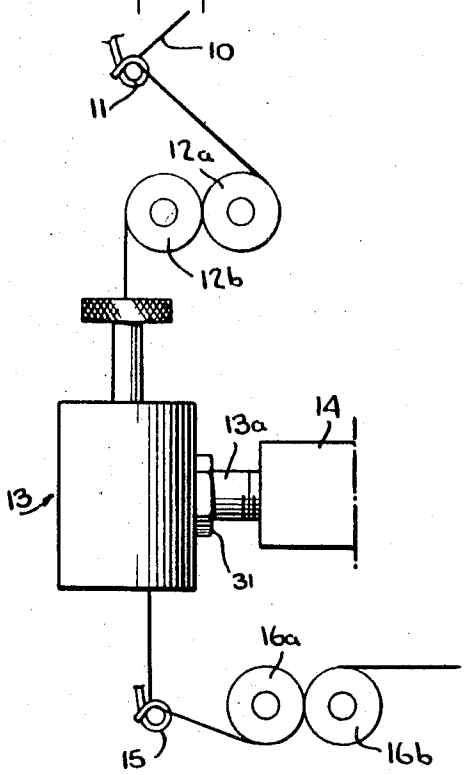


Fig. 2.

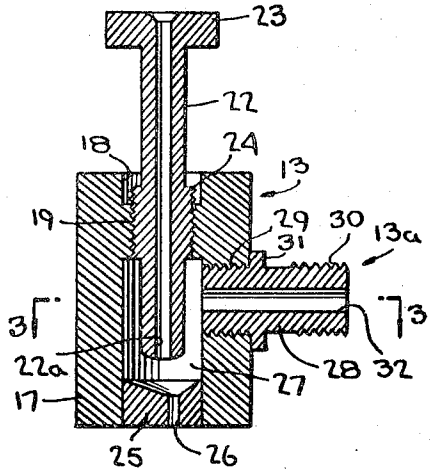


Fig. 3.

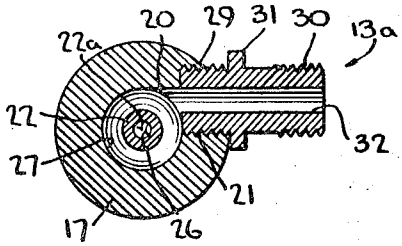


Fig. 6.

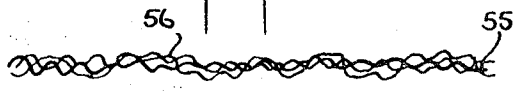
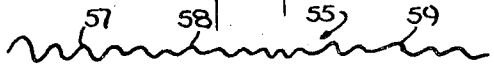


Fig. 7.



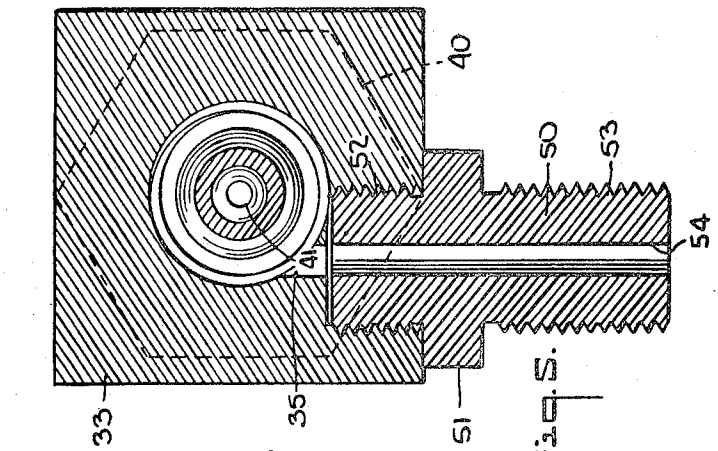

40
52
50
53
54
41
33
35
51

Fig. 5.

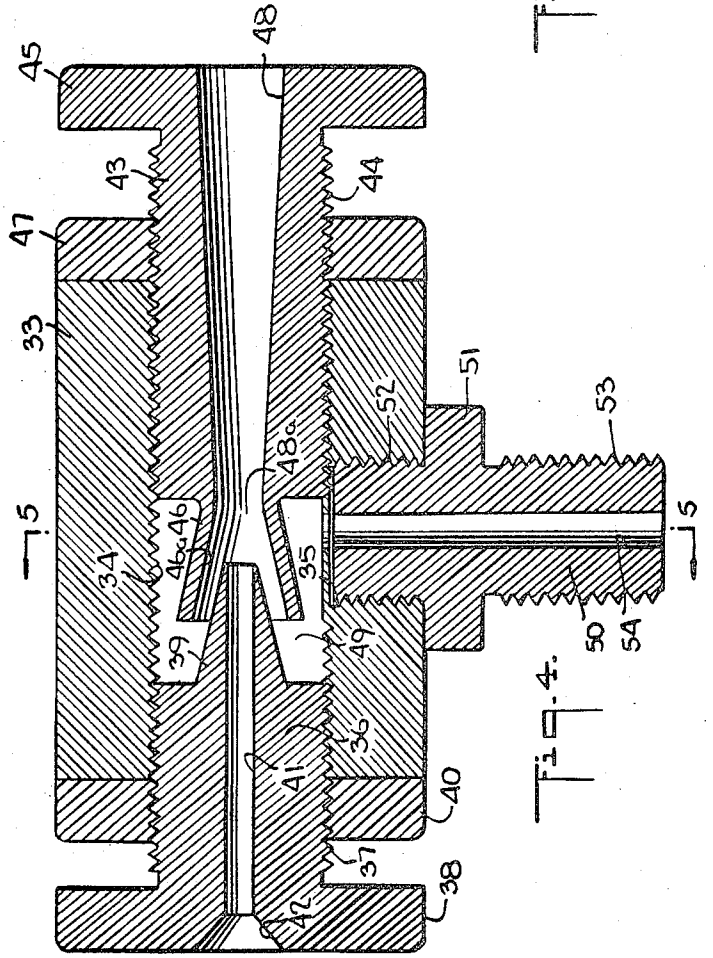
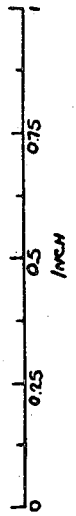

48
45
43
44
47
33
51
52
53
48a
46
46a
34
35
39
49
50
54
36
41
40
37
38
42

Fig. 4.


0
0.25
0.5
0.75
1
INCH

BULK YARN

This application is a continuation of application Ser. No. 687,077, filed July 10, 1967, now abandoned, which is a continuation of application Ser. No. 425,372, filed Dec. 24, 1964, now abandoned, which is a division of application Ser. No. 812,718, filed May 12, 1959, now abandoned.

This invention relates to voluminous yarns, and in particular to thermally set high denier steam bulk yarns, as well as to a process of and means for manufacturing such yarn.

The use of compressed air for the purpose of bulking continuous filament yarn (made of cellulose acetate or similar synthetic plastic materials) so as to impart thereto the hand or feel of a staple fiber spun yarn is well known to the art.

The straight-filament yarn (which may have an initial twist) is fed into one end of a chamber, formed in a device hereinafter referred to as an air jet. Attached to the jet and communicating with the chamber is an inlet pipe for admitting a stream of compressed air. The turbulence in the chamber causes the yarn passing therethrough to be whipped about so as to form the individual filaments into a multitude of small loops or whorls. If desired for better loop formation, the outlet passage for the loopy yarn may be located eccentrically with resppect to the common axis of the yarn inlet passageway and the chamber. The bulked yarn so prepared is well adapted for a variety of different uses, such as in sweaters or other articles of clothing, blankets and the like.

It is one of the important objects of the present invention to provide a voluminous yarn having an improved hand, feel and appearance as compared with known bulked yarns.

Another important object of the present invention is the provision of a process of and means for bulking or voluminizing yarn in such a manner as to impart thereto the desired improved physical characteristics.

Concurrently, it is also an object of the present invention to provide a process of and means for bulking yarn which are characterized by the use of hot fluids, particularly steam, as both the bulking medium and the bulk-setting medium.

A further object of the present invention is the provision of a bulked or voluminous yarn, the bulkiness of which is a function of crimps which, immediately upon formation thereof, are subjected to elevated temperatures so as to be set in the yarn.

Still a further object of the present invention is the provision of a bulked yarn as aforesaid the bulkiness of which is a function of crimping resulting from the yarn being subjected to a false twist by the steam, which sets the false twist in the yarn.

A related object of the present invention, therefore, is the provision of a venturi type jet into the bulking chamber of which steam under high pressure and at high flow velocity is fed eccentrically of the yarn passageway and of the chamber so as to create in the latter a vortex which imparts the desired false twist to the yarn.

It is a particular object of the present invention, furthermore, to provide a vortex-venturi jet as aforesaid for the purpose of steam bulking either a single yarn of low denier into a yarn of higher denier, or a plurality

of yarns of low denier, and possibly even yarns having initial opposite twists, into a single composite bulked or voluminous yarn having a high denier, suitable for use as a commercial carpet yarn.

More specifically, the vortex-venturi type jet according to the invention essentially comprises a housing having an axial main bore extending therethrough and a transverse bore located intermediate the housing ends and communicating with the main bore substantially tangentially or otherwise eccentrically of the latter. Arranged within the main bore are the means defining the yarn passageway, the venturi and the bulking or vortex chamber, while a steam inlet fitting is connected into the transverse bore and is provided with a central steam flow bore terminating at and communicating with the bulking chamber. Yarn fed into the jet housing along the main passageway from one end thereof reaches the venturi and is there subjected to the eddying or whirlpool action of the steam entering the surrounding bulking chamber via the transverse bore in the steam inlet fitting. In this manner, a false twist is imparted to the yarn by the steam which at the same time is maintained at a sufficiently high temperature to cause the yarn to set in its twisted condition. The so treated yarn is then withdrawn from the jet housing at the other end of the main passageway and may be fed to any desired take-up location.

Yarns bulked by means of such a jet have been found to resemble wool and to have a soft hand, yet are relatively strong and tenacious as well as abrasion-resistant, and moreover exhibit higher recoveries following stretching than the known unset loopy yarns. As contrasted with bulked yarn produced in conventional jets whose bulk is due to loops, the novel yarn's bulk is due to helical crimping. The tightness of the helix varies individually along each filament and the filaments are not in registry with one another as happens when using a false twist spindle. The novel yarn is more stable in length than conventionally false twisted yarns since it resists stretching due to the absence of registry between adjacent filaments and due to resistance of the filaments to slip past one another presumably because of the variations in the tightness of the helix along each filament.

In accordance with another aspect of the present invention, the hereinbefore set forth objects may be attained with a jet of the type disclosed in British Pat. No. 776,410, modified so that the steam inlet is offset relative to the axis of the jet housing, i.e., steam is admitted eccentrically rather than radially so that bulking will be of the crimped rather than the looped type. If desired, the orifice in the outlet plug may be enlarged or the plug altogether eliminated so long as the pressure, volume and rate of flow of the steam are of such values that a vortex is created. The crimped product is especially suited for use in carpets, draperies, upholstery and heavy decorative fabrics.

It is possible to apply the aforesaid principles of the present invention to a variety of textile machines, such as redraw machines, twisting machines, and the like with a minimum expenditure of money and labor. For multiple jet installations, moreover, the present invention contemplates the provision of means for adjusting the operation of each jet employed so as to ensure that the various yarns passing through the respective jets are all bulked to the same extent. Such adjustment in any given jet may be effected mechanically, for example by

changing the relative positions of the yarn inlet and outlet passageways within the bulking chamber. Alternatively, the adjustment may involve a change in the ambient temperature maintained within the jet housing, which may be effected by adjusting the parts of the jet so as to create a controlled suction at the yarn inlet and thereby to suck controlled amounts of a cool air into the jet housing. If the jet is operating under a particular set of conditions so that air leaves through the yarn inlet, temporary reduction of the steam pressure will create suction at the yarn inlet to make the jet self-threading.

The foregoing and other objects, characteristics and advantages of the present invention will become more fully clear from the following detailed description thereof when read in conjunction with the accompanying drawings, in which;

FIG. 1 is a diagrammatic view of the overall steam yet yarn bulking system according to the present invention;

FIG. 2 is a longitudinal sectional view of one type of jet employed in the system shown in FIG. 1;

FIG. 3 is a transverse sectional view taken along the line 3—3 in FIG. 2;

FIG. 4 is a sectional view of another type of jet capable of being used in the system shown in FIG. 1;

FIG. 5 is a transverse sectional view taken along the line 5—5 in FIG. 4, FIGS. 4 and 5 being drawn to the scale shown in the illustrated inch;

FIG. 6 is an enlarged view of the novel yarn; and

FIG. 7 is an enlarged schematic view of one of the filaments of FIG. 6.

As will be more fully explained hereinafter in connection with a description of preferred embodiments of certain apparatus features, the present invention provides a process of bulking synthetic, continuous filament yarn which broadly comprises the use of steam at elevated pressure to bulk the yarn and to set the bulk-defining deformation in the yarn. More particularly, the process is characterized by the steps of feeding such yarn into a jet, subjecting the yarn while in the jet to the action of a turbulent stream of steam which serves both a bulking function (of the false twist-forming type) and a bulk-setting function, drawing the bulked and set yarn out of the jet, and winding the yarn on a bobbin or spool for shipment, storage and/or subsequent use. In its more specific aspects, the process according to the invention is characterized by the fact that the overfeed ratio, i.e., the ratio of the linear speed at which the yarn is fed to the jet to the linear speed at which the bulked yarn is withdrawn from the jet, is greater than unity, e.g., about 1.05–3:1 and preferably about 1.10–2:1. Lower ratios approaching unity produce less crimp while higher ratios increase the bulk and the irregularity due to the presence of knots and tight spots in the product. The invention is also characterized by the fact that the drawdown ratio, i.e., the ratio of the linear speed at which the bulked yarn is wound on a take-up device to the linear speed at which the bulked yarn is withdrawn from the jet, is advantageously greater than unity, e.g., about 1.02–1.2:1 and preferably about 1.05–1.12:1. Too little drawdown raises the possibility that in use some crimp may be pulled out, thereby stretching the yarn; in addition the package will be soft and uneven. Too much drawdown reduces the bulk and may break the filaments. The drawdown may be effected by driving a take-up spindle at the desired speed. If it is desired to introduce twist into the yarn being taken up, a conventional downtwister may be employed and it will be necessary to provide a driven roll operating at the desired take-up speed just before the downtwister. The temperature of the steam supplied may range from about 100° to 150°C. up to a temperature beyond which the yarn will be damaged. The pressure of the steam should be at least sufficient to effect bulking and conveniently ranges from about 20 to 125 and preferably about 40 to 95 psig. Lower pressures produce little bulking unless the yarn speed is decreased with obvious reduction in the capacity of the apparatus. Higher pressures will damage the yarn unless the yarn speed is correspondingly high to reduce the time during which the yarn is subjected to the action of the steam.

The yarn may initially be twisted or untwisted and may be taken up with twist, if desired, or without twist. Where the feed yarns have initial twist, preferably this twist is in direction opposite to that of the steam in the vortex since this produces a more uniform crimp with fewer tight or hard spots.

The apparatus for carrying out the process as outlined above basically comprises in addition to yarn feeding, drawing and winding means of substantially conventional construction, jet means for subjecting the source yarn to the action of a stream of steam. The steam, while in the jet, not only performs a bulking operation on the yarn by imparting thereto a false twist but, by virtue of its elevated temperature, also performs a bulk setting operation. The false twist-crimp type bulking is effected by admission of the steam into the jet under such conditions that a vortex is created, e.g., by tangential introduction of the steam in sufficient amount and at sufficient pressure.

One jet suitable for producing vortical flow of the steam comprises a housing defining a bulking chamber in which there is provided a pair of facing mating conical projections on fittings defining the yarn inlet and outlet passageways, and the outlet fitting is shaped in the manner of a venturi. Steam enters the chamber eccentrically of the lattern and flows with a whirlpool or vortex motion about the said projections and continues so to flow upon entering the outlet passageway and thus the venturi. Consequently, the spinning steam imparts a false twist to the yarn passing through the jet, particularly to that portion of the yarn which is approximately centered at the venturi throat and extends backward and forward therefrom to the pair of fixed points, e.g., pigtail guides or the like, associated with the inlet and outlet ends of the jet.

Turning now to the drawings, and referring first to FIG. 1, it will be seen that in a yarn bulking system according to the present invention yarn **10**, which may be of the monofilament or multifilament type, is drawn from a source thereof (not shown) through a pigtail guide **11** by means of a pair of feed rolls **12***a* and **12***b* driven at a predetermined speed by any suitable drive means (not shown). The source yarn **10**, upon leaving the roll **12***b*, enters a steam jet **13** connected with a steam supply line **14** by means of a steam inlet fitting **13***a*. The structure of the jet **13** will be more fully described presently. Having been bulked in the jet, the yarn leaves the latter and is drawn through a pigtail guide or like means **15** by a pair of feed rolls **16***a* and **16***b* which are driven at a slower speed than the inlet feed rolls **12***a* and **12***b* and feed the bulked yarn to be

taken up by a device (not shown) at a slightly higher speed than the outlet feed rolls **16***a* and **16***b*.

As can best be seen from FIGs. **2** and **3**, one type of jet which may be employed in the system of FIG. **1** comprises a housing **17** provided with an axial, logitudinal bore **18** which is threaded over a portion of its length adjacent one and of the housing **17**, as shown at **19**. The housing **17** is further provided with a transverse bore **20** one end of which is open to the outside of the housing and the other end of which communicates with the bore **18** within the housing, the bore **20** being threaded over at least a portion of its length intermediate the said ends thereof, as shown at **21**. A yarn inlet tube **22**, provided at one end with a knurled or polygonal head or gripping member **23**, and intermediate its ends with external threads **24**, is threadedly mounted in the bore **18** of the housing **17** at the aforesaid one end of the latter and may thus be reciprocally displaced therein for adjustment of the second end of the inlet tube **22** relative to the associated opposite end of the housing, this end being obturated by a plug **25** inserted in the bore **18** and defining a yarn outlet passageway **26** arranged somewhat eccentrically with respect to the yarn inlet passageway **22***a* defined by the tube **22**. In this manner, there is further defined between the outlet plug **25** and the threaded portion **24** of the inlet tube **22** a chamber or space **27** which will hereinafter be referred to as the bulking chamber.

The steam inlet fitting **13***a* essentially comprises a body **28** provided at its opposite ends with external threads **29** and **30**, respectively, and intermediate its ends with an annular, preferably hexagonal or otherwise polygonal gripping member **31** which serves as the means engageable by a wrench or like tool for screwing the threaded end **29** into the threaded bore **20–21** and simultaneously as stop means engageable with the outer surface of the housing **17** to limit the maximum insertion of the fitting **13***a* into the bore **20**. The body **28** is further provided with an axial bore **32** defining the inlet flow path for steam fed to the jet by means of the supply line **14**, the outlet end of the latter being connected to the threaded end **30** of the body **28**. As can be seen in FIG. **3**, the vertical axial planes of the bulking chamber **27** and steam inlet passageway **32** do not coincide with each other, or, stated in other words, the passageway **32** does not extend radially of the bulking chamber **27**.

Another type of jet which may be employed in the system of FIG. **1** is illustrated in FIGS. **4** and **5**. As there shown the jet comprises an elongated housing **33** substantially square in cross-section, although it will be understood that other cross-sectional shapes may be employed. The housing **33** is provided with an axial bore **34** threaded throughout its length from one end of the housing to the other. Intermediate its ends, the housing **33** is provided with a countersunk transverse bore **35** communicating with the axial bore **34** and also threaded in its enlarged portion to the outer surface of the housing. The axis of bore **35** is arranged eccentrically, i.e., substantially tangentially, of the bore **34**.

A yarn inlet tube **36**, the body of which is externally threaded over its entire length, as shown at **37**, and which is provided at one end with a knurled, hexagonal or otherwise polygonal gripping member **38** and at the other end with conical, tapered nose or projection **39**, is threadedly mounted in the housing **33** at one end of the latter to an extent limited by a nut **40**. The tube **36** is provided with a central axial bore or yarn passageway **41** the inlet end **42** of which is flared outwardly to facilitate entry of the yarn thereinto.

A yarn outlet tube **43**, the body of which is externally threaded over its entire length, as shown at **44**, and which is provided at one end with a knurled hexagonal or otherwise polygonal head or gripping member **45** and at the other end with a frusto-conical, outwardly flared, tubular projection **46**, is threadedly mounted in the housing **33** at the second end of the latter to an extent limited by a nut **47**. The tube **43** is provided with a central axial bore or yarn passageway **48** which is widest at the end of the tube body defined by the gripping member **45** and narrowest at the opposite end of the body, as shown at **48***a*, the bore or interior **46***a* of the projection **46** becoming wider in a direction away from the body and merging with the narrow end **48***a* of the passageway **48**. The yarn outlet tube **43** with its projection **46** thus constitutes a venturi tube the throat or constriction of which is defined by the narrow end **48***a* of the bore **48**. The purpose and function of the venturi will become clear presently. As can be seen from FIG. **4**, the projections **39** and **46** are dimensioned in the form of mating male and female elements, and their relationship to one another, i.e., the extent to which the projection **39** is received within and surrounded by the projection **46**, may be adjusted by simply varying the extent to which the tubes **36** and **43** are threaded into the jet housing **33**. Between their facing ends and within the housing **33** the yarn inlet and outlet tubes **36** and **43** define a space or chamber **49** which together with the bore **46***a* in the projection **46** constitutes a vortex or bulking chamber for the yarn passing through the jet.

The steam fitting **13***b* for the jet shown in FIGS. **4** and **5** is in all respects substantially identical with the fitting **13***a* described hereinabove, consisting of a body **50** provided intermediate its ends with a hexagonal or otherwise polygonal gripping or manipulating member **51** and externally threaded at its opposite ends, as shown at **52** and **53**, the threads **52** enabling introduction of the fitting **13***b* into the bore **35** to the extent permitted by the member **51** or the shoulder in bore **35**, and the threads **53** being adapted for connection to the steam supply line **14** shown in FIG. **1**. The body **50** is provided with a central axial bore **54** extending from one end thereof to the other and communicating at one end with the vortex or bulking chamber **49** through bore **35**. Due to the previously mentioned offset or eccentric location of the axis of transverse bore **35**, the steam inlet passageway **54** will, of course, communicate with the vortex chamber **49** substantially tangentially of the latter (see FIG. **5**). From the foregoing, it will be understood that steam admitted at high flow speeds and under high pressure into the bore **54** in the body **50** of the fitting **13***b* will enter the chamber **49** in such a manner as to flow like an eddy or whirlpool about the projections **39** and **46** (in a clockwise direction as seen from the outlet end of the jet housing **33** and as seen in FIG. **5**).

In operation, the yarn to be bulked, which (as stated above) may be either of the monofilament or multifilament type, is fed by the rolls **12***a* and **12***b* into the inlet passageway **46***a*-**48***a*-**48** of the outlet tube **43**. The steam which is admitted into the chamber **49** and whirls or eddies about the projections **39** and **46** ultimately flows in its vertical state into the space between the

inner surface of the projection **46** and the outer surface of the projection **39.** Thus the steam, due to its rotary motion, imparts a strong false twist to the section of the yarn which is then passing through the jet, and it will be readily seen that this twist will be S from the feed roll **12**b to the venturi throat **48***a* and Z from the venturi throat to the pigtail guide **15.** The degree of twist, which, for an initially untwisted yarn, will be zero before the feed rolls **12***b* and **16***a*, and a maximum at the venturi throat **48***a*, will depend to a great extent on the rate of flow and pressure conditions of the steam. The degree of twist will further depend to a considerable extent on the tension maintained in the yarn during the time in which it is subjected to the false twist by the steam in the chamber **49.** It will be clear to those skilled in the art that the tension may be suitably adjusted by varying the rate of overfeed of the yarn, i.e., the speed differential between the feed rolls **12***a*, **12***b* and the feed rolls **16***a*, **16***b*.

In accordance with the present invention, of course, that portion of the false twist induced in the yarn by the steam beyond, i.e., downstream of, the venturi throat is set in the yarn due to the heating action of the same steam on the yarn before the latter exits from the jet via the outlet passageway **48.** However, since the degree of twist of the treated yarn at the feed roll **16***a* is zero, the yarn is effectively wound on the take-up device (not shown in FIG. **1**) in a pretensioned condition, i.e., with zero twist but with a tendency to assume its twisted state. When the yarn is subsequently unwound from the take-up device or bobbin, it will continue to tend to assume the set twist (Z under the described conditions) which will render the yarn crimped and bulky to an extent predetermined by the operating conditions existing in the jet.

A representative yarn is seen in FIG. **6** comprising a plurality of filaments **55, 56,** etc., separated from one another in longitudinal direction by varying amounts. FIG. **7** shows the filament **55** of FIG. **6** as it would appear if isolated from the yarn. It will be seen that along filament **55** there are portions **57, 58, 59,** etc., of different helix angles which are responsible for the nonregistry and high bulk of the yarn in FIG. **6** and for the resistance to stretching.

The novel yarn is excellent as the pile for carpeting but also has general utility wherever bulked yarns have heretofore been used.

Excellent steam bulked yarn of the type contemplated by the present invention has been produced under steam pressures ranging from about 20 to 125 psig. at overfeed ratios ranging from 1.14:1 to 1.50:1, and at a drawdown ratio of 1.05:1. Simultaneously feeding two ends, each comprising 50 filaments of black cellulose acetate and having a total denier of 950 but one end having **1**-S turn per inch and the other **1**-Z turn per inch, suitably lubricated, best results were obtained with an overfeed ratio of 1.40:1 at 80 psig. steam pressure. Analysis of the bulked yarns shows them to be free of broken filaments and possessed of tenacities ranging from about 0.6 to 0.8 gram per denier.

A bulked yarn having a tenacity of 0.96 gram per denier, an elongation of 40.8 percent and an average of 6.5 crimps per inch along each filament was produced by simultaneous feeding of two ends of cellulose acetate yarn at an overfeed ratio of 1.09:1 into a jet as shown in FIG. **4** supplied with steam at 90 psig. Each of the individual ends was made up of 50 filaments of cellulose acetate twisted with **1**-S turn per inch into a yarn of 950 denier. The bulked yarn was withdrawn from the jet and eventually taken up at the rate of 48 yards per minute, with a drawdown ratio of 1.02:1.

While the invention has been described with reference to the use of steam, other hot fluids may be employed, e.g., air, organic solvent vapors, hot liquids, and the like. Filamentary materials to which the process may be applied include all fibers which are softened or plasticized by the fluid, whether due to the composition of the fluid, the temperature, or both. Representative materials include cellulose organic acid esters such as cellulose acetate, rayon, polymers and copolymers of olefins such as ethylene and of vinyls such as vinyl chloride, vinyl acetate, and the like. Particularly good results are achieved using materials which undergo a crystalline change during hot steaming, such as nylon, polyesters such as polyethylene terephthalate, and especially cellulose organic acid esters having fewer than 0.29 free hydroxyl groups per anhydroglucose unit, e.g., cellulose triacetate, and the like. Yarns of different chemical composition or color may be plied and bulked or the filaments of a single yarn may be of different composition or color.

The initial filamentary materials advantageously are bundles of about 20 to 200 and preferably 50 to 100 filaments; generally the total denier ranges from about 100 or less to 3,000 or more and preferably about 1,000 to 2,000. While they may have no twist to begin with, advantageously they have about 0.5 to 1 turns per inch. The amount of twist applied by the false crimp-type jet will depend upon the speed of the yarn therethrough where maximum bulk is desired the twist imparted by the jet is preferably in opposite direction to the initial twist of the yarn.

It is to be understood that the foregoing detailed description is given merely by way of illustration and that many variations may be made therein without departing from the spirit of our invention.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A steam thermally set and steam false twist bulked multi-filament yarn comprising a plurality of false twisted helically crimped filaments, each of said filaments being characterized by varying helical tightness and a plurality of different helix angles along its length, said filaments being out of crimp registry with one another as the yarn issues from the false twister without further processing, said yarn having been false twisted in a venturi type steam jet into which the steam is fed eccentrically of the yarn passageway and the venturi chamber, the steam simultaneously imparting a false twist to the yarn, functioning as the false twist setting fluid in the steam jet and deregistering crimps of adjacent filaments, said yarn being substantially free of loops.

2. The yarn of claim **1** being substantially free of real twist.

3. The yarn of claim **1** having at least some real twist.

4. The yarn of claim **1** having from about 0.5 to about 1 turn per inch.

5. The yarn of claim **1** wherein said yarn is a polymeric material selected from the group consisting of nylon, polyethylene terephthalate and cellulose organic acid esters.

6. The yarn of claim 1 wherein the total denier is in the range of from about 100 to about 3,000.

7. The yarn of claim 1 wherein the total denier is in the range of from about 1,000 to about 2,000.

8. The yarn of claim 1 wherein said filaments comprise cellulose triacetate.

9. The yarn of claim 1 wherein at least some of said filaments have real S twist and at least some of said filaments have real Z twist.

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