Jan. 6, 1970 G. E. BENSON 3,488,670

METHOD AND APPARATUS FOR YARN TREATMENT

Original Filed May 8, 1966 3 Sheets-Sheet 1

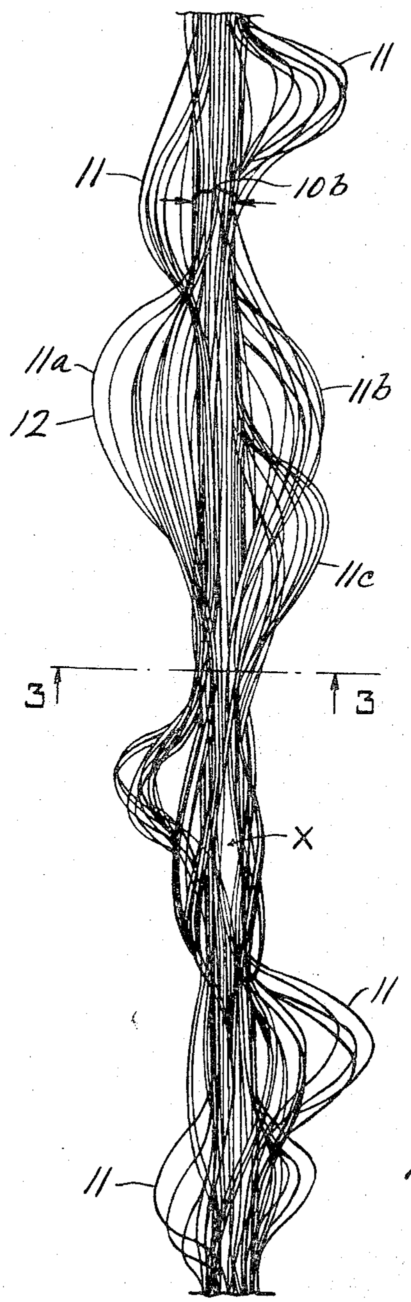

FIG-2-

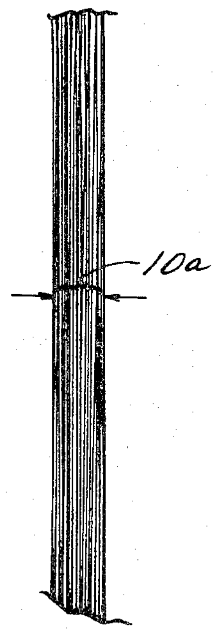

FIG-1-

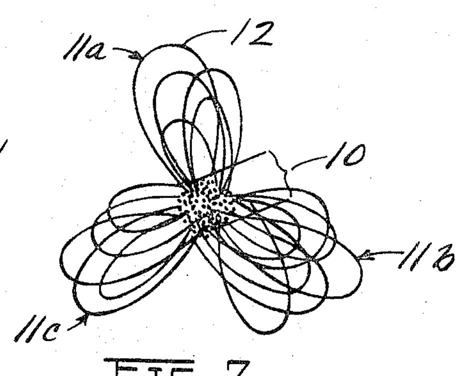

FIG-3-

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METHOD AND APPARATUS FOR YARN TREATMENT

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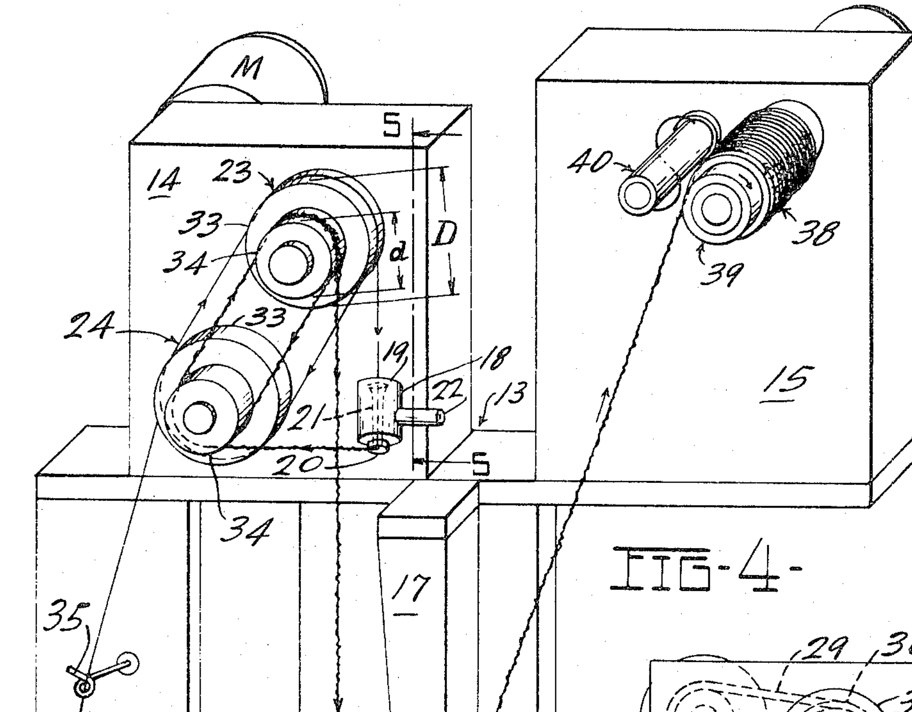

FIG-4-

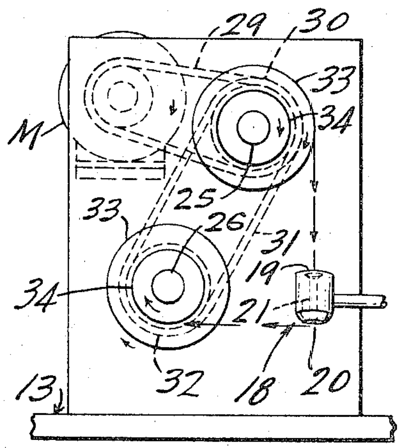

FIG-6-

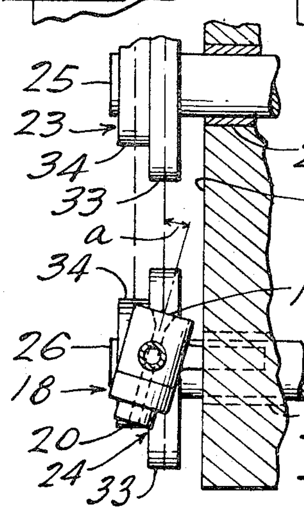

FIG-5-

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METHOD AND APPARATUS FOR YARN TREATMENT

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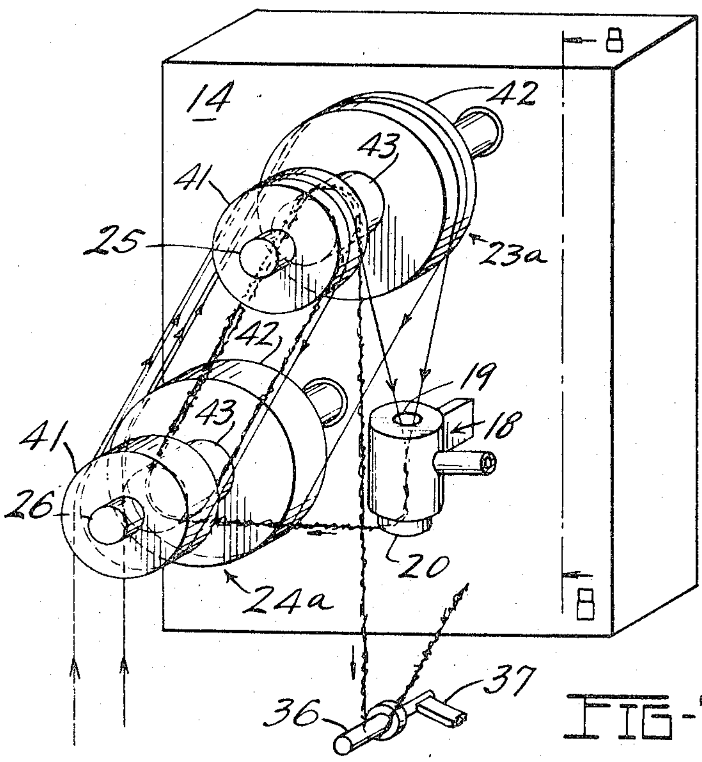

FIG-7-

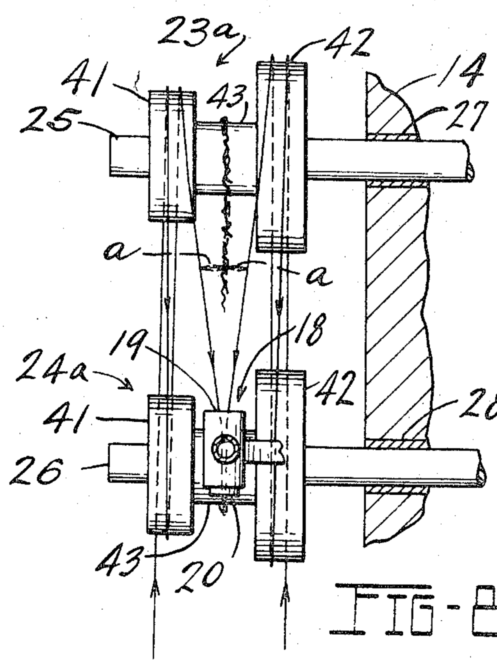

FIG-8-

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3,488,670

METHOD AND APPARATUS FOR YARN TREATMENT

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Original application May 8, 1966, Ser. No. 551,091, now Patent No. 3,411,287, dated Nov. 19, 1968. Divided and this application Apr. 16, 1968, Ser. No. 721,783
Int. Cl. D02g 3/24, 1/16
U.S. Cl. 28—1 14 Claims

ABSTRACT OF THE DISCLOSURE

A method and apparatus for producing a bulky linear textile product of continuous filaments having a core portion of substantially linear, closely grouped filaments and groups of dispersed filaments in successive regions along the outside surface of the core portion extending outwardly in elongated undulatory waves. The undulatory waves have substantially less filament density than the core portion and have a height substantially greater than the diameter of the core portion. The filaments forming the waves return to the core portion on each side of the wave and remain in the core portion with other filaments from the core portion forming the next adjacent wave. Selected filaments within the waves have different lengths so that the waves are comprised of filaments spaced at various distances from the core and spaced from one another within the wave. The product is further characterized by the absence of closed or crunodal loops and by the undulatory or sinusoidal shape of the waves whose forward and reverse slopes are substantially equal.

The apparatus for producing the bulky yarn includes a fluid bulking jet and a pair of identical multiple diameter rollers driven at a uniform speed to feed unbulked yarn to the jet and to take up bulked yarn from the jet. The jet is positioned with respect to the rollers such that (1) yarn leaving the yarn-bearing feed surface of a large diameter on one roller will enter the jet at a slight angle to the inlet-outlet yarn path through the jet, and (2) that yarn leaving the jet will be directed at substantially a right angle from the jet axis to the yarn-bearing take-up surface of a small diameter on one roller. Through the use of a pair of identical multiple diameter rollers, these dimensional relationships are made possible and a constant ratio between the feed and take-up speed will be maintained.

This is a division of my copending application Ser. No. 551,091, filed May 8, 1966, now U.S. Patent 3,411,287.

This invention relates to a method of apparatus for producing a novel yarn by passing untreated yarn at high speed through an area of fluid turbulence. 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 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 of staple 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.

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 fluid 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 uniform and substantial degree of bulkiness and, at the same time, 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 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 3000 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 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.

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 substantially 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 inlet 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.

It is an object of this invention to provide an apparatus and method for making 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 another object of this invention to provide a method and apparatus for producing 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 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 another object of this invention to provide an improved apparatus for texturing or bulking yarn 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 a 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.

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 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 produced by the apparatus and methods 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 prespective 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;

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

FIG. 7 is a schematic view in perspective, similar to a portion of FIG. 4, and showing another embodiment of the invention which includes a pair of multiple diameter driven rollers for use in treating two separate yarn sources in accordance with this invention; and

FIG. 8 is a cross-sectional view taken along line **8–8** of FIG. 7 showing in detail the alignment of the various components in the embodiment of FIG. 7.

Referring to FIG. 1, the improved bulky yarn made by the apparatus and method 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 in a yarn having a uniform average diameter, indicated by reference numeral **10*a***.

As seen in FIG. 2, the novel product 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 wave **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 wave 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 wave 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 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 **10*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 "*s*" twist was run through a fluid jet, of the type described in my copending application Ser. No. 407,758 filed Oct. 30, 1964, 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.

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 generally 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, filed Oct. 30, 1964.

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 **23** and **24** 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.

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 tilted 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 **18** positioned by the housing **14** as described, yarn from the yarn supply **16** is directed through a yarn guide of 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 **34** 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** are 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 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 build-up 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 appropirate 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 appropirate size which may be added after the heat setting.

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 unaffected 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, such as that illustrated in FIGS. 7 and 8. In these figures, like reference numerals designate like parts. Each of the feed and take-up rollers **23***a* and **24***a* would include three coaxial cylindrical sections **41–43** of different diameter. The first feed section **42** for the effect yarn would have the greatest diameter, the second feed section **41** for the core yarn would have an intermediate size diameter, and the third section **43** 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 **18** could be positioned in relation to the feed and take-up surface so that the yarn is withdrawn from the outlet orifice **20** 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 apparatuses shown in FIGS. 4 through 8 are 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 apparatuses described, due to their 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.

It will be apparent that various changes and modifications can be made in the specific details of the embodiments described above without departing from the scope and spirit of the attached claims.

I claim:

1. An apparatus for bulking yarn at high speed by passing such yarn through an area of fluid turbulence, said apparatus comprising, in combination, a yarn supply, a plurality of driven yarn feed and take-up rollers, each of said rollers having at least two yarn supporting surfaces of different diameter, drive means for rotating said rollers in synchronism, a fluid jet having a yarn inlet and a yarn outlet connected by a passage therethrough, means positioning said rollers in relation to said jet such that the axis of said jet passage is in a plane substantially tangential to the surface of larger diameter of one of said rollers and such that a line passing through said yarn outlet normal to said axis is substantially tangential to the surface of smaller diameter on another of said rollers, whereby, when yarn from said yarn supply is wound around and between the surfaces of larger diameter on said rollers, thence through said jet, thence wound around and between the surfaces of smaller diameter on said rollers and said rollers are driven at high speed in synchronism, said yarn will be unwound from the surface of larger diameter of one of said rollers and fed to said fluid jet in a path substantially parallel to said plane and will be taken from said jet in a direction substantially normal to said axis and whereby the amount of yarn fed to said jet will be greater than that withdrawn therefrom in proportion to the diameters of said yarn surfaces on each of said rollers.

2. An apparatus for bulking yarn at high speed by passing such yarn through an area of fluid turbulence, said apparatus comprising, in combination, a yarn supply, a plurality of driven yarn feed and take-up rollers, each of said rollers having at least two yarn supporting surfaces of different diameter, drive means for rotating said rollers in synchronism, a fluid jet having a yarn inlet and a yarn outlet connected by an axial passage therethrough, means positioning said rollers in relation to said jet such that the axis of said jet passage is in a plane tangential to the surface of larger diameter of one of said rollers and such that a line passing through said yarn outlet normal to said axis is tangential to the surface of smaller diameter on another of said rollers, and a constant tension take-up device whereby, when yarn from said yarn supply is wound around an between the surfaces of larger diameter on said rollers, thence through said jet, thence wound around and between the surfaces of smaller diameter on said rollers and thence fed to said take-up device and said rollers are driven at high speed in synchronism, said yarn will be unwound from the surface of larger diameter of one of said rollers and fed to said fluid jet in a path in said plane, will be taken from said jet in a direction normal to said axis and thence fed to said take-up device and whereby the amount of yarn fed to said jet will be greater than that withdrawn therefrom in proportion to the diameters of said yarn surfaces on each of said rollers.

3. The apparatus of claim **2** which further includes a liquid size applicator interposed between said take-up device and said rollers whereby yarn fed to said take-up device passes in contact with said applicator for the application of liquid size thereto.

4. The apparatus of claim **2** in which said yarn feed and take-up rollers are of equal dimension and in which each roller includes a first cylindrical section and a second cylindrical section of smaller diameter coaxially secured to said first section and in which said rollers are positioned in relation to said fluid jet such that the second sections of said rollers and the outlet orifice of said jet are in first common plane normal to the axis of said rollers and such that the first sections of said rollers and said inlet orifices are in a second common plane normal to the axis of said rollers.

5. The apparatus of claim **4** wherein said axis of said jet intersects said first and second planes at an angle of about 10°.

6. The apparatus of claim **2** wherein each of said yarn feed and take-up rollers are of equal dimension and in which each roller includes a first cylindrical section of a relatively large diameter, a second cylindrical section of a smaller diameter, and a third cylindrical section of a yet smaller diameter intermediate said first and second sections with each of said sections coaxially secured to one another, and wherein said rollers are positioned in fixed relation to said fluid jet such that the first sections of said rollers are in a first common plane normal to the axis of said rollers, the second sections of said rollers are in a second common plane normal to the axis of said rollers and said third sections and said jet axis are in a third common vertical plane intermediate said first and second planes and normal to the axis of said rollers.

7. An apparatus for bulking yarn at high speed by passing such yarn through an area of fluid turbulence, said apparatus comprising, in combination, a yarn supply, a pair of yarn rollers mounted for rotation on spaced apart, parallel axes, each of said rollers including a first cylindrical yarn feeding section and a second cylindrical yarn withdrawing section coaxially secured thereto and having a smaller diameter than said first cylindrical section, a fluid jet having a yarn inlet and a yarn outlet connected by an axial passage therethrough, means for rotating said rollers at the same peripheral speed, means for positioning said rollers and said jet in relation to one another such that the outer surface of the yarn feeding section of one of said rollers and the axis of said jet are in a first common plane parallel to the axes of rotation of said rollers and such that the outer surface of the yarn take-up section of the other of said rollers and the yarn outlet of said jet is in a second common plane parallel to the axes of rotation of said rollers with said first and second common planes being substantially normal to one another, whereby when yarn from said yarn supply is wound around and between the yarn feeding sections of said rollers, thence through said jet, thence around and between the yarn withdrawing sections of said rollers and thence to a take-up device and said rollers are rotated at high speed, such yarn will be unwound from the yarn feeding section of said rollers and fed to said fluid jet in said first common plane and will be withdrawn from said jet and wound upon the yarn take-up section of said rollers in said second common plane and thence fed to said take-up device and whereby the amount of yarn fed to said jet will be greater than that withdrawn therefrom in proportion to the diameters of the yarn feeding and yarn withdrawing sections of said rollers.

8. A method of bulking yarn at high speed by passing such yarn through an area of fluid turbulence within a fluid jet having a yarn inlet and yarn outlet connected by an axial passage therethrough, said method comprising the steps of winding such yarn around the outer surface of at least one yarn feed roller, feeding such yarn to said yarn inlet of such jet in a path which lies in a plane extending through the axis of said jet and which is tangential to said outer surface of said feed roller, thence winding such yarn around the outer surface of at least one yarn take-up roller such that said yarn extends directly from said yarn outlet of said jet to said take-up roller outer surface in a direction normal to said jet axis and in a plane tangential to said outer surface of said take-up roller, and driving said feed and take-up rollers at a peripheral speed such that yarn is fed to said jet in said plane at a speed greater than yarn is withdrawn from said jet along such normal direction.

9. The method of claim **8** wherein such yarn is fed to said yarn inlet of said jet along a path which is at an angle to said jet axis, measured within said plane, just sufficient to avoid fluid blow-back from said yarn inlet orifice of said jet.

10. The method of claim **9** wherein said yarn is withdrawn from said jet and wound onto said take-up roller at a speed in excess of 2000 feet per minute.

11. The method of claim **9** which further includes the steps of removing said yarn from said take-up roller and thence directing it to a constant tension winder device whereby a yarn package of uniform tightness is formed thereon.

12. A method of bulking a bundle of continuous filaments by passing said bundle through a zone of fluid turbulence within a fluid jet having an inlet and outlet connected by an axial passage therethrough, said method comprising the steps of passing said bundle around the outer surface of at least one feed roller, feeding said bundle to said inlet of said jet in a path along the axis of said jet and tangential to said outer surface of said feed roll, thence winding bundle around the outer surface of at least one take-up roller such that said bundle extends from the outlet of said jet to the outer surface of said take-up roller in a direction normal to said jet axis, and driving said feed and take-up rolls at a peripheral speed such that said bundle is fed to said jet in said plane at a fixed proportional speed greater than said bundle is withdrawn from said jet.

13. The method of claim **12** wherein said bundle is withdrawn from said jet at a speed in excess of 2000 feet per minute.

14. The method of claim **12** which further includes the steps of collecting said bundle from said take-up roller under constant tension to limit the possibility of imparting nonuniformities to the already bulked product.

References Cited

UNITED STATES PATENTS

2,799,598	7/1957	Biefeld et al.	28—75 X
2,852,906	9/1958	Breen	28—1.4 X
2,874,445	2/1959	Griset	28—1.4
2,884,756	5/1959	Head	57—34
2,958,112	11/1960	Hall	28—1.4
2,959,909	11/1960	Sutherland et al.	57—140
2,982,082	5/1961	Pool	28—1.4 X
3,127,729	4/1964	Head	28—1.4 X
3,178,795	4/1965	Warthen	28—1.3 X
3,299,485	1/1967	Hills et al.	28—75
3,380,242	4/1968	Richmond et al.	28—1.4 X

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28—72; 57—34, 157