June 10, 1969 G. E. BENSON 3,448,500

METHOD OF BULKING YARN

Filed Dec. 29, 1966 Sheet 1 of 2

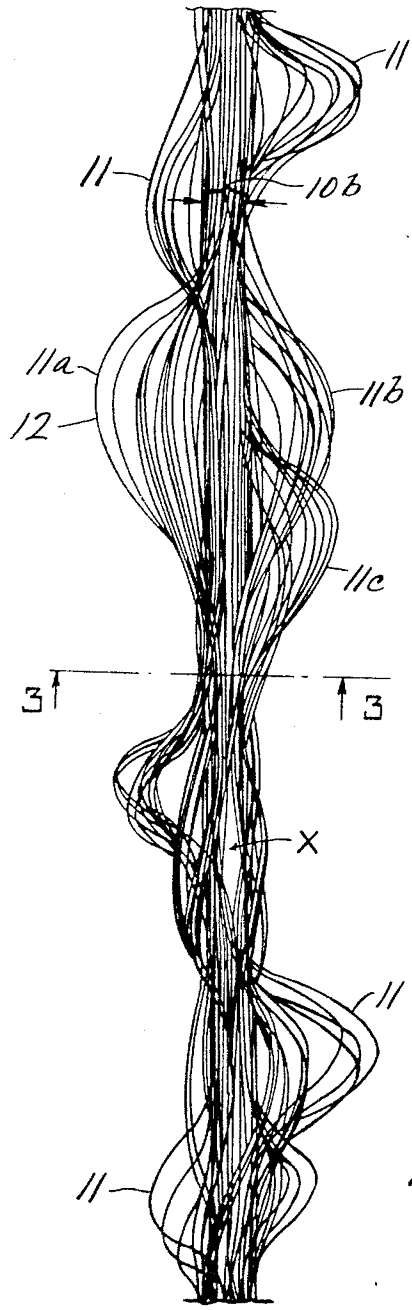

FIG-2-

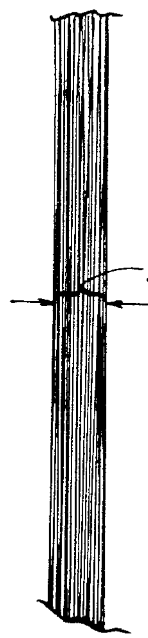

FIG-1-

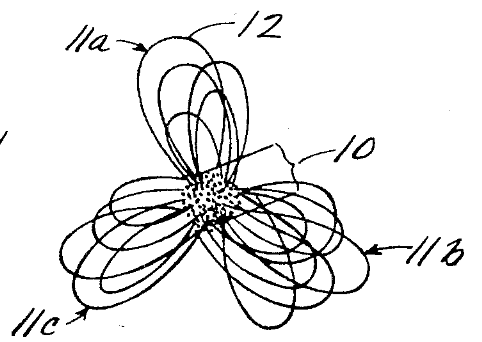

FIG-3-

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METHOD OF BULKING YARN

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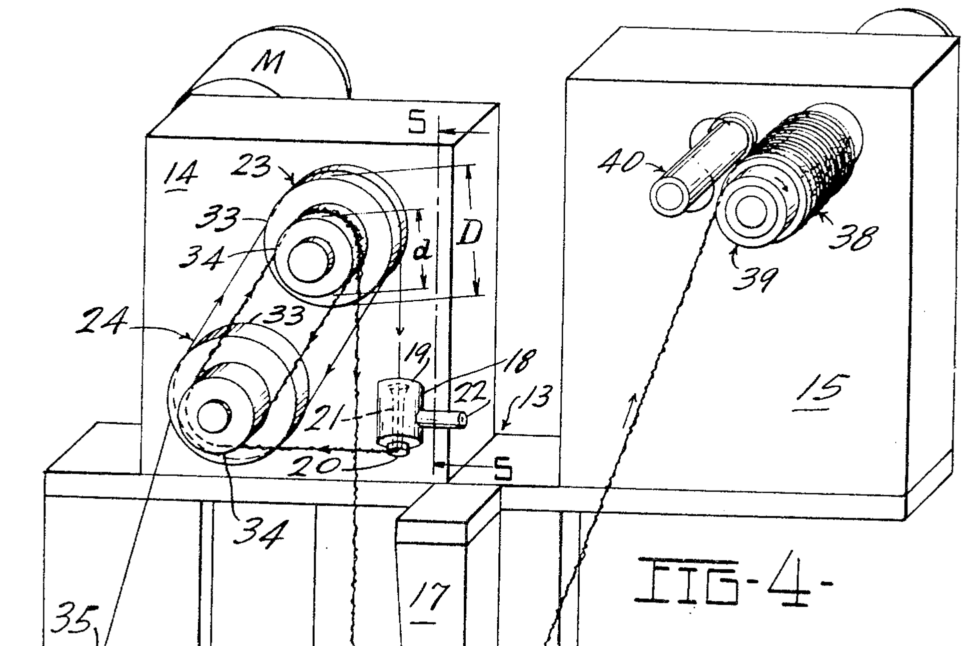
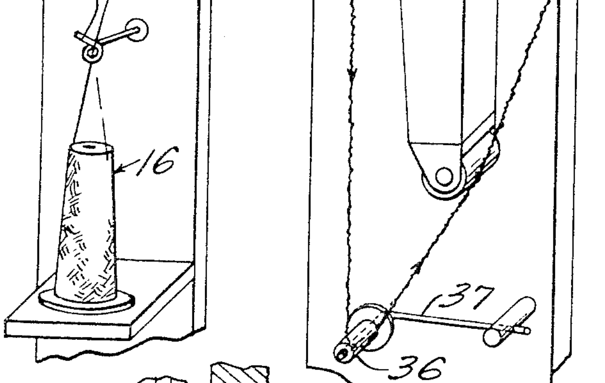

FIG-4-

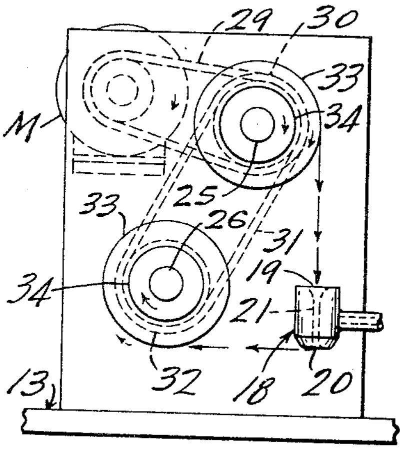

FIG-6-

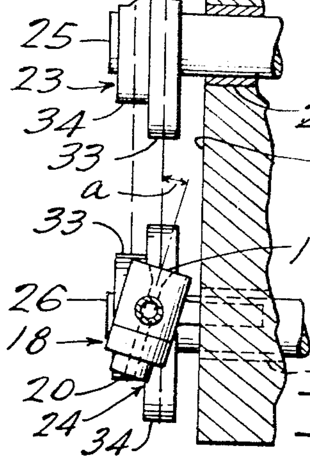

FIG-5-

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3,448,500
METHOD OF BULKING YARN

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Continuation-in-part of application Ser. No. 551,091, May 18, 1966. This application Dec. 29, 1966, Ser. No. 605,700
Int. Cl. D02g 3/22
U.S. Cl. 28—72 6 Claims

ABSTRACT OF THE DISCLOSURE

A method of producing a bulky textile product from a strand of textile filaments by passing successive increments of the strand through a zone of fluid turbulence at a high linear speed whereby groups of filaments are separated and displaced from those remaining in the strand to form arches or waves extending outwardly from the body of the strand. The zone of fluid turbulence may be provided by an enclosed fluid texturing jet and strand feed and take-up apparatus is used to pass the strand through the fluid jet at a speed such that the energy transferred to said strand filaments is sufficient to form the desired arches but is insufficient to break the groups of filaments or to distort the desired arches into closed loops.

This application is a continuation-in-part of my copending application Ser. No. 551,091, filed May 18, 1966, now U.S. Patent 3,411,287.

This invention relates to improved textile yarns and fabrics and an apparatus and method for producing such yarns and fabrics. It is a particular object of this invention to provide a fabric woven from glass yarns which has the texture and appearance of a fine cotton, silk or wool fabric and a hand equivalent to these fabrics.

Conventional glass yarns are hard, shiny and of high density and fabrics woven from such conventional yarns are consequently dense, hard and shiny. Previous attempts to "texturize" or bulk conventional glass yarns, particularly of a single strand, have not been fully satisfactory due to poor uniformity and have produced yarns which when woven present a nubby fabric which had only limited acceptance.

To achieve this improved fabric, this invention provides a novel bulky yarn and a method and apparatus for producing such novel yarn.

More specifically, this invention relates to a method and apparatus for the high speed production of an improved bulky yarn, which yarn is characterized by the fact that it has a uniformly higher degree of bulk or volume than yarns heretofore produced by prior art methods and apparatuses and which is further characterized by the absence of broken ends or fibers. The yarn produced by the method and apparatus of this invention is further characterized by the presence of randomly spaced, undulatory surface waves comprised of a discrete bundle of filaments which have been separated from a relatively densely packed core area and which are returned to and intermingled with the core area on each side of the individual wave. Fabrics woven from the improved bulky yarn of this invention are characterized by the appearance and hand of fine cotton, silk or wool and have a low density and soft texture uniformly throughout.

To obscure the nonuniformity of prior art bulked yarns, texturization was carried to the extent where the filaments were looped or broken to produce a rough, nubby and relatively weak yarn that could only be used to produce boucle and other rough surfaced fabrics. Bulky yarns in which relatively straight and closely compacted filaments have been separated and convoluted by passing the unbulked yarn through an enclosed area of fluid turbulence are well known in the prior art. United States Patent 2,783,609 discloses one such yarn and the apparatus for producing it. Bulky yarns of this type are characterized by the presence of a large number of closed or "crunodal" loops which vary in size in accordance with the pressure and the relative rates at which the yarn is fed to and withdrawn from the area of fluid turbulence or jet.

One of the difficulties encountered with prior art apparatuses and methods have been that it has been heretofore impossible to bulk or texture a yarn with a substantial degree of bulkiness and, at the same time, be highly uniform in the degree of bulkiness along the length of the yarn and avoid breakage of a substantial number of the filaments in the fluid turbulence. While it may be desirable in some instances to produce a staple type product characterized by the presence of a relatively large number of broken filaments, it is desirable in many instances to produce a bulky yarn characterized by the absence of broken filaments because such a yarn retains its original tensile strength and also has novel surface characteristics.

Another disadvantage of prior art apparatuses and processes for bulking yarns in a fluid jet has been the relative slow rate of feed obtainable. A number of apparatuses for feeding the unbulked or untextured yarns to the jet inlet and withdrawing them from the jet outlet at fixed speeds are currently available. Because such fluid bulking processes necessarily reduce the length of the yarn which had been bulked relative to that of the unbulked yarn, a number of apparatuses which "overfeed" one or a plurality of yarns to the jet have been developed.

U.S. Patent 2,874,444 discloses an apparatus including a freely rotatable, double diameter, coaxial pulley over which yarn is fed to the jet inlet from a first yarn surface of a relatively large diameter and is withdrawn from the jet outlet on a second yarn surface of relatively small diameter, thus fixing the overfeed ratio. Apparatuses of this nature are effective to maintain a fixed overfeed ratio between the yarn fed and yarn withdrawn from the jet but, because of certain difficulties in the apparatus such as inertia of the pulley and the direction in which the yarns are fed to and withdrawn from the jet, such apparatuses have been unable to be effectively used at yarn speeds in excess of about 500 feet per minute. At higher speeds, stresses are placed on the yarn and it is apt to completely break or to sever a large number of the filaments.

It has been discovered that, through the use of at least two coaxial, multiple diameter feed rollers which are in a fixed and predetermined position in relation to the inlet and outlet orifices of the fluid jet and are driven at high speed with the untextured yarn wrapped around and between the large diameter surfaces and thence fed to the jet and thence taken from the jet and wrapped around and between the small diameter surfaces, that speeds in excess of 3,000 feet per minute can be used in texturing yarns without breaking any of the yarn filaments.

It has also been discovered, through use of such an apparatus at high speed as previously described, that the yarn produced thereby has distinct and different characteristics from the yarns produced by previously known prior art processes and apparatuses. The yarn produced by the apparatus of this invention is characterized by the absence of any broken filaments and is also characterized by the presence of a large number of undulatory shaped waves each of which include selected numbers of filaments which are taken from the relatively densely packed core area on either side of the wave. This novel yarn is further characterized by a high bulk or loft, that is, the height of the undulatory waves is substantially greater than the diameter or thickness of the closely compacted core area of the textured yarn.

The improved yarns of this invention, characterized by uniform bulking without surface irregularities and by the absence of broken filaments and crunodal or closed loops, are produced by the high speed apparatus of this invention which is able to pass untextured yarn through highly turbulent zone at a linear yarn velocity sufficient to uniformly bulk the yarn while preventing the formation of completed or closed loops and preventing filament breakage. For a given amount of turbulence, (or fluid pressure applied to a turbulent zone in the texturing device), the improved yarns of this invention are produced by the device of this invention which passes them through the highly turbulent zone at a speed at which the energy transferred from the fluid turbulence to each increment of yarn is sufficient to separate a number of filaments into successive discrete undulatory arches or waves extending laterally from the core or bundle of yarn, but in insufficient to form closed or crunodal loops in such filaments. Preferably also the energy transferred is not sufficient to break a substatial number of such filaments. This energy-velocity relationship is described in greater detail below.

It is believed that the previously enumerated advantages of the instant apparatus and method are made possible through use of at least two coaxial, multiple-diameter driven feed rollers whereby the yarn from the larger diameter section of one of the feed rolls can be fed to the inlet orifice of the jet in a path which lies substantially in a plane passing through the axis of the jet and can be withdrawn from the outlet orifice of the jet in a path which is subtsantially normal to the axis of the jet. This manner of feeding and withdrawing the yarn to and from the jet is believed to account for the fact that the yarn may be textured with the instant apparatus at such high speed which has been unobtainable with prior art apparatuses. Furthermore, as will be subsequently explained, because the yarn feeding and take-up surfaces of the double diameter feed rolls are axially spaced apart on the coaxial feed rolls, it is possible to feed the yarn to the outlet orifice of the jet at a small angle to the axis of the jet but yet in a plane passing through the axis of the jet. This small angle is important in that it keeps the incoming yarn out of the "blow-back" from the inlet orifice of the jet which has caused problems in previous attempts at high speed. Blow-back is high velocity air which comes out of the inlet orifice of the jet, causing resistance to the incoming yarn and producing an initial fuzz or slight separation of the yarns prior to entering the jet.

By feeding the yarn to the inlet orifice of the jet at a slight angle to the axis of the jet to avoid the blow-back, the yarn enters the interior of the jet in a substantially unopened or compact condition where the forces of fluid turbulence initially strike only the surface portions of the yarn. When the yarn is passed through the jet at such high speeds, it is believed that a somewhat different bulking or texturing action takes place than in prior art apparatuses. This texturing action in which the forces of fluid turbulence affect only the surface areas of the yarn is believed to account for the novel characteristics of the yarn produced from the apparatus of this invention. Additionally, with the yarns passing through the turbulent zone within the jet at such high speeds, the energy transferred to the yarn from the turbulence, for a given amount of turbulence, is greatly reduced and is concentrated upon the external or surface areas of the yarn. For fixed amounts of high turbulence, (or fluid pressure supplied to a fluid jet), the device of this invention can attain a yarn feed velocity such that the energy available to each yarn increment passing through the turbulent zone is sufficient to separate the surface filaments into laterally extending undulatory waves but is insufficient to break or to form complete or crunodal loops in the filaments.

It is an object of this invention to provide a novel bulky yarn characterized by the absence of broken filaments or staple fibers and by the absence of closed or crunodal loops.

It is another object of this invention to provide a novel bulky yarn characterized by the presence of randomly occurring undulatory waves on the surface of the bulked yarn which are comprised of selected numbers of filaments which are drawn from the relatively densely packed core area of the yarn and are returned thereto after extending into a less densely packed wave.

It is still another object of this invention to provide a novel bulky yarn of glass fibers characterized by the presence of a number of undulatory waves of selected filaments drawn from a relatively densely packed core area of the yarn which waves are comprised of a selected group of filaments drawn from a relatively densely packed core section and in which the height of such waves, from their crest to the center of the core of the yarn, is substantially larger than the diameter of the core area of the yarn.

It is an object of this invention to provide an improved apparatus for texturing or bulking yarns by means of feeding the unbulked yarn at high speed through a fluid texturing jet.

It is another object of this invention to provide an improved apparatus for bulking yarns by feeding them at high speed to the yarn inlet of a fluid texturing jet in a direction slightly displaced from the axis of the jet and withdrawing the textured yarn from the outlet orifice of the jet in a direction substantially normal to the axis of the jet.

It is still another object of the invention to provide an apparatus for producing a novel bulky yarn which includes means for applying a liquid size to the yarn after it has been textured, and a high speed constant tension take-up device which forms a compact package of textured yarn of uniform tension.

It is still a further object of this invention to provide an improved method of producing a novel bulky yarn which method produces such yarn at a rate substantially in excess of any prior art methods.

It is yet a further object of this invention to provide a method of texturing yarn by passing it through an area of fluid turbulence, which method includes the steps of feeding the yarn at a first rate into the inlet orifice of a fluid jet at an angle slightly displaced from the axis of the jet and in withdrawing the yarn at a second, slower rate from the outlet orifice of the jet in a direction substantially normal to the axis of the jet.

It is another object of this invention to provide a method, and an apparatus for carrying out such method of texturing yarns by passing them through a zone of turbulence at a speed such that, for a given amount of high turbulence, the energy transferred to each increment of yarn is sufficient to separate a number of filaments into undulatory or wave-like arches extending laterally from the body of the yarn but is insufficient to rearrange the filament into closed or crunodal loops.

Other objects and advantages of this invention will be apparent to those skilled in the art from the following detailed description of the product, the method and a preferred embodiment of the apparatus, reference being made to the accompanying drawings in which:

FIG. 1 is a view, on a greatly enlarged scale, of a short section of an untextured or untreated yarn, prior to being treated by the apparatus of this invention;

FIG. 2 is a view also on a greatly enlarged scale, of a short section of the novel yarn product of this invention illustrating the undulatory wave-like configurations assumed by selected bundles of surface filaments which are produced from the relatively straight, closely packed filaments of the yarn shown in FIG. 1;

FIG. 3 is a cross-sectional view, taken along the lines 3—3 of FIG. 2, and showing the manner in which the undulatory waves formed by the bundles of surface filaments extend in all directions from the core thereof;

FIG. 4 is a schematic view in perspective of a complete yarn bulking apparatus of this invention, showing a yarn texturing fluid jet with yarn being fed to and taken from it by a pair of driven, double diameter, coaxial yarn feed and take-up rollers and further illustrating the manner in which the yarn is passed from the take-up roller to a liquid size applicator and thence to a constant tension winding device;

FIG. 5 is a cross-sectional view taken along line 5—5 of FIG. 4 and showing, on an enlarged scale, the alignment of the fluid jet inlet and outlet orifices with the axial centers of the yarn bearing surfaces of the feed and take-up rollers; and

FIG. 6 is a schematic view of a portion of FIG. 5 showing the drive mechanism for the feed and take-up rollers.

Referring to FIG. 1, the improved bulky yarn of this invention can be made from an untextured yarn or strand of continuous filament fibers of any origin. Glass fibers are particularly adapted for use in forming the bulky product of this invention. It is to be understood that the term "yarn," as used in this specification and the claims appended hereto, refers to a bundle of continuous filament fibers, twisted or untwisted. The filaments prior to being treated are generally parallel and are densely compacted into a yarn having a uniform average diameter, indicated by reference numeral **10***a*.

As seen in FIG. 2, the novel product of this invention comprises a generally linear, relatively dense core section, designated by reference numeral **10***b*, and a plurality of surface waves designated by reference numeral **11**. The surface waves **11** occur randomly along the length of the yarn and have generally equal forward and reverse slopes within each wave. As seen in FIG. 3, the waves **11***a*–**11***c* extend radially outwardly from the core section **10***b* in all directions so that the bulk or waves of the improved yarn extends radially outwardly from the center of the core section **10***b* by a substantially equal amount in all directions. The core section is further characterized by the presence of randomly occurring holes or splits, designated by reference letter X, formed by a separation of the core section filaments into distinct groups.

Each of the waves **11** is comprised of a group of filaments taken from the core section **10***b* on either side of the wave. The group of filaments forming the waves appear to lie on the opposite side of the core section from which the wave emerges so that the waves are bound in place by the main body of filaments of the core section. Within each wave **11**, the individual filaments are of varying length so that each wave is comprised of a number of filaments which are spaced apart, extending from the outermost filament **12** of the wave **11***a* and extending radially inwardly toward the core section **10***b*.

In addition to the fact that the waves **11***a*–**11***c* extend in all directions from the center of the core section **10***b*, as seen in FIG. 3, each of these waves, from its crest, such as from filament **12** in wave **11***a* to the core section **10***b*, is substantially greater in depth than the diameter of the core section **10***b*. Thus the novel yarn product is quite bulky in relation to its untextured source, shown in FIG. 1, and has surface characteristics distinct from that source and also from prior art yarn. Furthermore, because the waves **11** are comprised of a number of loosely compacted and spaced apart filaments, this bulkiness is imparted by displacement of relatively few filaments, so that the substantial majority of the filaments from the source yarn remain in the core section **10***b*.

Because the improved product of this invention is characterized by absence of broken fibers or staple and also by the absence of closed or crunodal loops, it has vastly superior qualities of tensile strength and the ability to retain its bulk when placed under tension than prior art

bulky yarns. Adjacent waves **11** are not formed of the same selected filaments but are composed of a different group of filaments coming out of the core area **11***b*. A relatively large number of filaments remains in the core section **10***b* from wave to wave and each wave retains its separate identity from the adjacent waves because its included filaments are returned to and gripped by the relatively closely packed core section **10***b*.

EXAMPLE 1

A continuous filament fibrous glass yarn comprised of a single strand of filaments having an average diameter of 0.00029 inch with a 1/0 "Z" twist was run through a fluid jet, of the type described in my copending application Ser. No. 407,758, originally filed Oct. 30, 1964, now U.S. Patent 3,381,346 supplied with air at 80 p.s.i.g. The yarn was fed to and taken-up from the jet in an apparatus similar to that shown in FIGS. 4–6. The exit speed of the bulked yarn from the jet was 3,000 feet per minute.

The bulked yarn made in this example had a breaking strength of 2.6 pounds and, under microscopic inspection, was found to be characterized by the absence of broken filaments and by the presence of the undulatory wave-like surface convolutions shown in FIG. 1. The bulkiness of the product was uniform throughout the length of the test samples. It appeared that the surface fibers of a particular wave returned on each side of the wave to the opposite side of a relatively dense core portion and that the height of the waves from their outermost fiber or crest to the core portion was substantially greater than the diameter of the core portion itself. Samples in accordance with this example were further characterized by the absence of closed or crunodal loops.

Woven textile products using the bulked yarn of this example had a uniform surface characteristic due to the uniformity of the bulked yarn. The yarn of this example may be woven as is or may be given an additional twist prior to weaving.

The relationship between linear yarn speed and amount of energy available to texture successive increments of yarn passing through the jet from the fluid turbulence directly affects the configuration of the bulked yarn, as previously stated. A series of tests was conducted on the apparatus and under the conditions set forth in Example 1 above upon the same yarn, with changes made only in the exit speed of the bulked yarn and in the air pressure supplied to the jet. These tests and the appearance of the resulting product under microscopic inspection are summarized below:

Example	Air pressure to jet—(p.s.i.g.)	Exit speed of bulked yarn (f.p.m.)	Appearance of the bulked product is characterized by—
2	40	300	Many small closed loops; many broken ends.
3	40	1,000	Bulkier wave-like arches; some smaller loops; some broken ends.
4	40	2,000	Long, shallow arches of few filaments; few broken ends.
5	60	300	Many closed loops and rings; broken ends.
6	60	1,000	Some closed loops and rings; broken ends.
7	60	2,000	Long arches, few closed loops; randomly occurring broken ends.
8	80	300	Many small closed loops; many broken ends; little relative bulk.
9	80	1,000	Many closed loops; many broken ends.
10	80	2,000	Many closed loops; randomly occurring arches; some broken ends.
1 [1]	80	3,000	No closed loops; successive wave-like arches of substantial lateral height; no broken ends.

[1] Repeated from above.

From the description of the bulked product formed in Examples 1–10 above, it will be apparent that, as the amount of turbulence or fluid pressure applied to the jet increases, the linear yarn speed must also be increased to provide a product having few broken ends or closed loops. Furthermore, inspection of the product of Example 1 indicated that it was superior to any other product produced at lower fluid pressures or linear yarn speeds. Consequently, the yarn of this invention is due to (a) very high turbulence which is capable of agitating and separating groups of surface filaments and pushing these groups laterally away from the body of the yarn and (b) high rates of yarn travel by which successive increments of yarn are passed through the turbulent zone at a speed sufficient to prevent filament breakage or formation of closed or crunodal loops. Such high speeds in excess of 2000 f.p.m. have been impossible to attain prior to the development of the apparatus of this invention, described below in detail.

Referring to FIGS. 4, 5 and 6, the preferred embodiment of an apparatus for texturing a yarn in accordance with the concepts of this invention is shown in detail. Referring particularly to FIG. 4, a horizontal platform **13** supports a vertically extending housing **14** and a winder mechanism **15**. Extending below the support platform **13** is a yarn supply, generally designated by reference numeral **16** and a liquid sizing applicator **17** whose function will be subsequently explained.

A fluid jet **18** having an inlet orifice **19** and an outlet orifice **20** with a general axial passage **21** extending therethrough is secured to the front face of the housing **14** with a fluid supply line **22** connected to a source of fluid or air pressure (not shown).

The construction and operation of such fluid jets are well known in the prior art. The jet used in this apparatus may be of the type disclosed in U.S. Patent 2,994,438 but is preferably of the type disclosed in my copending application, Ser. No. 407,758, originally filed Oct. 30, 1964, now U.S. Patent 3,381,346.

A pair of double diameter, coaxial yarn feed and take-up rollers **23** and **24** are secured to rotating shafts **25** and **26**, respectively, which shafts **25** and **26** are journaled for rotation on parallel axes in the housing **14** by suitable bearings **27** and **28**, schematically shown in FIG. 5.

As shown in phantom in FIG. 6, a suitable drive mechanism such as an electric motor M is connected by a belt **29** to a pulley **30** which is secured to the shaft **25**. A second belt **31** extends around a second pulley (not shown) secured to the shaft **25** and around a pulley **32** secured to the shaft **26**. Clockwise rotation of the motor, in the direction shown by the arrow in FIG. 6 will turn both the yarn feed and take-up rollers **23** and **24** in the same clockwise direction.

As will be subsequently explained, it is important that the peripheral or surface speed of each of the rollers **23** and **24** be identical at corresponding points on their surfaces. If the rollers **23** and **24** are of the same size, the pulleys connecting the drive belts **29** and **31** should also be of the same size. If the rollers **23** and **24** are of a different size, the size of their corresponding pulleys should be adjusted so that the surface or peripheral speed of the rollers **23** and **24** is the same for corresponding points on their outer diameters.

Assuming that each of the rollers **25** and **26** have identical dimensions in this preferred embodiment, each of these rollers includes a first cylindrical section **33** having a diameter D and a second coaxially secured cylindrical section **34** having a diameter d which is smaller than the diameter D. When the cylindrical sections **33** of D diameter are used to feed yarn to the jet **18** and the cylindrical sections **34** of d diameter are used to withdraw the textured yarn from the jet **18**, it will be seen that, because the cylindrical sections **33** and **34** are coaxial and are turned at the same angular speed, the peripheral speed of the sections **33**, due to the larger diameter, will cause the yarn to be fed to the jet **18** at a linear speed in excess of the speed with which the bulk yarn is withdrawn from the jet **18** by the sections **34**. Thus this amount of "overfeed" is determined by the ratio of the diameters, D/d. In the preferred embodiment, this ratio is such that the amount of overfeed is 10%, or D/d equals 1.10.

The positioning of the inlet orifice **19** and outlet orifice **20** of the jet **18** in relation to the external yarn bearing surfaces of the cylindrical sections **33** and **34** of the rollers **23** and **24** is important to assure that the apparatus is capable of feeding and withdrawing yarn to and from the jet **18** at high speed. As best seen in FIGS. 4 and 5, the axial passage **21**, which connects the inlet and outlet orifices **19** and **20** and is hereinafter referred to as the axis of the jet **18**, lies in a plane which is tangential to the outer or yarn bearing surface of the larger cylindrical section **33** of the roller **23**. As further seen in these figures, a line passing through the outlet orifice **20** and normal to the axis of the jet is tangential to the outer surface of the smaller cylindrical section **34** of the roller **24**. It has been determined that effective high speed yarn texturing can be best accomplished by removing the yarn immediately after it leaves the jet, at a right angle from the axis of the jet. It has further been determined that the preferred direction of entry of yarn being fed to the inlet orifice **19** of the jet **18** is in a direction which is only slightly displaced from the axis of the jet **18**.

Referring to FIG. 5, it will be seen that the jet **20** and its axis, as shown, is slightly titled or cocked from the vertical. This angular placement of the jet accomplishes three things. First, it places the inlet orifice **19** of the jet in a plane normal to the rotational axes of the rollers **23** and **24** and passing through the midpoint of the yarn bearing surface of the cylindrical section **33** of the roller **23** so that yarn supported on this surface at its middle is directed downwardly directly into the jet orifice **19**. Secondly, it places the outlet orifice **20** of the jet **18** in a plane normal to the rotational axes of the rollers **23** and **24** and passing through the midpoint of the yarn bearing surface of the smaller cylindrical section **34** of the roller **24** so that yarn being drawn from the jet will pass from the outlet orifice **20** directly to the midpoint of the outer surface on the cylindrical section **34** of the roller **24**. Thirdly, it places the axis of the jet **18** at an angle to the direction of yarn entering the jet **18** through the inlet orifice **19** to remove this entering yarn from the "blow-back" from the jets. As previously stated, it is desirable to avoid feeding the untextured yarn directly into the small amount of air which is blown back through the yarn inlet orifice **19** when producing the bulky yarns of this invention due to the fact that the blow-back apparently causes a small amount of yarn opening or fluffing prior to striking the principal zone of turbulence within the jet. The angle between the jet axis and the direction of the entering yarn, a, as shown in FIG. 5, is preferably about 10° which is sufficient to avoid the jet blow-back and yet permit the yarn to be fed into the interior of the jet **18** without striking, at a large angle, the edges of the inlet orifice **19** or other portions in the throat of the jet **18**.

With the yarn feed and take-up rollers **23** and **24** and the jet positioned by the housing **14** as described, yarn from the yarn supply **16** is directed through a yarn guide or pigtail **35** upwardly, thence around and between the outer surfaces of the larger cylindrical sections **33** of each of the rollers **23** and **24**. As used in this specification and appended claims, the expression "around and between" the yarn feed and take-up rollers **23** and **24** defines the path of the yarn shown in FIG. 4 in which the yarn is led around the remote outer surface of one of the rollers thence directly to the other roller, thence around its remote outer surface and back, without directly encircling either of the individual rollers **23** or **24**. The untextured yarn is directed around and between the outer surfaces of the cylindrical sections **33** a number of times sufficient to provide enough engagement with these surfaces to prevent slippage as the yarn is being withdrawn from the yarn supply **16** when the rollers are driven at high speed.

The yarn is directed from the surface of the section 33 of the roller 23 downwardly to the inlet orifice 19 of the jet 18, through the jet 18 and then from the outlet orifice 20 directly to the outer surface of the cylindrical section 35 of the roller 24. The yarn is then directed around and between the cylindrical sections 34 of both rollers 23 and 24 for a sufficient number of turns to insure against slipping as the yarn is withdrawn from the jet when the rollers 23 and 24 are driven at high speed. In practice, it has been determined that approximately 4–6 turns around and between each of the pairs of cylindrical sections 33 and 34 is sufficient to insure against slipping.

From the surface of the cylindrical section 34 of the roller 23 the textured yarn is led downwardly to a yarn guide or roller 36 which is rotatably secured upon the free end of a pivoted tension sensing arm 37 which is a part of the constant tension winder mechanism 15.

Constant tension winders such as those commercially available from a number of manufacturers include a tension sensing mechanism, such as a tension arm 37, which, through electrical or electrical-mechanical controls will vary the winding speed of the yarn package on its mandrel in accordance with variations in the tension of the yarn being wound. The textured yarn, after being led around the roller 36, is taken directly to a yarn package 38, wound on a mandrel 39 of the constant tension winder which includes a traverse mechanism 40. As seen in FIG. 4, the yarn leaving or passing by the roller 36 is contacted by the lowermost portion of a liquid size applicator 17.

The application of size to the bulked yarn after it leaves the jet 18 is desirable in certain instances to partially assist in holding the bulked waves 11 in place and further lock the filaments in their relation to one another. It is also desirable in assuring a uniform package buildup on the mandrel 39 and prevents "drafting" or flattening of the bulked yarn. Suitable liquid sizing may be starch, hot melt or solvent type coatings presently commercially available from a number of sources.

In lieu of the application of an appropriate size to the bulked yarn leaving the jet 18, as described above, the bulked yarns may be heat set or thermally relaxed by passing them through a zone of heat sufficient to fix them in their bulked or undulatory configurations. In the case of fibrous glass yarns, an elongate muffle furnace or open flame having a sufficiently high temperature to set the individual filaments may be used. This, of course, must be done prior to applying an appropriate size which may be added after the heat setting.

While the apparatus and method of this invention as heretofore described has most advantageous use in the texturing of glass yarns, they can also be used advantageously in the texturing of nylon, rayon, polyester or other organic or inorganic yarns. Additionally, composite yarns made up of continuous glass fibers and other fibers such as resin fibers of polyethylene, tetrafluoroethylene or a polyamide can also be texturized by the present technique and then heat set. In this regard the resin fibers can be selectively heat set to lock in the textured condition of the glass fibers with the glass uneffected by the heat. The resin fibers can also be heated to a plastic condition to effect cohesion of the resin fibers to the glass fibers.

Through the use of at least two yarn feed and take-up rollers 23 and 24 which are driven in synchronism, i.e., so that corresponding points on their yarn bearing surfaces of their cylindrical sections 33 and 34 have the same peripheral speed, it is possible to insure a constant amount of overfeed of the yarn into the jet in relation to the yarn withdrawn therefrom due to the difference in the diameters D and *d*. Also through the use of at least two rollers, it is possible to position the jet 18 with respect to the yarn bearing surfaces of each of the rollers so that yarn is fed to the jet in a direction lying within a plane passing through the axis of the jet but displaced by the angle *a* from the axis of the jet to avoid blow-back. It is further possible to withdraw the yarn from the jet orifice 20 in a direction normal to the axis of the jet. It is obvious that such an arrangement could not be accomplished with a single double diameter roller because the jet 18 could not be positioned to maintain these relationships.

The principle of using at least two driven feed rollers can be effectively utilized in a system in which separate yarn sources are combined in a fluid jet to produce a composite bulky product. In a process which combines two separate yarn sources, such as is disclosed in U.S. Patent 2,869,967, one source of untextured yarn is overfed to the jet at a first rate while a second source is overfed to the jet at a second rate which is faster than the first overfeed rate. The first and second yarns, which may be designated as "core" and "effect" yarns, are combined within the jet so that the core yarns maintain generally untextured and linear configurations while the effect yarns, which are overfed at a great rate, form the surface convolutions which give bulk to the composite product. In combining core and effect yarns at high speed, the difficulty of avoiding the blow-back from the jet inlet orifice and in positioning the take-up roller to withdraw the combined yarn from the jet outlet orifice at the right angle to the axis of the jet is also important. Accordingly, the concept of using at least two combined feed and take-up rollers of this invention can be used in an apparatus designed to combine core and effect yarns into a single bulked yarn. In such an apparatus, each of the feed and take-up rollers would include three coaxial cylindrical sections of different diameter. The first feed section for the effect yarn would have the greatest diameter, the second feed section for the core yarn would have an intermediate size diameter and the third section for the take-up of the composite yarn would have the smallest diameter. Such an arrangement would fix the two separate overfeed ratios due to the diameter differences. Similarly, a jet could be positioned in relation to the feed and take-up surface so that the yarn is withdrawn from the outlet orifice at an angle normal to the axis of the jet and so that the entering yarn from each of the core and effect feed roll surfaces is directed to the jet in a direction slightly displaced from the axis of the jet.

The apparatus shown in FIGS. 4 through 6 is capable of obtaining higher speeds in feeding and withdrawing yarn to and from a fluid jet at a fixed rate of overfeed than have heretofore been obtainable with other prior art drive and take-up mechanisms. In addition to the advantages of economy through fast production, the apparatus described, due to its ability to feed yarn through the area of fluid turbulence within the jet at such high speed, produces a different texturing action which results in the novel product characterized by the absence of broken filaments, the absence of crunodal loops, and the presence of undulatory waves comprised of selected ones of the filaments in the core area which return to the core area on either side of each wave and remain bound in place by relatively dense compaction of the core area which remains intact throughout the process.

As previously stated, fabrics, woven or unwoven, comprised of the improved bulked yarn of this invention are characterized by the appearance and texture of cotton, silk or woolen fabric. Because of the lofty or open nature of these yarns, fabrics composed of it also have superior wetting or impregnation characteristics when used as reinforcing in fiber-reinforced plastics. Resin laminates made of a plurality of resin impregnated fabric layers have better lamination strength due to thorough penetration or impregnation of the resin into the individual yarns of the fabric and due to the lateral extension of the lofted fibers toward the interfaces of the lamination or adjacent layers of fabric.

I claim:

1. A method of producing a bulky textile product comprising the steps of:

feeding a strand of densely grouped, generally parallel filaments into a zone of fluid turbulence at a speed greater than the speed at which such strand is withdrawn from said zone,

supplying fluid under sufficient pressure to said zone to create turbulent energy sufficient to separate groups of filaments of said strand, the speed of said strand through said zone being sufficiently high that only a portion of the filaments are separated from the strand as groups having wave-like arches in succesive increments of such strand but insufficient to break such groups or to distort such groups into closed loops, with other portions of said strand filaments remaining together in a densely grouped core, and

withdrawing such bulky product from said zone under a constant tension insufficient to remove such wave-like arches of said groups.

2. The method of claim **1** wherein said continuous filament yarn is removed from said turbulent zone at a linear speed greater than 2,000 feet per minute.

3. The method of claim **1** wherein such fluid is supplied to said zoone at a pressure greater than 60 pounds per square inch.

4. The method of claim **1** wherein such fluid supplied under pressure is air.

5. The method of claim **1** wherein such fluid is supplied at said zone at 60–80 pounds per square inch and said yarn is withdrawn from said enclosed zone at a linear speed between 2,000 and 3,000 feet per minute.

6. A method of bulking a strand of densely grouped, generally parallel filaments all extending lengthwise of the strand which comprises:

passing said strand lengthwise through a filament agitation zone provided by fluid turbulence created by an enclosed fluid jet, supplying fluid under pressure greater than 60 p.s.i.g., at a linear speed exceeding 2,000 feet per minute, to separate a number of filaments from said strand, the rate of travel through said zone being sufficient to permit the transfer of energy to the filaments in said zone for separation of said filaments and formation of such separated filaments into undulating waves extending laterally from the remainder of said strand successively along its length with said remainder retaining its densely grouped configuration, with said rate of travel not permitting the formation of closed loops in such separated filaments.

References Cited

UNITED STATES PATENTS

2,783,609	3/1957	Breen	57—140
2,852,906	9/1958	Breen	57—34
2,874,443	2/1959	Griset	28—1
2,884,756	5/1959	Head	57—34
2,958,112	11/1960	Hall	28—1
2,959,909	11/1960	Suhterland et al.	57—140
2,982,082	5/1961	Pool	57—34
3,053,038	9/1962	Weiss et al.	57—34
3,084,413	4/1963	Hallden	28—1
3,110,151	11/1963	Bunting et al.	57—157

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28—1; 57—34, 140, 157