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[54] METHOD FOR PRODUCING BULKY YARN

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[52] **U.S. Cl.** **28/72.14,** 28/72.12
[51] **Int. Cl.** **D02g 1/12**
[58] **Field of Search** .... 28/72.12, 72.14, 1 SM

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[57] **ABSTRACT**

Polypropylene multifilament yarn is continuously jetted from a jet nozzle toward a stuffing member composed of numerous stuffing elements together with super heated steam from the jet nozzle during the relative displacement of the jet nozzle to the stuffing member. The stuffing member is provided with cubical spaces for retaining the multifilament yarn. The multifilament yarn is fixed its deformation by the plastifying action of the super heated steam while being retained in the cubical spaces of the stuffing member, and next the multifilament yarn having crimps is stripped from the stuffing member. The abovementioned process can be performed as a part of a continuous process composed of drawing and crimping, or of melt spinning, and drawing and crimping. Several types of stuffing members including a cylindrical stuffing member covered by numerous needles or honey-comb like elements, a pair of endless-belt type stuffing members, and a cage type are disclosed.

6 Claims, 11 Drawing Figures

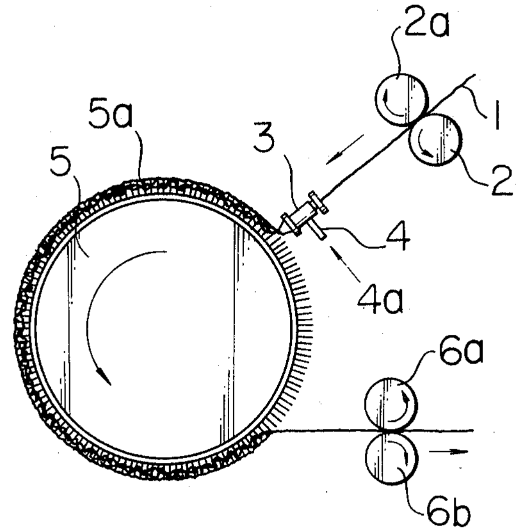


Fig. 1

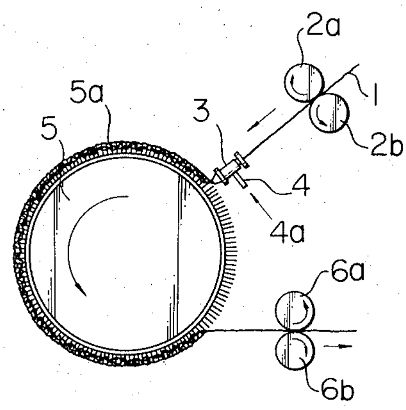


Fig. 2

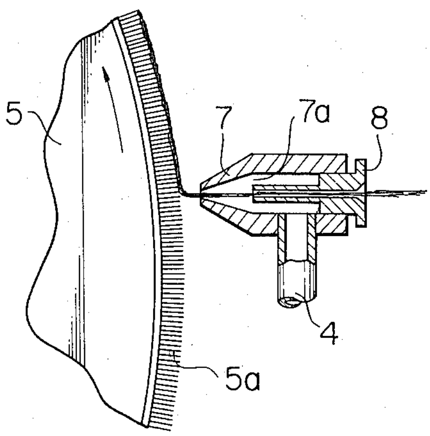


Fig. 3

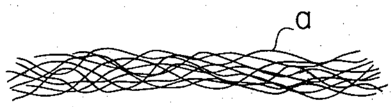


Fig. 4

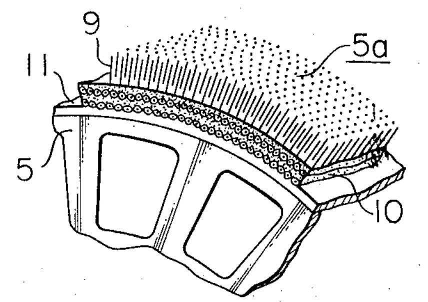


Fig. 5

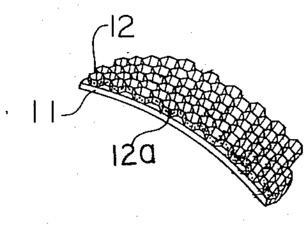


Fig. 6

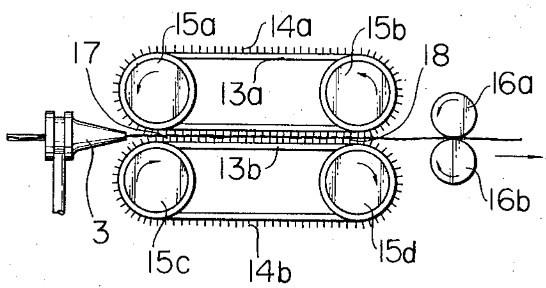


Fig. 7

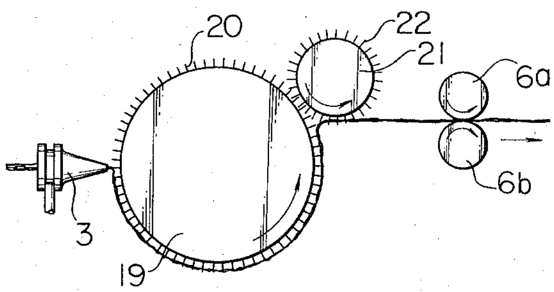


Fig. 8

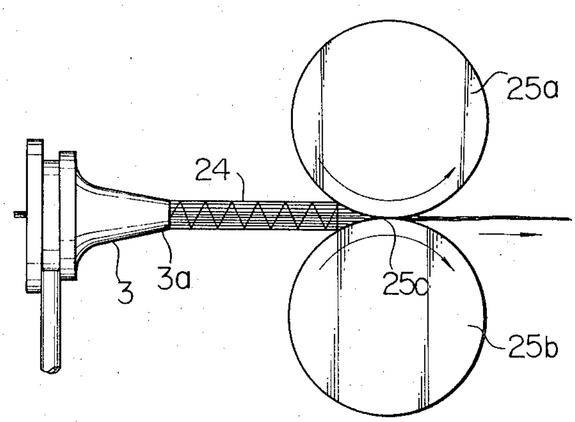
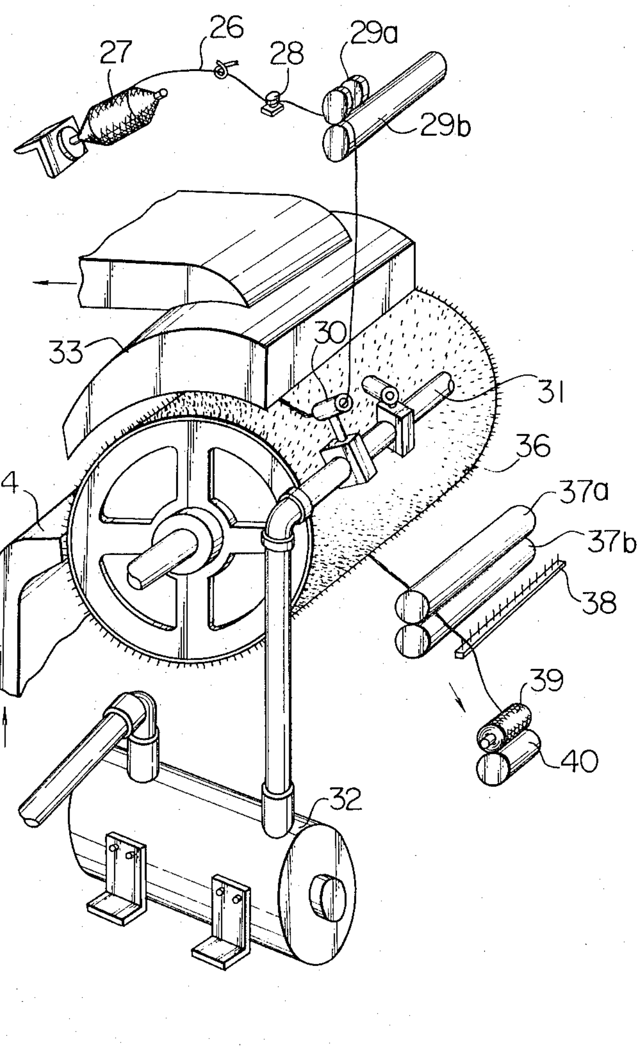


Fig. 9



INVENTOR

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ATTORNEY

Fig. 10

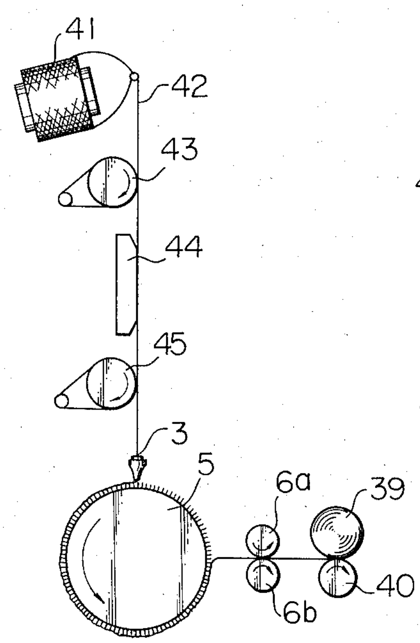
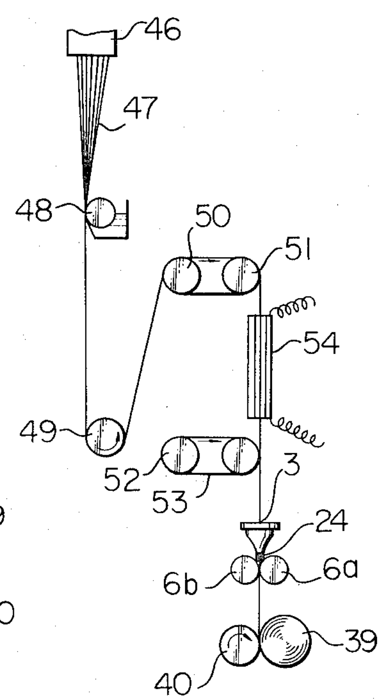


Fig. 11



INVENTOR

BY

ATTORNEY

METHOD FOR PRODUCING BULKY YARN

This invention relates to a method for producing bulky yarn composed of crimped polypropylene filaments, and to a novel apparatus for carrying out this process.

In general, polypropylene fiber is provided with higher crystallinity than other synthetic fibers such as, polyamide fiber and certain radicals such as, thermally active radicals or chemically active radicals and consequently, it is difficult to produce a bulky polypropylene yarn having stable crimps where the conventional method of texturing synthetic yarn is applied.

It is well-known that a superior set of synthetic fiber can be obtained by crimping of the fiber by heat in a wet condition in comparison with the conventional methods utilizing dry heat.

Consequently, in the present invention, polypropylene filaments having a preferably high setability are only considered, and an economical and practical method for treating the material-yarn with a practical speed of processing is disclosed.

The principal object of the present invention is to provide a method and apparatus for producing bulky yarn having remarkable crimp-effects by means of fixing the fibrous structure of polypropylene filaments having low crystalline structure in a condition of high crystalline structure while the polypropylene structure is mechanically crimped simultaneously.

Another object of the present invention is to provide a method and apparatus for producing bulky yarn having frequent interlacing of component filaments and stable crimps arranged in the yarn at random.

Still another object of the present invention is to provide a method and apparatus for producing crimped yarn free from any deformation of the cross-section of the filaments and degradation of filaments by fiber in high temperature, by means of heating the circumference of each individual filament.

A further object of the present invention is to provide an economical and practical method and apparatus for producing bulky yarn.

A still further object of the present invention is to provide a method and apparatus for continuously (simultaneously) operating the drawing process with the crimping process after the melt spinning process.

Other objects and features of the invention will more fully appear from the following description and the accompanying drawings and will be particularly pointed out in the claims.

FIG. 1 is a sectional view of an embodiment of the apparatus of the present invention,

FIG. 2 is an enlarged sectional view of a portion of the nozzle of the yarn feeding and heating device of FIG. 1,

FIG. 3 is a view of a high bulk multifilament yarn which has been made into a bulky configuration composed of crimped filaments according to the present invention,

FIG. 4 is a schematic view of a portion of a cylindrical barrier member of the apparatus shown in FIG. 1,

FIG. 5 is a schematic view of a portion of a modified cylindrical member of the apparatus according to the present invention,

FIGS. 6, 7 and 8 are sectional views of other embodiments of the apparatus of the present invention,

FIG. 9 is a schematic view of the apparatus shown in FIG. 1,

FIG. 10 is a skeleton diagram of a continuous apparatus comprising a drawing device and texturing device in accordance with the present invention, and

FIG. 11 is a skeleton diagram of another continuous apparatus comprising spinning and drawing and texturing devices in accordance with the present invention.

Generally, the method for producing bulky yarn of the present invention comprises stuffing polypropylene multifilament yarn having a fiber density below 0.901, for example, undrawn yarn, yarn produced by draw spinning at a draw ratio in a range between 1.5 and 3.0, or cold-drawn yarn produced by a drawing process at room temperature or a temperature below 90°C, into a stuffing device having numerous hard projections together with a stream of super heated steam, whereby fine irregular crimps are randomly imparted to the individual filaments and the filaments are plastified simultaneously. Therefore, the crimps of the multifilament are completely fixed. To attain the objects of the present invention, polypropylene multifilament yarn having low crystalline structure, in other words having a structure of mainly semeti-crystal, is preferably used. The semeti-crystal of the polypropylene multifilaments is changed to a mono-clinic structure by heat treatment at high temperature in a wet condition so as to fix the crimps in the multifilament yarn. It is required to heat-treat the polypropylene filaments at a sufficiently high temperature in a wet condition for a sufficient time to obtain a stable heat setting of the crimps and convert the molecular structure of the polypropylene filaments. To attain the above-mentioned objects, super-heated steam at high pressure is used for carrying the multifilament yarn to the stuffing means via a jet nozzle, whereby the yarn is positively supplied to the stuffing means.

The stuffing means of the present invention comprises a movable body composed of a stuffing member having a plurality of projections which do not disturb the stuffing of the material into the stuffing member by the stream of super heated steam. Further, as the filaments on the stuffing member are conveyed by the movement of the stuffing member for a predetermined distance and time, a sufficient time for stable setting of the crimps by super heated steam can be utilized. The stuffing of the yarn into the stuffing member is performed by the stream the super heated steam and, therefore, the individual filaments can be deformed in any direction, whereby, random crimps of the filaments can be obtained in any direction while the conventional mechanical stuffing operation provides crimps of filaments in primarily one direction.

In the present invention, the stuffing means is moved during the operation and a certain resistance to the taking up of the yarn from the stuffing means while moving the stuffing member is inevitable. The above-mentioned resistance causes cutting of filaments, making a fuzzy and poor appearance of the product bulky yarn.

To avoid the above-mentioned drawback of the present method, the fineness of the filaments is preferably chosen in a selected range of fineness, that is, the fineness of the individual filaments in a range between 10 denier and 50 denier is preferable so as to attain the objects of the present invention. If the yarn used is composed of individual filaments having a fineness over 50^d, the result of the stuffing operation is not satisfactory since, development of very rough crimps occurs.

A shrinkable composite polypropylene multifilament yarn can also be used to attain the present purpose. In this case, the combined effect of the crimping by the shrinkable property of the yarn with the abovementioned stuffing operation will produce bulky yarn having excellent bulkiness and stretchability.

Referring to FIG. **1**, a polypropylene multifilament yarn **1** is fed by a pair of feed rollers **2**a and **2**b to a jet nozzle **3**, and the yarn **1** is stuffed into a cylindrical stuffing member **5***a* disposed on the circumferential surface of a cylinder **5** together with super heated steam which is supplied to the nozzle **3** by way of a connecting conduit **4** secured to the nozzle **3** as shown by an arrow **4***a*. The jet nozzle **3** is positioned in close proximity to the rotating surface of the stuffing member **5***a* of the cylinder **5**. The circumferential speed of the feed rollers **2***a* and **2***b* is constant. In this embodiment, the cylindrical stuffing member **5***a* is composed of numerous needle-like projections disposed on the circumferential surface of the cylinder **5**. Therefore, there are numerous fine cubical spaces in the stuffing member of the cylinder **5**. The multifilament yarn **1**, caught by the cubical spaces of the stuffing member **5***a*, is carried with the rotation of the cylinder **5** and finally taken up from the stuffing member **5***a* by a pair of delivery rollers **6***a* and **6***b* and wound into a package by a conventional winding means.

The jet nozzle **3** is composed of a main cylindrical body **7** provided with a jet conduit **7***a* and a yarn guide member **8** engaged at its forward end with a rearward portion of the jet conduit **7***a*. The connecting conduit **4** is also connected at its one end with the cylindrical body **7**, as shown in FIG. **2**. The super heated steam is supplied to the jet conduit **7***a* from a supply source via the connecting conduit **4**. The multifilament yarn **1** is sucked into the jet conduit **7***a* by the suction caused by the super heated steam supplied from the jet conduit **7***a* in a high pressure condition, and then blown toward the stuffing member **5***a* of the cylinder **5**, whereby the multifilament yarn **1** comes in contact with the super heated steam while being carried from the yarn guide member **8** to the stuffing member **5***a*. The individual filaments of the yarn **1** are interlaced with each other by the high pressure of the super heated steam and when the yarn **1** is impinged onto the stuffing member **5***a*, the multifilament yarn **1** is stuffed into cubical spaces of the stuffing member **5***a* at random, whereby the desired fine crimps of the filaments are imparted. As the super heated steam blows toward the stuffing member **5***a*, the crimps of the filaments are set.

The shape of the filament crimps obtained by the abovementioned process has a particular configuration composed of numerous interlaced filaments having stable fine crimps developed in random arrangement as shown in FIG. **3**. Further it is noticed that the shape of the crimps is a cubical one. Consequently, the yarn produced by the present method has an excellent bulkiness and soft handle. The bulkiness of the textile cloth, such as a tufted carpet made of the multifilament yarn of the present invention, is so sufficient that a textile cloth having very light weight effectively be produced.

Referring to FIG. **4**, the stuffing member **5***a* comprises a foundation-cloth **10** secured to the cylindrical surface **11** of the cylinder **5** and numerous needles **9** perpendicularly disposed onto the foundation-cloth **10**. The needles **9** are made of stainless steel. Various densities and sizes of the needles **9** can be used in accordance with the requirements for crimp conditioning, that is, when finer crimps are required, a larger density of needles must be applied.

By our experiment, was noticed that a ratio between the height (**1**) of the needles **9** and a distance (p) between the adjacent needles is very important for attaining our purpose and it is preferable to apply the ratio $1/p$ in a range from **3** to **5**. When the ratio $1/p$ is below **3**, the yarn stuffed into the stuffing member **5***a* can possibly escape from the stuffing member **5***a* and when the ratio $1/p$ is over **5**, the yarn is stuffed into the cubical spaces of the stuffing member **5***a* so tightly that the resistance for stripping the yarn from the stuffing member **5***a* becomes large, whereby breakage of the filaments occurs.

The density of the needles in a range between 500/square inch and 900/square inch is desirably used and the height of the needles within a range of 3 mm to 10 mm is preferably applied to attain the purpose of the present invention. Further, the sharper the tip portion of the needles, the smaller is the force necessary for stripping the crimped yarns from the stuffing member and, therefore fuzzy crimps of the yarn can be prevented. It is desirable that the setting angle of the needles to the foundation-cloth is slightly inclined to the foundation-cloth, for example, the angle is 85° to 90°, and consequently, a smooth stuffing and stripping operation can be obtained.

It is also beneficial that the circumferential surface of the stuffing member shown in FIG. **4** be covered by a net-like sheet having a very rough mesh, whereby the combined crimping action by the cubical spaces of the stuffing member **5***a* and the net-like sheet is imparted to the multifilament yarn, and fine multi-dimensional crimps of the yarn can be obtained.

When the above-mentioned net-like sheet is disposed internally of the stuffing member **5***a* with a certain space between the foundation **11**, the reverse flow of the jetted air from the foundation after passing through the net-like sheet is interfered with by the sheet and, therefore, it is necessary to blow the jet stream to the stuffing member **5***a* in a high pressure condition.

Referring to FIG. **5**, another embodiment of the stuffing member is composed of numeral stuffing elements having cubical space of honeycomb like cross-section. The member **12** is made of stainless steel having a very thin thickness in a range between 0.1 and 0.2 mm, and the length of the maximum side of the honeycomb like shape is in a range between 3 and 4 mm. The stuffing action, where the stuffing member shown in FIG. **5** is used, is almost the same as the first embodiment, but the resistance for stripping the crimped yarn from the stuffing member **12** is less than in the stuffing member **5***a* shown in FIG. **4**, and the breakage of filaments can be prevented, whereby, a bulky-yarn of very fine filaments can be obtained by this second embodiment without obstacles.

To increase the production rate of the processing together with the durability of the stuffing member, the jet nozzle **7** is relatively changed in its transversal position to the cylindrical surface of the stuffing member **5***a* at slow speed. It is also useful to transversely displace the stuffing member **5***a* instead of the transversal motion of the jet nozzle **7**. By the abovementioned traverse motion of the jet nozzle **7**, the multifilament yarn is provided with effective crimps.

The production rate of the present method must be substantially considered from a view point of stability of the crimp or in other words, the temperature of the jet stream and the time of the multifilament yarn in the cubical spaces of the stuffing member 5*a* or 12, affects the stability of the crimp. Consequently, it is helpful to raise the temperature of the super heated steam as high as possible to increase the production rate it is also helpful to heat the multifilament yarn before the present treatment to increase the production rate.

It is also possible to increase the production rate by extending the stuffing time of the multifilament yarn in the cubical spaces of the stuffing member 5*a* or 12, because stable setting of the crimps can be obtained in spite of increased rotation speed of the cylinder 5. To attain the above-mentioned effective stuffing result, the diameter of the cylinder 5 must be sufficiently large in order to establish a large circumferential area of the stuffing member 5*a* or the transversal supply of the multifilament yarn from the jet nozzle 3 must be operated at a sufficient frequency of the traverse motion of the nozzle 3 to increase the capacity of the stuffing member 5*a*. By the above-mentioned method, the production rate of the present method can be remarkably increased in comparison with the conventional bulky treatment of multifilament yarn.

The super heated steam maintained at a temperature in a range from 120°C to 185°C is preferably used for the present method.

The relation between the feed speed (V_1) of the multifilament yarn from the jet nozzle 3 and the circumferential speed (V_2) of the stuffing member 5*a* or 12, must be carefully chosen or otherwise the condition of the crimps changes widely. It is preferable to apply the ratio V_1/V_2 in a range from 5 to 15. Further it is desirable to apply the following speed ratios to operate the present process satisfactorily, that is, $V_1/V_3 = 1.1 \sim 1.5$, $V_3/V_4 = 1.0 \sim 1.2$, where V_3 designates the delivery speed of the crimped yarn from the rotating stuffing member, V_4 designates the winding speed of the crimped yarn delivered from the delivery rollers 6*a* and 6*b*.

In FIG. 6, a modified embodiment of the present invention is shown. The stuffing member comprises a pair of endless needle clothings 14*a* and 14*b* which are secured to endless belts 13*a* and 13*b*, respectively in such a way that the needle clothings 14*a* and 14*b* face each other with a slightly engaging condition as shown in FIG. 6. The endless belts 13*a* and 13*b* are belted on pairs of rollers 15*a* and 15*b*, 15*c* and 15*d*, respectively. The rollers 15*a*, 15*b*, 15*c* and 15*d* rotate in the direction shown by the arrows. A jet nozzle 3 having the same construction is disposed at a position closely adjacent to a starting position 17 facing both needle clothings 14*a* and 14*b*. A pair of delivery rollers 16*a* and 16*b* are disposed to a position behind the leaving position 18 of both needle clothings 14*a* and 14*b*. The needle clothings 14*a* and 14*b* are provided with numerous needles perpendicularly secured to their foundation, respectively. The distance between the positions 17 and 18 and the engaging condition of the needle clothings 14*a* and 14*b* must be chosen carefully, because the needle clothings 14*a* and 14*b* at the slightly engaging condition form numerous cubical spaces while moving along the line between the positions 17 and 18. A multifilament yarn supplied to the component stuffing member by a super heated steam jet from the jet nozzle 3 and stuffed into the cubical spaces formed by the needle clothings 14*a* and 14*b* is carried to the position 18. At the position 18, the needle clothings 14*a* and 14*b* disengage and the multifilament yarn carried by the cubical spaces is freed from the needle clothings 14*a* and 14*b* without obstacles, such as sticking to the needles. While being carried by the cubical spaces of the needle-clothings 14*a* and 14*b*, three-dimensional crimps are imparted to the multifilament yarn and the crimped yarn is delivered by the delivery rollers 16*a* and 16*b*. It was noticed that the preferable engaging length of the needles is 20 to 30 percent in comparison with the height of the needles.

As mentioned above, the multifilament yarn fed by the jet nozzle 3 to the stuffing member is sufficiently stuffed into the cubical spaces formed by the engagement of the needle-clothings 14*a* and 14*b* via the superheated steam and the individual filaments of the yarn stuffed into the cubical spaces of the stuffing member are subjected to heat treatment by the super heated steam blown from the jet nozzle 3 while being stuffed into the cubical spaces of the stuffing members, whereby fine and stable crimps of the filaments are produced. Further, needle clothings 14*a* and 14*b* disengage at the position 18, whereby the crimped multifilament yarn is smoothly stripped from the cubical stuffing spaces with very low tension.

Referring to FIG. 7, another embodiment of the stuffing member comprises a pair of cylindrical stuffing components, a main stuffing member 20 and a small stuffing member 22 disposed in a slight engaging condition. The main stuffing member 20 is composed of a cylindrical needle-clothing secured to the cylindrical surface of a cylinder 19 continuously rotating in a direction shown by the arrow, while the small stuffing member 22 is also composed of cylindrical needle-clothing secured to the cylindrical surface of a small cylinder 21 continuously rotating in a direction shown by the arrow. It is preferable to apply, for example, coarse needle-density to the stuffing member having small diameter in comparison with the main stuffing member and to apply a faster circumferential speed to the component stuffing member having smaller diameter, for example, 20 percent faster than the circumferential speed of the stuffing member having larger diameter. The engagement of the needles of the component stuffing cylinders is preferably arranged in such a condition that the engaging length of the needles is in a range between 30 percent to 50 percent of the height of the needles. The jet nozzle 3 having the same structure as shown in FIG. 1 is closely disposed to the main stuffing member 20 as shown in FIG. 7. The crimping action of this embodiment is operated in same manner as the first embodiment except for the second stuffing member 22, which takes off the crimped multifilament yarn from the main stuffing member very smoothly.

Referring to FIG. 8, further embodiment of the present invention comprises a cylindrical cage 24 and a jet nozzle 3 directly connected by its outlet 3*a* with the inlet of the cylindrical cage 24 and a pair of delivery rollers 25*a* and 25*b* disposed in such a way that the outlet of the cylindrical cage 24 closely faces a nip point 25*c* of the rollers 25*a* and 25*b*. The rollers 25*a* and 25*b* rotate at high speed, and the jet nozzle 3 is provided with a similar structure as in the first embodiment shown in FIG. 2.

In the above-mentioned embodiment, the multifilament yarn is stuffed into the cage **24** together with the super heated steam from the jet nozzle **3,** and the multifilament yarn is taken up from the cage **24** by the delivery action of the delivery rollers **25***a* and **25***b*. Fine and random crimps are imparted to the multifilament yarn and these crimps of the individual filaments are set by the super heated steam while the multifilament yarn is passing through the cage **24.** It is possible to maintain the condition of the multifilament yarn in the cage by maintaining the balanced condition of the feeding speed of the multifilament yarn from the jet nozzle **3** and the circumferential speed of the delivery rollers **25***a* and **25***b*. The cage **24** is composed of a combination of fine straight stainless steel rods and needles, and the mesh between the rods must be below 1 mm, otherwise it is possible for the individual filaments to escape from the space between the adjacent rods, and the escape of the filaments causes yarn breakage during the operation. In the practice of the abovementioned embodiment, it is desirable to discharge the super heated steam in the cage **24** by means of an exhaust fan (not shown). By our mill test, the feeding speed of the multifilament yarn from the jet nozzle **3** can be more than 300 m/min. and the production rate of the present device is remarkably higher than the conventional bulky texturing method. In the above-mentioned high speed supply of the yarn, the crimped yarn is taken up from the cage **24** by the delivery rollers **25***a* and **25***b* the circumferential speed of which may be in a range between one tenth or one fifth of the feeding speed, without any obstacles for the winding operation.

In FIG. **9,** a practical device of the first embodiment of the invention is shown. A polypropylene drawn multifilament yarn **26** is supplied from a package **27** and fed to a pair of feed rollers **29***a* and **29***b* under tension below 0.1 g/den. by way of a tension device **28.** Next the yarn **26** is supplied to a jet nozzle **30.** The jet nozzle **30** is connected to a steam supply conduit **31** which is connected to a supply source **32** of the super heated steam. The jet nozzle **30** is closely disposed to a stuffing member **36** which is already illustrated in the explanation of the first embodiment. The multifilament yarn supplied to the jet nozzle **30** is jetted to the rotating stuffing member **36** and stuffed into the cubical spaces of the rotating stuffing member **36.** The multifilament yarn is provided with fine and random crimps as already illustrated, and then delivered by a pair of delivery rollers **37***a* and **37***b*, to form a package **39** of the crimped bulky yarn by the frictional contact with a winding roll **40.** The super heated steam jet from the jet nozzle **30** is exhausted by a drafter **33** and cooling air is blown to the cylindrical surface of the stuffing member **36** via a duct **34** as shown in FIG. **9** so as to set the crimps of the filaments in a short time. In the embodiment shown in FIG. **9,** a plurality of jet nozzles are mounted on the conduit **31** and a yarn guide **38** is attached for separating the multiple units. The jet nozzle **30** is so constructed that when the jet nozzle **30** is turned toward the stuffing member **36** the supply of the super heated steam is commenced, and when the jet nozzle **30** is turned toward the opposite direction, the supply of the steam is stopped.

As already illustrated in the first embodiment shown in FIG. **1,** the distance between the stuffing member and the outlet of the jet nozzle is a very important factor which affects the quality of the yarn. By our experiments, in the case of using a multifilament yarn having a thickness in a range between 1,000 denier and 2,000 denier, it is preferable to choose the above-mentioned distance in a range between 3 and 5 mm. and in the case of using yarn having a large thickness, the above-mentioned distance must be large, but on the contrary, in the case of a fine thickness, the distance must be small.

A continuous process composed of a draw process and a crimping process utilizing the device of the present invention is shown in FIG. **10.** An undrawn yarn **42** is supplied from a package **41** and a drawing operation is performed at a drawing zone between a feed roller **43** and a delivery roller **45,** with a constant draw ratio. In the case of drawing in a heated condition, a heater **44** is used in the drawing process. It is also possible to use the heater **44** as a pre-heater when it is required to speed up the texturing operation. The crimping device of this embodiment is similar to the practical device shown in FIG. **9** and, therefore the illustration of the crimping device is omitted. The advantage of the above-mentioned continuous process is that there is no unbalanced shrinkage of the drawn yarn at the different positions in the package.

Another continuous process including a melt spinning process is shown in FIG. **11.** In this embodiment, filaments **47** melt spun from a spinneret **46** are drawn by a drawing device composed of feed rollers **50** and **51** and delivery rollers **52** and **53** after supplying a spin-finish by an oiling roller **48** and passing a guide roll **49.** When it is required to operate the drawing under heat, a heater, such as a ceramic heater **54,** is preferably used. As the delivery speed of the drawing device directly connected with the melt-spinning device is so high, in the case of a continuous process, it is desirable to apply the device shown in FIG. **8,** which has a sufficient capacity for imparting crimps to the multifilament yarn at a processing speed of more than 300 m/min.

EXAMPLE 1

Polypropylene polymer having an intrinsic viscosity of 14 measured in tetralin is mixed with an adequate quantity of stabilizer and extruded through a spinning nozzle at a processing temperature of 270°C so as to acquire an undrawn filament yarn. The undrawn filament yarn is next fed to a draw machine and is subjected to a drawing operation carried out under processing conditions illustrated in Table 1 so as to acquire a multifilament yarn including 120 filaments and having a total thickness of 1850 denier. Next, the multifilament yarn thus acquired is processed through the apparatus shown in FIG. **1** at processing conditions shown below.

Temperature of the super heated steam in °C. — 155

Pressure in the super heated steam in kg/cm^2 — 0.8

Effective diameter of the jet nozzle in mm. — 1.2
Height of the stuffing member in mm. — 4.0
Diameter of a stuffing member in mm. — 0.2
Number of the stuffing members per in^2. — 840
Clearance between the jet nozzle end and the stuffing member ends in mm. — 5
Feeding speed of the yarn in meters/min. — 60
Peripheral speed of the stuffing member ends in meters/min. — 10
Take-up speed of the yarn in meters/min. — 51

The functional features of the crimped yarn thus acquired are illustrated in Table 1 together with those of the undrawn filament yarn.

TABLE 1

Drawing condition/Items	Temperature of the heated plate in °C	25	50	90	110	140
	Drawing ratio in percent	2.00	2.50	3.20	3.80	4.50
Filament yarn before crimping operation.	Tenacity in g/denier	2.41	2.65	3.05	3.42	3.86
	Breaking elongation in percent	163	127	89	68	42
Crimped multifilament yarn	Tenacity in g/denier	2.78	3.02	3.17	3.45	3.87
	Breaking elongation in percent	73	71	64	52	40
Percent shrinkage in boiling water	Material yarn	19.8	16.5	13.7	8.1	4.3
	Crimped yarn	0.6	0.5	0.5	0.4	0.2
Percent crimp elongation		43.8	39.2	37.0	28.2	20.5
Percent crimp		29.7	26.0	25.3	17.7	13.2
Percent crimp recovery		87.3	89.0	87.5	86.1	86.4

The items shown in the table are obtained by the following measurements.

A skein of 20 winds is prepared on a reeler having a peripheral length of 1 meter under a constant yarn tension, hung over a stainless steel rod of 5 mm. dia. for at least eight hours, subjected to a dry thermal treatment at 70°C for 10 minutes under an atmospheric pressure and left for at least four hours in a standard room condition (20°C and 65 percent RH.). After the aforementioned preparation, the hank is loaded with an initial loading of 1 mg/denier and the length L_0 of the hank at a moment 1 minute after loading was recorded. Next, the hank is loaded by 100 mg/denier and the length L_1 of the hank at a moment 1 minute after loading is recorded. 2 minutes after unloading, the hank is again loaded with an initial loading of 1 mg/denier and the length L_2 of the hank at a moment 1 minute after loading is recorded. Then, the values of the items are given by the following.

Per cent crimp elongation = $(L_1 - L_0/L_0) \times 100$

Per cent crimp = $(L_1 - L_2/L_2) \times 100$

Per cent crimp recovery = $(L_1 - L_2/L_1 - L_0) \times 100$

As is understood from the results shown in Table 1, employment of the drawing operation of the material yarn at a temperature lower than 90°C assures effective manufacture of a crimped yarn having superior crimping properties to those possessed by the ordinary yarn drawn at a high temperature and a large drawing ratio. Further, it should be noted that, in case of the yarn drawn at a low temperature and a small drawing ratio, the tenacity of the parn is remarkably enhanced with considerable reduction in shrinkage in boiling water and the drawbacks possessed by the material yarn are completely eliminated by the application of the drawing opration. Being procided with random crimps having various crimp pitches and with excellent bulkiness, the crimped yarn thus manufactured is adapted for use in room accessories with elegant appearance and excellent elastic properties. Further, because of the air jet type manufacturing system, the crimped yarn manufactured is provided with improved interlacing effect of the crimps of the individual filaments resulting in relatively easy treatment of the yarn throughout the whole process. Thus the crimped yarn of the present invention completely eliminates such drawbacks of the conventional stuffing-box type crimped yarn as a low bulkiness due to two dimensional crimp configuration or an uncomfortable touch due to a zig-zag configuration of the crimps. It is impossible to provide the false-twist type crimped yarn with the excellent properties of the crimped yarn of the present invention because of the limitation in the fineness of the yarn manufactured. The below shown degrees of randomness are calculated concerning the crimped yarn of the present invention drawn at 90°C and a drawing ratio of 3.20 and a crimped yarn manufactured by the conventional mechanical stuffing-box system and the result is 1.89 for the former and 5.31 for the latter.

Degree of randomness =

$$\frac{\sum_{i=1}^{n} (x_i - \bar{x})^4}{NS^4}$$

wherein

x_i = Respective length of the crimps.

$\bar{x}$ = Average length of the N crimps.

S = Standard deviation in the length distribution of the N crimps.

Without regard to the processing conditions, the calculated degrees of randomness of the crimped yarns manufactured on the apparatus shown in FIG. 1 are smaller than 2.80 and this proves the preferable randomness of the crimps possessed by the crimped yarn of the present invention.

EXAMPLE 2

Polypropylene polymer having an intrinsic viscosity of 2.1 measured in tetralin is mixed with an adequate quantity of stabliizer and extruded through a spinning nozzle at 275°C so as to acquire an undrawn filament yarn of 3,700 denier and containing 120 filaments. After being processed through the drawing apparatus shown in FIG. **10**, the drawn filament yarn obtained is successively fed to the apparatus shown in FIG. **1**. In the drawing operation, the temperature of the heater **44** was maintained at 88°C, the yarns are drawn at a drawing ratio of 2.2 in the region between the feed roller **43** and the delivery roller **45** and the delivery speed of the yarn is 160 meters/min. The crimping treatment is carried out almost in the same manner as in Example 1 with the only exception being that the processing temperature is kept at 165°C, the peripheral speed of the stuffing member ends is 24 meters/min. and the takeup speed is 126 meters/min. Thus, differences in the processing conditions resulted from the relatively high processing speed employed in the present example. The crimped yarn thus acquired is provided with excellent functional features similar to those of the crimped yarn manufactured in Example 1. Combination of the crimping operation with the drawing operation adopted in the present example brought about preferably compact interlacing of the yarn crimps despite the almost non-twisted configuration of the yarn manufactured eliminating unfavourable filament separation or fluff formation which are usually the cases with the conventional air jet type crimping system, stuffing-box type crimping system or false-twist type crimping system. Such compactly interlaced configuration of the crimps of the yarn resulted in easy handling of the yarn in the subsequent processings.

EXAMPLE 3

Polypropylene polymer having an intrinsic viscosity of 2.3 measured in tetralin and mixed with an adequate quantity of stabilizer is extruded through a spinning nozzle at 278°C so as to acquire an undrawn multifilament yarn of 1,850 denier and containing 120 filaments. The undrawn multifilament yarn is next fed to an apparatus shown in FIG. **10** so as to undergo a crimping treatment under the following processing conditions.

Temperature of the super heated steam in °C — 153

Feeding speed of the yarn in meters/min. — 80
Peripheral speed of the stuffing member ends in meters/min. — 14
Take-up speed of the yarn in meters/min. — 79

The processing conditions of the yarn through the crimping treatment are similar to those employed in Example 1 and the characteristic features of the crimped yarn thus obtained are shown in Table 2.

TABLE 2

Item	Sample	Undrawn filament yarn	Drawn filament yarn (Temp.: 140°C) (Ratio: 4.50)
Filament yarn before crimping operation.	Tenacity in g/denier	1.81	3.86
	Breaking elongation in percent	450	42
Crimped filament yarn	Teancity in g/denier	2.41	3.87
	Breaking elongation in percent	132	40
Percent shrinkage in boiling water	Material yarn	3.5	6.0
	Crimped yarn	0.1	0.2
Percent crimp elongation		38.5	20.5
Percent crimp		263	132
Percent crimp recovery		90.3	86.4

As is apparent from the result shown in the table, the tenacity of the undrawn filament yarn is enhanced remarkably by processing the yarn through the crimping apparatus of the present invention and crimps obtained are far more stable in their configuration when compared with the ordinary drawn yarn which is drawn at high temperature and drawing ratio. The biggest advantage of the present invention is that an application of a thermal treatment upon a polypropylene undrawn filament yarn causes rubber-like elasticization of the yarn resulting in the provision of excellent crimp elasticity and that, because of such excellent crimp elasticity of the polypropylene crimped yarn obtained, the textile products made up of such crimped yarns are provided with novel and unique handling quality and touch.

EXAMPLE 4

A drawn filament yarn which is drawn at a temperature of 50°C and a drawing ratio of 2.5 is processed through the crimping apparatus shown in FIG. **8** under the following processing conditions.

Temperature of the super heated steam in °C. — 170

Pressure of the super heated steam in kg/cm^2 — 2.3

Diameter of the jet nozzle in mm. — 1.6
Inside diameter of the stuffing cage in mm. — 3.6
Length of the stuffing cage in mm. — 45.0
Diameter of the cage needles in mm. — 0.3
Number of the cage needles — 26
Feeding speed of the yarn in meters/min. — 480
Take-up speed of the yarn in meters/min. — 425

As is apparent from the above, the yarn can be processed through the apparatus at an extremely high processing speed and the crimped yarn manufactured is provided with a unique bulky configuration characteristic to the crimped yarns made by the air jet system.

EXAMPLE 5

Polypropylene polymer having an intrinsic viscosity of 2.1 measured in tetralin and mixed with adequate quantity of stabilizer is extruded through a spinning nozzle of 275°C, passed through the oiling apparatus shown in FIG. **11**, subjected successively to a drawing operation at 90°C and a drawing ratio of 1.7 and subsequently fed to a crimping apparatus shown in FIG. **8**. The processing conditions in this example are similar to those employed in Example 4 with the only exception being that the delivery speed of the yarn from the drawing apparatus is 650 meters/min. The temperature of the super heated steam is 175°C and the take-up speed is 500 meters/min. By directly feeding the filament yarn to the crimping apparatus in the present example, the manufacture of the crimped yarn adapted for use in room decoration can be carried out with the highest production efficiency and lowest production cost.

EXAMPLE 6

Polypropylene polymer pellets having an intrinsic viscosity of 1.45 measured in tetralin and mixed with an adequate quantity of stabilizer are fed to a composite spinning machine, melt extruded independently at extruding temperatures of 255°C and 325°C, spun via gear pumps through a spinning nozzle having 60 holes at a composite ratio of 1 : 1 and a spinning temperature of 245°C and subjected to a drawing operation at room temperature and a drawing ratio of 4.0 so as to acquire a multifilament yarn of 1,050 denier containing 60 filaments. The multifilament yarn thus obtained is next fed to a crimping apparatus shown in FIG. **8**. The processing conditions are similar to those employed in Example 4 with the only exception being that the temperature of the super heated steam is 155°C and the take-up speed of the yarn manufactured is 405 meters/min. The crimped yarn obtained in this manner can be provided with crimps developed by the application of the super heated steam together with random crimps formed by the crimping apparatus of the present invention. In accordance with the degree of crimps to be expected, it is also possible to process the yarn at higher processing speeds by lowering the temperature of the super heated steam. The combined effect of the aforementioned two types of crimps enables production of textile products having a wide range of utilization.

EXAMPLE 7

A polypropylene filament yarn (1,850 denier × 120 filaments) which is drawn at 90°C and a drawing ratio of 3.20 in Example 1 is processed through the crimping apparatus shown in FIG. **9**. In this case, the crimping apparatus is provided with a curved heated plate having a surface curvature of 3,000 mm. and an effective length of 60 cm. and disposed in between the feed rollers **29***a*, **29***b* and the jet nozzle **30**. The yarn is heated at 142°C while passing over the heated plate prior to being fed to the nozzle. The feeding speed of the yarn is 120 meter/min., the peripheral speed of the stuffing member is 20 meters/min. and the take-up speed is of 103 meters/min.

TABLE 3

		Crimped yarn					
		Tenacity in g/denier	Breaking elongation in percent	Percent crimp elongation	Percent crimp	Percent crimp recovery	Percent shrinkage by treatment
Feeding speed of the yarn in meters/min.	60	3.17	64	37.0	25.3	87.5	13.5
	120	3.20	62	38.5	25.8	86.1	6.1

As is apparent from the results in the table, it is possible to reduce the degree of shrinkage by treatment using the application of pre-heating.

EXAMPLE 8

A drum provided with a stuffing member composed of numerous stuffing elements having cubical spaces shown in FIG. **5** is substituted for the cylinder **36** of the apparatus shown in FIG. **9**. The height of each stuffing element is 5 mm. and a sidelength of it is 2 mm. A polypropylene multifilament yarn (1,850 denier × 120 filaments) which is drawn at 90°C and a drawing ratio of 3.20 in Example 1 was processed through the aforementioned apparatus under the following processing conditions.

Temperature of the super heated steam in °C. — 155

Pressure of the super heated steam in kg/cm² — 0.9

Diameter of the jet nozzle in mm. — 1.2

Clearance between the nozzle and the stuffing box in mm. — 4.5

Feeding speed of the yarn in meters/min. — 72

Peripheral speed of the stuffing member in meters/min. — 13 Take-up speed in meters/min. — 54

The functional properties of the yarn thus obtained are illustrated in the following table.

Tenacity in g/denier	Breaking elongation in %	Per cent crimp elongation	Per cent crimp	Per cent crimp recovery
3.25	67	34.4	23.9	88.5

As is apparent from the results shown in the table, despite the relatively smaller crimping property than that obtained in the case of the cylinder **36**, the crimped yarn manufactured on the apparatus of the present example is provided with enhanced tenacity and less formation of fluffs due to relatively easy removal of the yarn from the surface of the drum of this type.

EXAMPLE 9

An apparatus shown in FIG. **7** is accompanied with a small cylinder **21** rotating in a meshing condition with the main cylinder **29** and a polypropylene multifilament yarn drawn at 90°C and a drawing ratio of 3.20 in Example 1 is processed through the apparatus under the following processing conditions.

Diameter of the main cylinder in cm. — 70

Diameter of the small cylinder in cm. — 15

Peripheral speed of the main cylinder in meters/min. — 10

Peripheral speed of the small cylinder in meters/min. — 13

Although the resulting functional properties of the yarn manufactured by the apparatus of the present example is essentially similar to those manufactured by the apparatus shown in FIG. **9**, the processability of the yarn is outstandingly different. In the case of the apparatus shown in FIG. **9**, fluctuation in the removal of the filaments from the surface of the cylinder is due to the difference in the shrinkage of the individual filaments which causes breakage of the stuffing members. However, by employing the small cylinder, fluctuation in the removal of the filaments is effectively eliminated and the breakage of the stuffing members was effectively prevented.

EXAMPLE 10

A polypropylene multifilament yarn drawn at 90°C and a drawing ratio of 3.20 in Example **1** is processed through the crimping apparatus shown in FIG. **6** under the following processing conditions.

Temperature of the super heated steam in °C. — 158

Pressure of the super heated steam in kg/cm². — 0.95

Diameter of the jet nozzle in mm. — 1.2

Effective height of the stuffing members in mm. — 4.0

Diameter of the stuffing members in mm. — 0.2

Number of the stuffing members per square inch — 550

Clearance between the jet nozzle and the stuffing members in mm. — 8.0

Feeding speed of the yarn in meters/min. — 120

Peripheral speed of the stuffing member in meters/min. — 20

Take-up speed of the yarn in meters/min. — 104

The resulting functional properties of the crimped yarn obtained are illustrated in the following table.

Tenacity in g/denier	Breaking elongation in %	Per cent crimp elongation	Per cent crimp	Per cent crimp recovery
3.19	66	39.4	27.8	87.3

The crimped yarn of the present example is provided with excellent crimps due to the combined effect of the ejection by the super heated steam with the production of crimps due to the meshing of a pair of facing stuffing member belts. Easy separation of filaments from the surface of the stuffing members results in provision of enhanced strength of the crimped yarn obtained. troubles resulting in the case of the apparatus shown in FIG. 9 are completely eliminated.

EXAMPLE 11

An undrawn multifilament yarn (1,850 denier × 120 filaments) obtained in Example 1 is fed to a drawing apparatus shown in FIG. 10 and, subsequently and successively, processed through the crimping apparatus shown in FIG. 1 under the following processing conditions. In this case, the stuffing member is of a bi-layer construction having a space intervening between the stuffing member and the base fabric.

Height of the stuffing members in mm. (Above the base fabric) — 5
Number of the stuffing members per in². — 520
Density of the needles per inch. — 10
Position of the needles above the base fabric in mm. — 3
Temperature of the super heated steam in °C. — 158
Feeding speed of the yarn in meters/min. — 90
Peripheral speed of the stuffing member in meters/-min. — 14
Take-up speed in meters/min. — 88

In the present case, with individual filaments being satisfactorily pressed into production members, effective stuffing of crimps upon the individual filaments is assured without any unfavourable reflection of the fluid ejected from the jet nozzle.

While the invention has been described in conjunction with certain embodiments thereof it is to be understood that various modifications and changes may be made without departing from the spirit and scope of the present invention.

What is claimed is:

1. A method for manufacturing bulky yarn composed of a plurality of crimped polypropylene filaments comprising, jetting polypropylene multifilament yarn together with super heated steam into numerous fiber-receptive spaces defined by numerous pin-like protuberances planted upon a surface member, stuffing said multifilament yarn into said fiber-receptive spaces continuously by an ejecting force of said super heated steam, simultaneously plastifying said multifilament yarn while moving said surface member in a mutually relative condition with said yarn and without said steam flowing through said surface member, retaining said multifilament yarn temporarily in said fiber-receptive spaces and simultaneously fixing crimp deformations of individual filaments effected by said stuffing action while being carried by said fiber-receptive spaces, subsequently stripping said multifilament yarn from said fiber-receptive spaces, whereby random and stable three dimensional crimps are imparted to said individual polypropylene filaments of said yarn.

2. A method for manufacturing bulky yarn according to claim 1, wherein said jetting of said polypropylene multifilament yarn together with said super heated steam is along a path transverse to the path of travel of said moving surface member and adjacent and above said fiber-receptive spaces.

3. A method for manufacturing bulky yarn composed of a plurality of crimped polypropylene filaments in a spinning process including a drawing and texturing operation, comprising jetting polypropylene multifilament yarn delivered from a drawing operation together with super heated steam into a plurality of numerous fiber-receptive spaces defined by numerous pin-like protuberances planted upon a surface member, stuffing said multifilament yarn into said fiber-receptive spaces continuously by an ejecting force of said super heated steam without said steam flowing through said surface member, simultaneously plastifying said multifilament yarn, while moving said fiber-receptive spaces in a mutually relative condition with said yarn, retaining said multi-filament yarn temporarily in said fiber-receptive spaces and simultaneously fixing crimp deformations of individual filaments created by said stuffing action, while being carried by said fiber-receptive spaces, subsequently stripping said multifilament yarn from said fiber-receptive spaces, whereby fine and random and stable three dimensional crimps are imparted to said individual polypropylene filaments of said yarn.

4. A method of manufacturing bulky yarn comprising, impinging on a substantially fluid-impervious, travelling, continuous, surface a multifilament, thermoplastic yarn in a plasticized condition, and propelled longitudinally along a path onto said surface at a speed greater than the speed of travel of said surface, while impinging the yarn on said surface crimping said yarn and retaining the multifilament yarn impinged laterally in laterally-pervious cubical spaces defined by spaced, fixed rigid pins on said surface and distributing longitudinally said yarn in said cubical spaces, setting the plasticized yarn on said travelling surface, and removing the set yarn as crimped yarn from said surface and cubical spaces.

5. A method of manufacturing bulky yarn comprising, propelling longitudinally along a given path multifilament yarn in a softened condition, impinging the softened yarn on a substantially fluid-impervious surface travelling relative to said path along a path effective to develop back pressure on yarn impinged on said surface, before impinging the multifilament yarn on said surface softening said multifilament yarn, while impinging the yarn on said surface crimping said yarn and retaining the multifilament yarn impinged on said surface with rigid pins upstanding on said surface and distributed thereon in a spaced condition defining fiber-receiving spaces laterally-pervious to fluid for crimping and retaining the impinged yarn laterally at points disposed longitudinally of said yarn, setting the yarn while retained on said travelling surface, and removing the yarn from said surface after setting as crimped yarn.

6. A method of manufacturing bulky yarn comprising, propelling longitudinally along a path multifilament, thermoplastic yarn in a plasticized condition, impinging the plasticized yarn on a substantially fluid-impervious surface travelling relative to said path substantially normal thereto and at a speed less than the speed of longitudinal travel of said yarn being propelled, while impinging the yarn on said surface crimping and retaining laterally the yarn at spaced, rigid fixed pins distributed longitudinally of the yarn impinged on said surface, setting the yarn on said surface, and removing the set yarn from said surface as crimped yarn.

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