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(54) Polypropylene filament yarn and process for making same.

(57) A process for making filament yarn products is disclosed in which polypropylene, having a molecular weight distribution of less than about 7 and a melt index between about 20 and about 60 is melt spun to produce an as-spun product or additionally interlaced before take-up, twist-drawn, heat set, draw-textured by false-twisting, simultaneously draw-textured, sequentially draw-textured, draw-twisted, draw-Taslan textured, stuffer box crimped and cut into staple fibers, or a plurality of yarns are simultaneously draw-textured by false-twisting while reversing the direction of twist of alternate yarns and thereafter interlacing. Products of improved tenacity, improved birefringence and low elongation are produced.

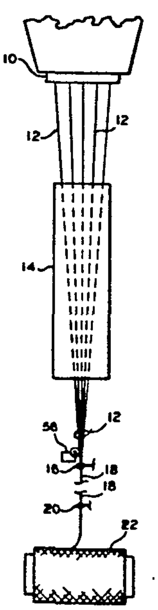

FIG. I

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POLYPROPYLENE FILAMENT YARN AND PROCESS FOR MAKING SAME

Background of the Invention

The present invention relates to a process for making fibrous polyolefin products by melt spinning and products thereof.

While fibrous polyolefins, particularly polypropylene, have been found to possess certain characteristics superior to other synthetic fibrous materials, it is generally recognized that fibrous polyolefins have peculiarities not possessed by other synthetic fibers, which often limit the processability of such materials and limit the end uses to which the products can be applied. For example, the processability limitations result in relatively low extrusion, spinning and wind-up speeds. Often high breakout rates are experienced and further processing of the spun fibers is limited, to the extent that inconsistent texture, broken filaments, lack of color control and difficulty in knitting and weaving are often encountered. The products produced by melt spinning polyolefins also have relatively high spun denier, low tenacity, low birefringence, high elongation, high boiling water shrinkage, low modulus of elasticity, as well as other limitations which limit the uses to which the fibrous materials can be applied. It is also recognized that polyolefin fibers cannot generally be utilized in their as-spun state, i.e., with little or no further processing.

It is therefore an object of the present invention to provide an improved process for producing fibrous polyolefin products which overcomes the above-mentioned and other disadvantages of prior art processes and improved fibrous polyolefin products which overcome the above-mentioned and other disadvantages of prior art products. Another object of the present invention is to provide a process for producing melt spun, fibrous polyolefin products and fibrous polyolefin products which can be utilized with little or no additional processing. Another object of the present invention is to provide an improved process for producing fibrous polyolefin products which can be carried out at relatively high speeds, particularly higher speeds of extrusion, spinning and wind-up. Another and further object of the present invention is to provide an improved process for producing fibrous polyolefin products which result in products of a low spun denier with consequent lower draw ratios and improved products thereof. Yet another object of the present invention is to provide an improved process for producing fibrous polyolefin products of improved processability, particularly reduced breakout, higher draw ratios, higher and more constant twist levels during false twist texturing, better ease of handling in knitting, weaving, etc., improved color control and improved products thereof. A still further object of the present invention is to provide fibrous polypropylene products having a low spun denier, high tenacity, high birefringence, low elongation, low boiling water shrinkage, high modulus of elasticity and/or high break strength. A still further object of the present invention is to provide fibrous polyolefin products of improved coherency and/or bulkiness. These and other objects of the present invention will be apparent from the following description.

Summary of the Invention

In accordance with the present invention, novel polyolefin filament products are produced by melt spinning a polyolefin having a molecular weight distribution of less than about 7 (a MW/MN ratio determined by gel permeation chromatography) and a melt flow of between about 20 and about 60 which are useful in their as-spun condition without further processing and have high tenacity, high birefringence and low elongation. In other aspects, the novel products can be converted to other useful products by one or more additional processing steps, including improving the coherency and/or bulkiness by heat setting, texturing, jet texturing such as using a Taslan jet, plying, entangling, and cutting into staple. Still another aspect of the process includes drawing the melt spun fibers, twist-drawing, draw-texturing, draw-twisting, draw-winding, and/or draw-entangling.

Detailed Description

The process of the present invention comprises producing polyolefin, particularly polypropylene, filament products by melt spinning a polypropylene having a molecular weight distribution of less than about 7 and a melt flow between about 20 and about 60.

The term "molecular weight distribution", as utilized herein, refers to the ratio of the weight average molecular weight to the number average molecular weight. The term "melt flow", as utilized herein, refers to the weight in grams of the polymer which can be extruded within a particular time under a constant dead weight load at a given temperature as determined by ASTM-D-1238, Condition "L". The term "as-spun" as used herein, refers to the filament products of the invention in their condition when taken up on the first wind up package after having been melt spun. Various terms have been used in the art to designate treatments of a plurality of collected filaments or a yarn and a plurality of yarns to improve the coherency of the filaments and/or improve the bulk of the yarn. A process in which the yarn or yarns are heated, twisted, cooled and then untwisted is generally referred to as "false-twist texturing" or simply "texturing". This terminology is almost universally accepted and will be utilized as above defined in the present application. By contrast, where a yarn or yarns is twisted but not subsequently untwisted, the universally accepted terms which will be used herein are "true twist" or simply "twist". Some confusion exists however in the terms used to describe other such treatments, particularly where the yarn or yarns are subjected to a jet or jets of air under pressure. In the latter instance, the results produced and the terminology applied depends upon the condition of treatment, such as air pressure, the direction of the air jet relative to the path of yarn travel and the relative tension being applied to the yarn during treatment. The term "Taslan texturing" (Taslan is a trademark of E.I.duPont de Nemours and Company) as used herein is meant to refer to a process and product in which a jet or jets of air are directed against the yarn, usually in the direction of travel of the yarn, forming a turbulent region, the speed or tension on the yarn is greater at the entrance to the jet than at the exit (net overfeed) and the filaments of the resultant product have a multitude of ring-like loops, coils and whorls at random intervals along their lengths. The term "entangling" or "intermingling", sometimes called "interlacing" as used herein, refers to a process and product in which a jet or jets of air are directed against the yarn or yarns, usually at a 90° angle to the yarn path, the speed or tension on the yarn is substantially the same at the entrance and exit of the intermingler and the resultant product has a high degree of intermingling or entangling of the filaments but is substantially free of loops, coils and whorls. Finally, "plying" is used to refer to a process and products in which two or more yarns are formed into a single yarn by twisting or intermingling in a jet. The terms "cold draw" or simply "draw" refers to a process in which filaments or yarns are drawn or stretched (with or without heat and during or after windup) after the spun filaments have solidified as opposed to drawing which occurs during the spinning of the filaments and before the solidification thereof. Stretching which occurs while spinning and before the filaments have solidified will be referred to as "melt drawing" and the products thereof as "partially oriented" products. The term "finish" indicates a liquid composition applied to the yarn during melt spinning that acts as a lubricant and imparts desirable characteristics to the yarn.

In a preferred embodiment, melt spinning is carried out at a take-up speed within the range of about 1200 to 5000 meters per minute and still more preferably between about 1500 and 4000 meters per minute.

In another embodiment unique products are obtained by melt spinning, carried out at take-up speeds in the range of 800-1200 meters per minute, draw-texturing at least three of the yarns as spun with the direction of twist for two yarns being different from the third, then plying the yarns in an interlacing jet. The product of this embodiment is simultaneously draw-textured at a draw ratio of 4.0 to 1 to 2.0 to 1.

The products produced in accordance with the present invention have a number of advantageous characteristics not heretofore present in melt spun polyolefins. Specifically, the polyolefin filaments have a spun denier below about 25 per filament. In the as-spun condition, the products have a high birefringence, usually in excess of about 0.015. The products also have low elongations between about 100 and 350 percent as measured by ASTM Method 2256 and preferably in the range of about 100 to 250 percent. In the alternative, drawn filament materials can be produced having conventional spun deniers but which are drawn at lower draw ratios. The as-spun products also have a high tenacity above about 2.4 grams/denier and, to the extent that the filament materials are further processed by drawing or twisting, higher cold draw ratios may be utilized. For example, draw ratios within the range of 2.0/1 to 4.0/1 can be utilized.

While the polyolefin filament products of the present invention are useful in their as-spun condition, these products can be further processed by a wide variety of treatments to form the same into yarns of desired characteristics for use in a variety of textile products, such as woven or nonwoven material, tufted products and the like. For example, the products may be heat set and entangled. Such processes to improve the coherency may be performed during the spinning operation (prior to winding up) or after collecting the fibers and winding the same. Excellent products can also be produced by crimping, such as steam crimping, or stuffer box crimping and cutting the crimped materials into staple. The as-spun products of the present invention can also be further improved by subjecting the same to further processing which includes cold drawing. Such processing can involve spin-drawing, twist-drawing, false-twist texturing, draw-texturing, draw-twisting, and draw-Taslan texturing.

The preferred polyolefin, fiber-forming materials for use in accordance with the present invention are homopolymers of polypropylene. However, a fiber-forming resin comprising a copolymer of propylene with a small amount (less than 15%) of an olefinic monomer, such as ethylene, butene or a diene monomer, such as butadiene, isoprene, etc, may be employed. If desired, a fiber-forming resin blend composed of a predominant amount of a propylene polymer and a small amount (less than 15%) of at least one polymer of the above mentioned olefinic or diene compound may be used. Therefore the term "polypropylene" as used herein is intended to include the propylene homopolymers, polymer blends and copolymers mentioned above. As for the fiber forming resin, it is preferable to employ a crystalline polypropylene homopolymer having a molecular weight distribution of less than about 7 and a melt flow of between about 20 and about 60.

The present invention will be more readily understood by reference to the drawings.

Brief Description of the Drawings

FIGURE 1 schematically illustrates a melt-spinning process for producing an as-spun product;

FIGURE 2 schematically illustrates an embodiment in which a yarn is twist-drawn;

FIGURE 3 schematically illustrates several techniques for improving the coherency and/or bulking a yarn;

FIGURE 4 schematically illustrates an embodiment in which a yarn is sequentially draw-textured;

FIGURE 5 schematically illustrates an embodiment in which a yarn is simultaneously draw-textured;

FIGURE 6 schematically illustrates in slightly greater detail a false-twist texturing operation;

FIGURE 7 schematically illustrates a spin-draw embodiment;

FIGURE 8 schematically illustrates an embodiment in which a yarn is draw-twisted;

FIGURE 9 schematically illustrates an embodiment in which two yarns are draw-Taslan textured;

FIGURE 10 schematically illustrates an embodiment including crimping and cutting into staple; and

FIGURE 11 schematically illustrates an embodiment in which a plurality of yarns are draw-textured and interlaced.

In referring to the drawings it should be recognized that the spatial relationships of the elements are not necessarily those which would be utilized in a commercial operation and that certain elements and items of equipment have been enlarged with respect to other elements or items of equipment so that the character thereof can be illustrated in somewhat greater detail.

In accordance with FIGURE 1, which illustrates one embodiment of the present invention, a plurality of filaments are melt spun from spinneret 10. The filaments 12 then pass through a quench zone 14 where they are cooled by blowing air therethrough. Applicator 56 applies a finish to the yarn. The filaments 12 then pass through converging guide 16 where they are collected to form a yarn 18. Converging guide 16, as will appear hereinafter, may be a pigtail type eyelet, a slotted roller, or any conventional converging or collecting means. The yarn 18 then passes to a conventional winder wherein traversing guide 20 moves laterally to wind the yarn and form a package 22. The drawing that occurs between the spinneret 10 and the take-up package 22 provides partial orientation of the yarn. As has been pointed out previously, filaments and yarn made in accordance with the present invention are useful for various purposes in their as-spun condition with no subsequent processing or treatment other than that shown in FIGURE 1.

FIGURE 2 of the drawings shows another embodiment of the present invention wherein yarn, produced in accordance with FIGURE 1, is further processed by twist-drawing. In accordance with FIGURE 2, a yarn package 22, such as that produced in FIGURE 1 is mounted on twister 24. The yarn is drawn off package 22 and passes through pretension gate 26, thence through the core of package 22 and through rotatable spindle 28. Rotatable spindle 28 is attached to shaft 30 which is driven by belt 32. Twister 24 is referred to as a "two-for-one twister" in that it inserts two turns of true twist for each rotation of spindle 28. The twisted yarn then passes through guide elements 34 and 36. The yarn is wrapped several times about feed rolls 42 and several times about draw rolls 46 which operate at speed greater than rolls 42 and thus draw or stretch the yarn in the zone between the rolls. Optionally, the drawn yarn can pass over heater 44 to rolls 46 to heat the yarn during drawing, or the rolls 42 and 46 can be heated, eliminating the need for hot plate heater 44. From draw rolls 46 the yarn passes over stationary guide 48 and thence through traverse guide 50 of a winder, which ultimately forms package 52. A more detailed description of the operation shown in FIGURE 2 can be found in U.S. Patent 4,122,667.

FIGURE 3 illustrates a modification of the present invention in which one or more treatments are given to the as-spun yarn 18 to improve the coherency and/or bulkiness of the filaments of the yarn. These treatments include entangling the yarn and/or heat setting the yarn. Specifically, the plurality of filaments 12 pass over ceramic guide 54 where they are collected or converged, in the same manner as in eyelet-type converging guide 16 of FIGURE 1, to form the yarn 18. The yarn 18 may then be passed over applicator 56 which applies a finish to the yarn and thereby improves the coherency of the filaments of the yarn and acts as a lubricant during processing. Finish applicator 56, as shown in the drawing, is what is known as a "kiss roll". The yarn 18 then passes over ceramic guide 58 and thence to godet rolls 60. From godet rolls 60 the yarn passes through a jet type entangler 62. Entangler 62 may be of the type shown and described in U.S. Patent 2,783,609. In this type of entangler the filaments of the yarn are intermingled, but have no significant coils, loops or whorls, by a high velocity air jet. This treatment improves the coherency of the filaments of the yarn for windup. The entangled yarn then passes to winder 64 where it is wound on package 66. It should be recognized at this point that the finish applicator 56 and entangler 62 may be used alone or in combination and that either or both may be placed in any of a number of different positions between converging guide 54 and winder 64. In an alternative form of improving the coherency of the filaments of the yarn, the yarn package 66 may be placed in an autoclave 68 where the yarn is heat set at about 120°C. The heat-set yarn also has improved coherency of the filaments when used alone or it may be used in combination with the application of a finish and/or entangling.

FIGURE 4 of the drawings illustrates yet another embodiment of the present invention wherein the yarn 18, as produced in FIGURE 1, is subjected to a subsequent treatment involving draw-texturing. In accordance with the embodiment of FIGURE 4, the yarn 18 passes around input rolls 70 thence about hot pin 72 or across an appropriate hot plate and finally around draw rolls 74 which are rotated at a speed greater than input rolls 70 to thereby stretch or draw the yarn. The drawn yarn then passes over a plate-type first stage heater 76. From heater 76 the yarn passes through a disc-type, false-twist spindle 78. From disc-type false-twist spindle 78 the yarn passes between intermediate rolls 80 and thence to second stage heater 82. From second stage heater 82 the yarn passes through output rolls 84 and thence to takeup package 86 which is driven by package drive roll 88. It should be noted that a conventional false twist spindle could be substituted for the disc type illustrated here and in the other embodiments.

FIGURE 5 of the drawings illustrates an alternative form of the method of FIGURE 4 which is referred to in the art as simultaneous draw-texturing. It is to be observed that the process of FIGURE 5 differs from that of FIGURE 4 only to the extent that hot pin 72 and rolls 80 are eliminated and the yarn is heated and drawn simultaneously with the insertion of false twist to the yarn by positioning draw rolls 74 downstream of disc-type false-twist spindle 78.

FIGURE 6 of the drawings, although schematic in nature, shows in somewhat greater detail the false twist texturing operation and graphically illustrates why it is referred to as "friction" false twisting. Specifically, the yarn 18 passes over first stage heater 76 and thence to disc-type false-twist spindle 78, illustrated as an array of rotating friction discs that impart false twist to the yarn. In the zone containing first stage heater 76 to disc-type false-twist spindle 78, twist is inserted and heat set in the yarn. From the lower end of heater 76 to disc-type false twist spindle 78 a cooling zone makes up the lower or downstream portion of the twist-heat-set zone. After passing through disc-type false twist spindle 78 and thence to intermediate feed rolls 80, the yarn is untwisted. Since the previous treatment twisted the yarn and heat set this twist the untwisting will not straighten the elements or filaments but instead results in a yarn whose coherency and bulkiness are improved by the false twisting.

FIGURE 7 of the drawings illustrates yet another embodiment of the present invention wherein a yarn is formed by a simple spin-draw operation. In accordance with FIGURE 7 the yarn 18, formed by passage over converging guide 54, passes over feed rolls 90, thence to heater 92 and draw rolls 94, operating at a higher speed than rolls 90.

FIGURE 8 of the drawings shows yet another after-treatment to which the as-spun yarn of FIGURE 1 can be subjected. Specifically, the operation of FIGURE 8 is what is generally referred to as draw-twist. In accordance with FIGURE 8 the yarn 18 from package 22 passes over feed rolls 96, over heater 98 and thence over draw rolls 100. The latter, of course, are operated at a speed higher than the speed of feed rolls 96 to thereby stretch or draw the yarn. The drawn yarn then passes through guide 102 and thence to rotatable flyer 104 which winds the yarn up on pirn 106. As flyer 104 rotates, it inserts true twist in the yarn. It should be recognized at this point that a spin-drawn yarn, prepared in accordance with FIGURE 7, or a draw-twisted yarn prepared in accordance with FIGURE 8 may thereafter be subjected to a false twist-texturing operation, as performed in the double heater, false-twist texturing machines illustrated in FIGURES 5 and 6 of the drawings.

FIGURE 9 illustrates an after treatment of the as-spun yarn produced in FIGURE 1 wherein the yarn 18 is draw-Taslan textured as an effect yarn and combined with a core yarn 19. In accordance with FIGURE 9 the yarn 18 from package 22 is passed through a draw zone comprising feed rolls 108, heater 110 and draw rolls 112 and feed rolls 113. From the draw zone the yarn 18 is passed to a Taslan jet 114. Core yarn 19 from package 23 is passed by feed rolls 115 operating at a slower speed than rolls 113 to Taslan jet 114. As previously indicated, the yarns in passing through Taslan jet 114 are subjected to turbulence in a high velocity air stream and separated from the air stream by being jetted against baffle 116 and then turned in a generally perpendicular path. Due to the overfeed of yarn 18, it becomes the effect yarn. Passage through the jet 114 results in the filaments of the yarn forming loops, rings and whorls therein and effecting some intermingling of the filaments. Generally, the yarns are under tension as they enter Taslan jet 114 and as the core and effect yarn 119 exits Taslan jet 114 it is traveling at a reduced speed and this reduction in tension during the turbulence contributes to the formation of the loops, etc. The yarn 119 then passes through guide 118 to takeup rolls 120, thence through traverse guide 122 of a winder and onto a package 124. Taslan jet 114 is of the type well known in the art and will not be further described herein.

The embodiment of the present invention shown in FIGURE 10 subjects the yarn 18, produced in accordance with FIGURE 1, to a subsequent treatment involving crimping of the yarn and, optionally, cutting the crimped yarn into staple. Specifically, the yarn 18 is fed to crimper 126 which comprises feed rolls 128 and stuffer box 130. The specific crimper shown is a steam crimper and a preferred steam crimper is shown and described in U.S. Patent 3,911,539. From the stuffer box 130 the crimped yarn passes to J-box 132, over tensioning rolls 134 and thence to staple cutter 136. Staple cutter 136 cuts the crimped yarn into short fibers or staple which are then passed to bailer 138. At this point it should be recognized that additional finish may be applied to the yarn prior to passage through crimper 126 and the yarn may be cold drawn prior to the crimping operation.

FIGURE 11 of the drawings illustrates a novel technique for forming a plied and interlaced yarn from a plurality of draw-textured yarns produced in accordance with the draw-texturing operations illustrated in FIGURES 4, 5, and 6. Preferably, a plurality of yarns are simultaneously draw-textured as illustrated in FIGURE 5. Specifically, three separate yarns 18A, 18B and 18C, respectively, are simultaneously draw-textured by passing the same through disc-type false-twist spindles 78A, 78B and 78C, draw rolls 74A, 74B and 74C, second stage heaters 82A, 82B and 82C and output rolls 84A, 84B and 84C. While the draw-texturing devices are shown as offset in FIGURE 11, for clarity of illustration only, it is to be understood that units A, B and C would be in side-by-side relationship in actual operation. The draw-textured yarns 18A, 18B and 18C are thereafter passed through an entangling or interlacing device 140 which plies the yarns together. The interlacer 140 is the same type entangler or interlacer as 62, referred to in the description of FIGURE 3 for a single yarn. Interlacer 140 generally comprises a tube through which a plurality of yarns are fed. The tube through which the yarns pass is provided with air from an annular plenum zone supplied with air by means of air supply 142. To aid in stringup of the yarns in interlacer 140, the interlacer is provided with a slot 144, which is preferably at an angle so as to aid in retention of the yarns in the yarn tube. The interlaced yarn then is wound up on takeup package 146 driven by package drive roll 148. It has been found in accordance with the present invention that the system of FIGURE 11 is particularly useful in the production of a heather-type yarn, in which three different colors of yarn are plied by interlacing. Specifically, it has been found, in accordance with the present invention, that, in a system such as that of FIGURE 11, if a plurality of yarns to be interlaced are all twisted in the same direction this results in a high torque being applied to the yarns. However, it was discovered that if alternate ones of the plurality of yarns were false twisted in the opposite direction, this undue torque was essentially eliminated and a heather-type yarn of substantially improved characteristics was produced. This is illustrated in FIGURE 11 by the rotational direction arrows applied to false-twist spindles 78A, 78B and 78C. In this particular illustration, where three yarns are interlaced, the middle yarn or 18B would be false twisted in the opposite direction to yarns 18A and 18C. It should be recognized however that more than three yarns could be interlaced, in fact as many as eight could be interlaced. Where more than three yarns are interlaced, as previously indicated, alternate false-twist spindles would be operated in a reverse direction.

The following examples illustrate the nature and advantages of the present invention.

EXAMPLE I

A comparison was made of the as-spun properties of a conventional melt spun polypropylene having a broad Molecular Weight Distribution = 12.1 and a low resin Melt Flow = 10-12 (Resin A); two polypropylenes having a broad Molecular Weight Distribution = 12 and a high resin Melt Flow = 30 and 44, (Resins E and K, respectively), a polypropylene having a broad Molecular Weight Distribution = 12 and a low resin Melt Flow = 3 (resin L) and a plurality of different resins having narrow Molecular Weight Distributions (4.2 to 7.5) and high resin Melt Flows (21 to 57). The letter designations in Table I indicate the individual resins utilized. Runs 1 to 12, 19, 20, 22 and 25 utilized a 12x48 mil spinnerette with 325 mesh screen. Runs 1 to 12 utilized a spin temperature of 293°C and runs 19, 20, 22 and 25 a spin temperature of 246°C. Since some difficulties in spinning and quenching were encountered and it appeared desirable to spin resin B at lower spin speeds for comparison runs 13 through 18, 21, 23, 24 and 26 were spun at 254°C spin temperature through a 32-hole - 0.012x0.048 inch spinnerette and utilizing quench air at 80 ft/min. Some difficulties were again experienced at spin speeds above 2400 meters/minute and runs 36 through 43 were spun through a spinnerette with 0.03x0.090 inch holes. Runs 44 through 57 were spun, utilizing a spinnerette having 0.012x0.048 inch holes at a spin temperature of 312°C. Runs 27 through 35 were run at a spin temperature of 250°C, a nominal godet speed (spin speed of 2500 meters/minute) and utilizing quench air at 80 ft/min. A finish herein designated finish C as in Table V was applied to the collected filaments at a rate of 1% by weight and comprised 86.63% Nopcolube 2152P (Diamond Shamrock, Morristown, N.Y.), 13.32% ethoxylated cetyl/stearyl alcohol (25 moles ethylene oxide per molecule) and 0.05% of Givgard DXN (sold by Givaudin Corp. of Clifton, N.J.) an antimicrobial preservation agent. It is to be noted that the melt flow listed in Table I is "melt spun melt flow" or the melt flow as measured after melt spinning. Generally, the resin melt flow of relatively low resin melt flow polymers will differ significantly from the melt spun melt flow but with relatively high resin melt flow polymers the melt spun melt flow will not change appreciably.

TABLE I

Run Sample	Molecular Weight Distribution	Melt Spun Melt Flow	Spin Speed m/m	lb./hr. Thread line	Tenacity	Elongation	Boiling Water Shrinkage	5% Modulus	Birefringence	Denier
1-A	12.1	10.4	400	1.8	1.3	711	2.2		0.004	307
2-A	12.1	10.4	400	2.0	1.2	735	1.8		0.004	342
3-A	12.1	10.9	400	3.7	1.3	614	1.8		0.008	315
4-A	12.1	10.4	800	4.1	1.3	647	1.6		0.008	348
5-A	12.1	10.4	1200	5.6	1.4	632	1.6		0.012	319
6-A	12.1	10.4	1200	6.1	1.3	537	1.8		0.013	345
7-A	12.1	10.4	1200	5.6	1.3	572	1.8		0.012	315
8-A	12.1	10.4	1200	6.0	1.3	551	2.2		0.012	340
9-A	12.1	10.4	1600	7.4	1.3	575	1.8		0.016	313
10-A	12.1	10.4	1600	8.0	1.4	534	2.0		0.018	339
11-A	12.1	10.4	2000	9.4	1.4	548	2.0		0.017	321
12-A	12.1	10.4	2000	10.7	1.3	549	2.2		0.018	363
13-B	4.2	37	400	2.1	1.2	698	0.2	5.1	0.007	350
14-B	4.2	37	800	3.7	1.7	466	1.2	6.0	0.012	312
15-B	4.2	37	1200	4.9	2.1	367	0.6	7.0	0.018	276
16-B	4.2	37	1200	4.8	2.1	354	0.6	6.9	0.018	270
17-B	4.2	37	1600	5.9	2.4	312	1.4	8.2	0.022	250
18-B	4.2	37	2000	6.2	2.6	287	2.1	9.9	0.022	212
19-B	4.2	37	2000	7.3	2.6	268	2.0		0.022	250
20-B	4.2	37	2000	8.2	2.6	273	2.0		0.022	278
21-B	4.2	37	2400	6.4	2.8	212	3.7	10.8	0.025	181
22-B	4.2	37	2600	7.7	2.9	197	3.8		0.023	201
23-B	4.2	37	2800	7.2	2.9	187	3.0	13.4	0.025	174
24-B	4.2	37	3200	7.9	3.1	183	3.2	15.0	0.025	167
25-B	4.2	37	3200	7.7	3.2	190	4.0		0.023	164
26-B	4.2	37	3600	8.4	3.1	175	3.1	17.6	0.025	159
27-C	5.0	21	2500		3.0	181	2.9	93*	0.024	180
28-D	7.5	29	2500		2.8	197	2.9	89*	0.024	180
29-E	12	30	2500		2.4	261	2.5	109*	0.022	177
30-F	4.2	50	2500		3.1	182	2.0	91*	0.023	175

TABLE I (Cont.)

Run Sample	Molecular Weight Distribution	Melt Spun Melt Flow	Spin Speed m/m	lb./hr. Thread-line	Tenacity	Elongation	Boiling Water Shrinkage	5% Modulus	Birefringence	Denier
31-G	4.9	57	2500		2.9	201	2.0	90*	0.023	177
32-H	5.3	47	2500		2.5	235	2.5	99*	0.022	176
33-I	5.3	49	2500		1.8	315	2.9	112*	0.021	176
34-J	5.3	40	2500		2.4	251	2.5	106*	0.023	174
35-K	12	44	2500		1.1	564	3.1	129*	0.017	174
36-B	4.2	37	2400	6.4	2.8	218	3.7	10.8	0.025	176
37-B	4.2	39	2800	7.2	2.9	215	3.1	13.2	0.025	182
38-B	4.2	37	3200	7.9	2.8	196	3.7	15.0	0.025	167
39-B	4.2	37	3600	8.5	3.0	192	4.1	16.9	0.025	160
40-B	4.2	37	4000	8.6	3.0	180	3.9	19.1	0.019	146
41-C	5.0	21	2400	6.5	2.9	239	2.9	13.4	0.025	184
42-C	5.0	21	2800	7.2	2.7	213	2.8	15.1	0.025	174
43-C	5.0	21	3200	7.4	2.6	236	3.1	15.9	0.025	158
44-L	12	9-12	400	2.0	1.6	610	0.2	5.7	0.007	345
45-L	12	9-12	800	3.7	2.1	488	1.0	8.0	0.016	317
46-L	12	9-12	1200	4.8	2.1	405	1.5	12.2	0.021	271
47-L	12	9-12	1200	4.8	2.1	429	1.8	11.7	0.020	272
48-L	12	9-12	1600	5.9	2.1	416	1.9	12.6	0.021	250
49-L	12	9-12	2000	6.2	2.1	388	1.6	14.5	0.021	212
50-L	12	9-12	2400	6.4	2.3	423	1.7	15.3	0.021	182
51-L	12	9-12	2800	7.1	2.3	387	2.2	16.7	0.019	172
52-L	12	9-12	3200	7.8	2.2	436	2.4	15.8	0.021	165
53-L	12	9-12	3600	8.3	2.3	417	2.0	17.6	0.022	157
54-L	12	9-12	4000	8.5	2.4	381	2.0	19.4	0.021	145
5-L	12	9-12	4000	6.3	1.3	301	2.4	11.1	0.020	107
56-L	12	9-12	4000	4.3	2.5	337	2.6	29.2	0.018	74
57-L	12	9-12	4000	2.6	3.5	370	4.9	33.6	0.020	45

* Grams load at 5% elongation (from stress-strain curves)

Table I

Observation of the results set forth in Table I show that the narrow Molecular Weight Distribution - high Melt Flow resins exhibited a number of improved properties, including low elongation, high birefringence, high tenacity and low spun denier, particularly at high spin speeds above about 1500 meters/minutes. From the properties shown it is clear that the narrow Molecular Weight Distribution - high Melt Flow products of the present invention can be utilized for numerous commercial purposes in their as-spun condition without further treatment or little additional treatment.

Since the largest volumes of samples at the full range of spin speeds and the as-spun physical properties of yarns produced from Resin L approached those of the preferred narrow Molecular Weight Distribution - high Melt flow resins, samples of yarns produced in runs 44 through 57 were cold drawn without twisting to determine whether further treatment would be beneficial. In these tests, the yarns were drawn at a speed of 314 meters/min., with 7 and 6-1/2 wraps about the feed rolls and the draw rolls, respectively, and with temperatures of 80 and 125°C on the feed rolls and draw rolls, respectively.

The physical properties of the drawn yarns are set forth in Table II below.

TABLE II

Sample	Max. Draw*	Drawn Tenacity	Elongation	Boiling Water Shrinkage	Modulus 1%	Modulus 5%	Birefringence	Denier
44-L	4.4	7.3	40	3.4	55	38	0.032	87
45-L	3.7	7.4	36	2.7	53	43	0.033	96
46-L	3.6	8.0	38	2.1	57	48	0.033	83
47-L	3.4	7.9	33	2.7	63	51	0.032	87
48-L	3.1	6.8	46	4.1	50	44	0.032	91
49-L	2.9	6.6	68	5.9	49	45	0.033	80
50-L	3.0	6.5	54	3.9	51	44	0.031	67
51-L	2.6	5.5	74	3.5	48	38	0.032	75
52-L	2.9	6.6	59	2.6	50	44	0.031	64
53-L	2.5	5.8	68	2.2	44	39	0.030	69
54-L	2.6	6.3	72	2.1	48	44	0.031	61
55-L	2.5	6.2	56	2.2	50	44	0.028	46
56-L	1.9	4.9	101	1.8	50	39	0.028	42
57-L	1.9	5.0	72	2.1	50	39	0.028	27

*Ran 5 min. without break-out by starting at higher ratio and reducing gradually until good running achieved.

It is to be observed that improvement in properties required cold drawing at high draw ratios.

Polymer B was melt spun using a 70 hole 0.020 x 0.020 inch hole spinnerette and a 360 mesh screen in an effort to make yarn having a total denier of 300. Quench air was 80 ft/min. A finish C was applied to the yarn at a rate of 1% by weight and comprised 86.63% Nopcolube 2152P (Diamond Shamrock, Morristown, N.J.) 13.32% Ethoxylated cetyl/stearyl alcohol (25 moles ethylene oxide per molecule) and 0.05% Givgard DXN. The yarns were also heat set for 5 hours at the temperature indicated. These runs and the physical properties of the yarn are set forth in Table III below.

TABLE III

Run Sample	Spin Speed m/min.	Heat Set Temp,°F	Denier	Tenacity	Elongation	Boiling Water Shrinkage	Modulus 1%	Modulus 5%
58-B	3500	None	298	2.3	166	14.7	17	12
59-B	3500	230	300	2.3	149	0.6	23	15
60-B	3500	270	299	1.8	115	0.9	18	12
61-B	2500	None	285	1.6	230	12.5	11	
62-B	2500	230	285	2.0	178	0.5	19	12
63-B	2500	270	80-159	2.8	121	0.9	27	19

Run 63 is rather meaningless since the supply of polymer began to run out at the end of the run. Also problems of lost filaments occurred in the spinning at 3500 m/min. However, the data clearly indicates that heat setting does reduce the elongation and shrinkage significantly. In spite of the spinning problems at 3500 m/min. it can also be seen that the higher speed (3500 m/min.) produces a yarn of higher tenacity and lower elongation than spinning at the lower speed (2500 m/min.).

In order to determine what effect false-twist draw-texturing during spinning would have on products of the present invention, three polypropylenes were run under varying conditions of draw ratio and twist ratios to produce 600, 700, 800 and 900 denier yarns from each polymer. In these runs the polymers were each run on a 34 hole, 0.012x0.048 inch hole spinnerette with a 325 mesh screen. A polymer pressure of 2000 psig, a spinning speed of 800 m/min. and a quench air rate of 80 ft/min. were utilized in all runs. Polymer temperatures (°C) at each of four extruder zones and the polymer properties were as follows:

Polymer	MWD	Resin MF	Z_1	Z_2	Z_3	Z_4
C	5.0	21	205	235	250	250
M	5.0	34	205	235	250	250
N		12	230	250	280	280

0.5% by weight of a finish, herein designated finish B as in Table V, comprising a 10% emulsion of a reactive polysiloxane (Dow Corning 1111 Emulsion, sold by Dow Corning Corp.) was applied to the yarns.

A Scragg, 12 ceramic disc friction texturing machine was utilized, with temperatures of 150°C at both the first and second heaters. Twist and contraction factor were measured on snatched samples. Overfeed was 12% to the setting zone. Denier was calculated at the draw roll using the formula:

$$\frac{\text{Undrawn Denier}}{\text{Draw Ratio}}$$

The speed of the draw roll was 297 m/min. at D/Y 1.56 and 272 m/min. at D/Y 1.71.

Table IV below sets forth the results of these runs.

TABLE IV

Sample Resin	SD	t_1/t_2	FD	CF	tpi
DR=2.225 D/Y=1.56					
66-N	600	64/95	270	1.55	35
65-N	800	100/62	360	1.50	24
66-C	600	25/35	270	1.53	33
67-C	700	34/45	315	1.56	31
68-C	800	40/52	360	1.53	28
69-C	900	43/52	404	1.57	27
70-M	600	27/37	270	1.54	32
71-M	700	34/43	315	1.55	30
72-M	800	42/55	360	1.49	26
73-M	900	48/58	404	1.47	23
DR=2.225 D/Y=1.71					
74-N	600	66/36	270	1.58	35
75-C	600	27/27	270	1.51	34
76-C	800	40/43	360	1.46	28
77-M	600	28/25	270	1.63	36
78-M	800	41/46	360	1.50	27
DR=2.407 D/Y=1.56					
79-N	600	65/45	Unable to snatch sample		
80-C	600	26/40	249	1.55	36
81-C	800	41/56	332	1.50	29
82-M	600	31/55	249	1.45	34
83-M	800	41/59	332	1.48	29
DR=2.407 D/Y=1.71					
84-N	600	64/44	249	1.68	33
85-C	600	29/36	249	1.62	35

86-C	800	42/44	332	1.50	29
87-M	600	30/38	249	1.56	36
88-M	800	44/45	332	1.55	31
	DR=2.622	D/Y=1.56			
89-N	600	60/48	229	1.60	38
90-C	600	28/40	229	1.63	38
91-C	800	41/55	305	1.54	32
92-M	600	30/42	229	1.57	39
93-M	800	43/62	305	1.54	32
	DR=2.622	D/Y=1.71			
94-M	600	31/35	229	1.55	37
95-M	800	46/51	305	1.51	31
	DR=2.821	D/Y=1.71			
96-M	600	34/41	213	1.51	39
97-M	800	49/63	284	1.49	33
	DR=3.023	D/Y=1.71			
98-M	600	38/47	198	1.50	41
99-M	800	48/62	265	1.46	34
	DR=3.206	D/Y=1.71			
100-M	600	39/46	187	1.53	43
101-M	800	52/65	250	1.47	35
	DR=3.413	D/Y=1.71			
102-M	600	43/57	176	1.52	45
103-M	800	51/63	234	1.56	38

Symbols above represent the following:

DR = Draw ratio

D/Y = Surface speed of discs/linear speed of yarn

SD = Spun Denier

t_1 = tension in grams as measured above false twist spindle

t_2 = tension in grams as measured below false twist spindle

FD = Denier at draw roll - Undrawn Denier/Draw Ratio

CF = Contraction Factor - untwisted length/twisted length

tpi = turns per inch

600 spun denier yarn of polymer N had broken filaments at a draw ratio of 2.622 and D/Y of 1.56 and would not run at higher draw ratios and D/Y's.

It was concluded during the above runs and from an analysis of the data, increased D/Y decreases t_2 but has little effect on twist, the low melt flow polymer did not run well under any conditions as compared with the high melt flow polymers and tpi is a function of denier and is little affected by draw ratios, D/Y and tension.

Based on the good performance attained in the previous tests, polymer M was false-twist, draw-textured in a variety of colors to produce 250 denier through the 34-hole spinnerette. All samples were spun at 800 as-spun denier and at 800 m/minute. Draw-texturing conditions were at a draw ratio of 3.413, D/Y of 1.71, 272 m/min., heater temperatures of 150°C and an overfeed across the second heater (to setting zone) of 12%. Two different finishes, namely, the previously described finishes B and C, were applied in some runs.

Table V lists the as-spun properties.

TABLE V

Run-Polymer	Color	Finish	Denier	Tenacity	Elongation
104-M	Natural	C	798	1.4	504
105-F	Natural	C	807	1.1	615
106-M	White	C	804	1.4	541
107-M	White	B	804	1.4	541
108-M	Lemon	C	803	1.3	587
109-M	Gold Leaf	C	812	1.0	745
110-M	Gold Leaf	B	812	1.0	745
111-M	Blaze Red	C	807	1.0	717
112-M	Spice Brown	C	813	1.0	710
113-M	Spice Brown	B	813	1.0	710
114-M	Velvet	C	821	1.1	906
115-M	Black	C	814	1.2	609
116-M	Black	B	814	1.2	609

The properties of the finished yarns after draw-texturing are set forth in Table VI.

TABLE VI

Run-Polymer	Color	Finish	t1/t2	CF	tpi
104-M	Natural	C	52/70	1.49	36
105-F	Natural	C	37/50	1.50	37
106-M	White	C	39/48	1.54	39
107-M	White	B	44/30	1.54	39
108-M	Lemon	C	37/34	1.52	38
109-M	Gold Leaf	C	30/30	1.55	37
110-M	Gold Leaf	B	30/28	1.61	40
111-M	Blaze Red	C	29/22	1.60	38
112-M	Spice Brown	C	30/17	1.58	40
113-M	Spice Brown	B	32/28	-*	-*
114-M	Velvet	C	30/17	1.58	39
115-M	Black	C	35/22	1.52	40
116-M	Black	B	38/26	1.51	40

*Yarn broke out

All samples in the above test spun without incident. However, the yarns to which finish B was applied fused during texturing and the yarn of run 113 broke out in attempting to snatch.

In order to prepare 3-ply yarns the spinning and false-twist draw-texturing of the previous runs were repeated except for those instances where finish B had been utilized. Operation of an entangler of the type referred to in FIGURE 3 was tried but found to produce too much entanglement. Thereafter, an interlacer of the type specifically referred to in the discussion of FIGURE 11 was used with each position of the disc type false-twisters all rotating in the same direction but the composite yarn produced was of high torque. Finally, the last mentioned interlacer was used with the false-twist positions alternating direction of twist and the air to the interlacer or entangling jet at 30 psi. Two composite yarns of three yarns each in accordance with the method described with reference to FIGURE 11. This procedure eliminated the excess torque and produced acceptable composite yarns.

Table VII sets forth the properties of the individual yarns and the two composite yarns.

TABLE VII

Run Polymer	Color	Denier	Tenacity	Elongation	LSS*
117-M	Natural	255	4.0	31	9.8
118-F	Natural	261	3.0	38	13.3
119-M	White	243	4.4	44	12.5
120-M	Lemon	252	3.9	46	13.8
121-M	Gold Leaf	255	2.8	63	9.6
122-M	Blaze Red	251	3.0	73	12.0
123-M	Spice Brown	248	2.3	27	9.6
124-M	Velvet Brown	252	2.9	31	13.6
125-M	Black	254	3.8	60	14.4
126	Composite 121-122-125	792	2.9	65	5.9
127	Composite 120-124-123	786	3.1	45	2.4

*LSS is the Leesona Skein Shrinkage Test

It was determined from the above data that the entangling procedure utilized herein (entangling during spinning and prior to windup) also increased the denier above what would theoretically be expected by a conventional entangling procedure (entangling individual yarns after windup). It should be recognized that as many as 6 to 8 yarns could be similarly interlaced to produce composite yarns of 1500 to 2000 denier.

The composite yarns were also knit and woven into fabrics without difficulty. The knit sample was boiled off and developed good bulk and pleasing hand. The composite yarns could be used in hand knit items, upholstery fabrics, etc.

This test was carried out to evaluate the Taslan texturing of yarns produced in accordance with the present invention which have been twisted but not drawn. Polymer B was spun at 2500 m/min. and in the same manner and under the same conditions as the previous example except that it was wound at 40 grams tension. The yarn was twisted on a Single Spindle Dienes Twister at 465 m/min., and 5500 rpm spindle speed to produce 0.3 twist level. The properties of the untwisted and twisted yarns are set forth in Table VIII below.

TABLE VIII

Run - Polymer		Condition	Denier	Tenacity	Elongation	Shrinkage
128	B	Untwisted	312	2.0	284	8.9
	B	0.3 Twist	303	1.9	246	9.3

This yarn, a twist-drawn yarn from polymer A and a core yarn from polymer A were Taslan textured at a core feed rate of 187 m/min., an effective feed rate of 337 m/min. and a take-up speed of 182 m/min. The yarn was also run side-by-side with a commercial yarn with the speed being the maximum to get acceptable bonding with the core in the commercial yarn. Inspection of the yarns indicated that the yarn of the present invention tangled with the core yarn better than the commercial yarn.

In order to evaluate draw-Taslan texturing of the yarns of the present invention a series of runs were made comparing yarns prepared from Polymer C and from Polymer N at different spin speeds and in different colors. A 34-hole, round, 0.015 x 0.019 inch spinnerette was used. Spinning temperatures (°C) were 250°C for polymer C and 292°C for polymer N.

The quench air rate was <80 ft/min. and 1.1% by weight of finish B was applied. Table IX below sets forth the as-spun deniers obtained.

TABLE IX

Run - Polymer		Color	Spin Speed	Denier
129	C	Blue	800	464
130	C	Blue	800	399
131	C	Blue	1100	404
132	C	Blue	1100	349
133	C	Blue	1500	351
134	C	Blue	1500	301
135	C	Blue	2200	252
136	N	Blue	800	460
137	N	Blue	800	400
138	N	Blue	1100	402
139	N	Blue	1100	348
140	N	Blue	1500	352
141	N	Blue	1500	303
142	N	Blue	2200	248
143	C	Brown	800	460
144	C	Brown	800	401
145	C	Brown	1100	409
146	C	Brown	1100	350
147	C	Brown	1500	352
148	C	Brown	1500	300
149	C	Brown	2200	252

Samples of Polymer C spun well at all speeds but difficulties were encountered in quenching Polymer N at 1500 and 2200 m/min. due to the presence of wild filaments.

BAD ORIGINAL

The yarns produced were then drawn on the apparatus of FIGURE 2 under varied heat conditions during draw, namely, utilizing heated draw rolls, cold draw rolls and a hot 10-inch plate operating at either 140°C or 120°C, and cold draw rolls with no heating of any type. Drawing was conducted at a speed of 800 m/min. and with 7 and 6-1/2 wraps around the feed rolls and draw rolls, respectively. Table X sets forth the properties of the yarns produced.

TABLE X

Run Polymer	Draw Condition	Draw Ratio	Draw Tension	Drawn Denier	Actual Draw	Hunter D-25 Colorimeter L	a	b	VL	Va	Vb	VE
129-C	hot rolls	3.53	165	132	1.00	25.7	+5.0	-21.9				
	plate 140°	3.53	160	136	0.97				+0.4	-0.4	-0.8	1.0
	plate 120°	3.53	165	137	0.96				+0.3	-0.4	-0.9	1.1
	cold	3.53	200	138	0.95				+0.8	-0.9	-0.7	1.4
130-C	hot rolls	3.07	135	126	1.03	25.8	+5.4	-23.0				
	plate 140°	3.07	135	133	0.98				+0.1	-0.1	-0.6	0.6
	plate 120°	3.07	140	134	0.97				+0.3	-0.4	-0.4	0.6
	cold	3.07	180	135	0.86				+0.5	-1.1	+0.1	1.3
131-C	hot rolls	3.07	170	133	0.99	26.4	+3.4	-21.2				
	plate 140°	3.07	165	138	0.95				+0.1	-0.3	-0.9	0.9
	plate 120°	3.07	180	138	0.95				0	-0.4	-0.7	0.8
	cold	3.07	205	142	0.93				+0.7	-1.1	0	1.4
132-C	hot rolls	2.69	135	127	1.02	26.3	+3.4	-21.1				
	plate 140°	2.69	130	135	0.96				+0.2	-0.3	-0.6	0.6
	plate 120°	2.69	145	135	0.96				+0.3	-0.3	-0.7	0.8
	cold	2.69	195	127	0.95				+0.7	-0.9	-0.4	1.3
133-C	hot rolls	2.69	180	133	0.98	26.3	+3.7	-21.2				
	plate 140°	2.69	180	139	0.94				-0.2	-0.2	-0.7	0.8
	plate 120°	2.69	190	139	0.94				0	-0.6	-0.7	1.0
	cold	2.69	220	143	0.91				+0.2	-1.1	-0.2	1.2
134-C	hot rolls	2.30	145	130	1.01	25.9	+3.9	-21.1				
	plate 140°	2.30	150	136	0.96				+0.7	-0.6	-0.7	1.1
	plate 120°	2.30	155	132	0.96				+0.2	-0.6	-0.9	1.1
	cold	2.30	215	140	0.94				+0.6	-1.1	-0.2	1.3
135-C	hot rolls	1.92	180	135	0.97	25.7	+4.0	-21.1				
	plate 140°	1.92	175	138	0.95				+0.4	-0.3	-0.3	0.5
	plate 120°	1.92	195	145	0.91				+3.3	-0.9	-3.1	4.6
	cold	1.92	235	143	0.92				+0.4	-1.0	+0.4	1.2
136-N	hot rolls	3.53	210	141	0.93	27.5	+1.4	-21.0				
	plate 140°	3.53	210	146	0.92				+0.4	-0.3	-0.7	1.0
	plate 120°	3.53	250	144	0.91				+0.6	-0.4	-0.7	1.1
	cold	3.53	240*	149	0.88				+0.9	-0.4	-0.8	1.3

TABLE X (Cont.)

Run Polymer	Draw Condition	Draw Ratio	Draw Tension	Drawn Denier	Actual Draw	Hunter D-25 Colorimeter L	a	b	∇L	∇a	∇b	∇E
137-N	hot rolls	3.07	185	140	0.93	27.5	+1.4	-21.3				
	plate 140°	3.07	195	142	0.92				+0.5	-0.4	-0.5	0.9
	plate 120°	3.07	220	141	0.92				+0.5	-0.4	-0.5	0.9
	cold	3.07	220	146	0.89				+1.4	-0.6	-0.8	1.8
138-N	hot rolls	3.07	220	140	0.94	27.4	+1.7	-20.6				
	plate 140°	3.07	230	150	0.87				+1.2	-0.3	-2.1	2.5
	plate 120°	3.07	240*	150	0.87				+1.9	-0.4	-2.3	3.0
	cold	3.07	280*	144	0.91				+2.5	-0.3	-3.1	4.0
139-N	hot rolls	2.69	195	138	0.94	27.1	+1.7	-20.8				
	plate 140°	2.69	200	142	0.91				+1.9	-0.4	-2.1	2.9
	plate 120°	2.69	225	144	0.90				+1.9	-0.5	-2.1	2.9
	cold	2.69	250*	150	0.87				+1.7	0	-3.0	3.5
140-N	hot rolls	2.69	210	147	0.89	27.9	+1.8	-20.5				
	plate 140°	2.69	210	150	0.87				+2.2	+0.2	-4.3	4.8
	plate 120°	2.69	210*	144	0.91				+2.1	+0.2	-4.3	4.7
	cold	2.69	270*	152	0.86				+3.1	+0.6	-4.6	5.5
141-N	hot rolls	2.30	195	139	0.95	28.0	+1.5	-20.3				
	plate 140°	2.30	200	145	0.91				+2.1	+0.4	-4.2	4.7
	plate 120°	2.30	205	155	0.85				+2.2	+0.4	-4.4	4.9
	cold	2.30	260	156	0.84				+2.0	+0.7	-4.6	5.0
142-N	hot rolls	1.92	190	144	0.90	28.4	+1.8	-20.9				
	plate 140°	1.92	190	150	0.86				+1.4	+0.5	-3.1	3.4
	plate 120°	1.92	195	149	0.87				+1.0	+0.7	-2.7	2.8
	cold	1.92	260*	152	0.85				-0.5	+0.7	-0.3	0.8
143-N	hot rolls	3.53	160	132	0.99	24.6	+6.2	+ 8.0				
	plate 140°	3.53	160	136	0.96				+1.2	+0.5	+0.9	1.5
	plate 120°	3.53	165	137	0.95				+2.2	+0.2	+1.0	2.5
	cold	3.53	215	140	0.93				+3.4	+0.2	+1.1	3.6
144-N	hot rolls	3.07	130	128	1.01	25.6	+4.8	+8.8				
	plate 140°	3.07	135	135	0.96				-0.6	+0.7	+0.4	0.9
	plate 120°	3.07	145	135	0.96				+0.5	+0.5	+0.6	0.8
	cold	3.07	180	138	0.94				+1.8	+0.4	+0.7	2.0

TABLE X (Cont.)

Run Polymer	Draw Condition	Draw Ratio	Draw Tension	Drawn Denier	Actual Draw	Hunter D-25 Colorimeter L	a	b	∇L	∇a	∇b	∇E
145-N	hot rolls	3.07	165	134	0.97	24.7	+4.9	+8.4				
	plate 140°	3.07	160	138	0.95				+1.4	+0.3	+0.7	1.6
	plate 120°	3.07	170	140	0.93				+1.2	+0.4	+0.7	1.5
	cold	3.07	200	143	0.91				+2.4	+0.3	+0.9	2.6
146-N	hot rolls	2.69	130	129	1.01	24.6	+5.2	+8.7				
	plate 140°	2.69	135	135	0.96				+1.1	+0.1	+0.4	1.2
	plate 120°	2.69	135	137	0.95				+0.3	+0.2	+0.3	0.3
	cold	2.69	180	138	0.94				+1.9	+0.2	+0.4	2.0
147-N	hot rolls	2.69	170	135	0.97	23.9	+5.2	+8.2				
	plate 140°	2.69	165	139	0.94				+1.9	+0.3	+0.6	2.0
	plate 120°	2.69	185	139	0.94				+1.1	+0.2	+0.6	1.3
	cold	2.69	21	143	0.92				+2.5	+0.2	+0.7	2.7
148-N	hot rolls	2.30	135	131	1.00	24.2	+4.8	+8.4				
	plate 140°	2.30	135	135	0.97				+0.8	+0.3	+0.5	1.0
	plate 120°	2.30	150	137	0.95				+0.6	+0.3	+0.5	0.8
	cold	2.30	195	139	0.97				+1.7	+0.3	+0.7	1.9
149-N	hot rolls	1.92	165	131	1.00	24.2	+4.8	+8.4				
	plate 140°	1.92	155	136	0.96				+0.4	+0.3	+0.4	0.6
	plate 120°	1.92	165	138	0.95				+0.5	+0.3	+0.4	0.5
	cold	1.92	220	143	0.91				+1.0	+0.3	+0.4	1.1

*In run 136 it was necessary to draw at 400 m/m with no heating; broken filaments were observed in run 137 with no heating; broken filaments occurred in run 138 with the plate at 140° and it was necessary to draw at 400 and 100 m/min. with the plate at 120° and no heating, respectively, because of broken filament; in run 139, broken filaments were observed with the heated plate at 140° and 120° and broken filament occurred while drawing at 400 m/min. without heating; in run 140 broken filaments occurred with the plate at 1400 but ran well with the plate at 120 with drawing a 400 m/m while broken filaments were observed with no heating and drawing at 100 m/min.; broken filaments were observed in run 141 without heating; and, in run 142, broken filaments occurred without heating and drawing had to be carried out at 200 m/min.

It is clear, from the results set forth in Table X that the drawing efficiency (lack of broken filaments, etc.) is much better for the narrow molecular weight distribution Polymer C than for the broad molecular weight distribution (conventional) Polymer N, both with the heated plate and with no heating. The actual draw was also higher for Polymer C than for Polymer N and increased as draw tension decreased. The color data shows a greater color effect on Polymer N, when it is cold drawn, than on Polymer C. The hot plate and lower draw tensions appear to improve the color differences of Polymer C samples. The unusual result (low WE) observed in run 142 when the sample of Polymer N spun at 2200 m/min. was cold drawn resulted from the sample continuing to shrink after windup. In general, the low WL values with cold draw indicate that light color results, but this can be remedied by color adjustments. Analysis of the above runs lead to the conclusion that Polymer C can be cold drawn (with a hot plate) during spinning at 1400 to 1800 m/min. and at full extruder output (380#/hr) with only minimal color adjustment.

While specific examples and items of equipment have been set forth herein, it is to be understood that such recitations are illustrative only and are not to be limiting.

CLAIMS

1. A process for making filament yarn; comprising, melt-spinning a polypropylene having a molecular weight distribution of less than about 7 and a resin melt flow between about 20 and about 60, applying a finish, and taking up the filament yarn at a speed above about 1200 meters per minute.

2. A process in accordance with claim 1 wherein the filaments are interlaced before takeup.

3. A process according to claim 2 wherein the filaments are additionally twist-drawn.

4. A process according to claim 2 wherein the filaments are additionally heat set.

5. A process according to claim 2 wherein the filaments are additionally sequentially draw-textured by false twisting.

6. A process according to claim 2 wherein the filaments are additionally simultaneously draw-textured.

7. A process according to claim 2 wherein the filaments are additionally draw-twisted.

8. A process according to claim 2 wherein the filaments are additionally draw-Taslan textured.

9. A process according to claim 2 wherein the filaments are additionally stuffer box crimped and cut into staple fibers.

10. A process for making filament yarn; comprising, melt-spinning a polypropylene having a molecular weight distribution of less than about 7 and a resin melt flow between about 20 and about 60, applying a finish, and taking up the filament yarn at a speed between about 800 and about 1200 meters per minute.

11. A process according to claim 10 wherein a plurality of the yarns are simultaneously draw-textured by false twisting while reversing the direction of twist of alternate yarns and thereafter the said yarns are plied in an interlacing jet.

12. A process according to claim 11 wherein the plurality of yarns are simultaneously draw-textured at a draw ratio between about 2 to 1 and about 4 to 1.

13. A polypropylene filament yarn product melt spun from a polypropylene having a molecular weight distribution of less than about 7 and a melt flow between about 20 and about 60, said filaments having a birefringence above about 0.15, a tenacity above about 2.4 grams per denier, an elongation between about 100 and about 350 percent, and a denier per filament of less than about 25.

14. A polypropylene filament yarn produced according to a process of one of claims 1 to 12.

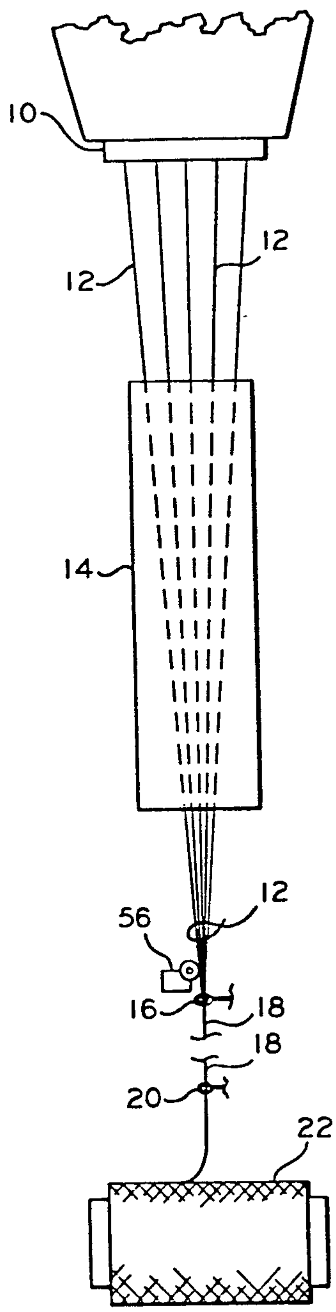
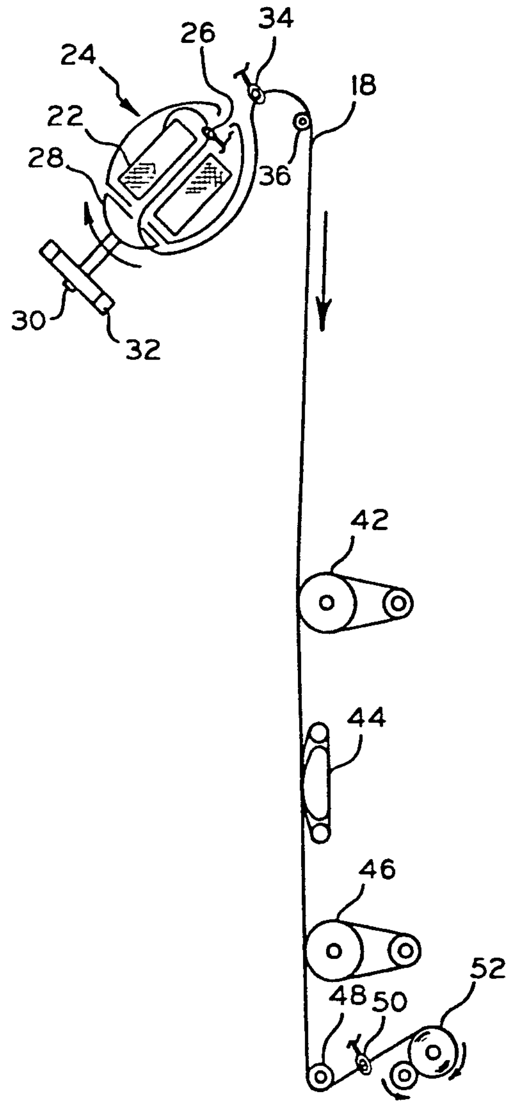

10
12
12
14
12
56
16
18
18
20
22

FIG. 1


24
26
34
18
22
28
36
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32
42
44
46
48
50
52

FIG. 2

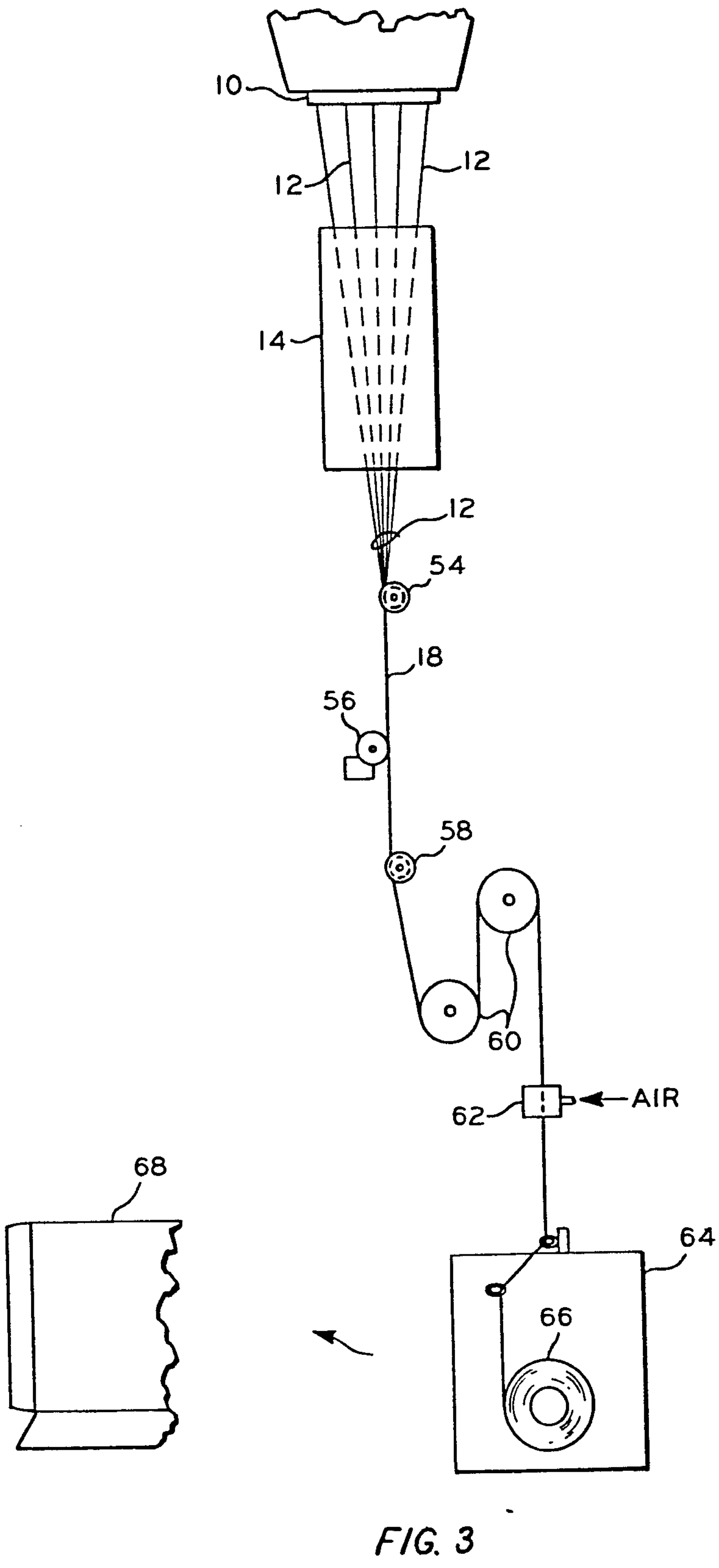

FIG. 3

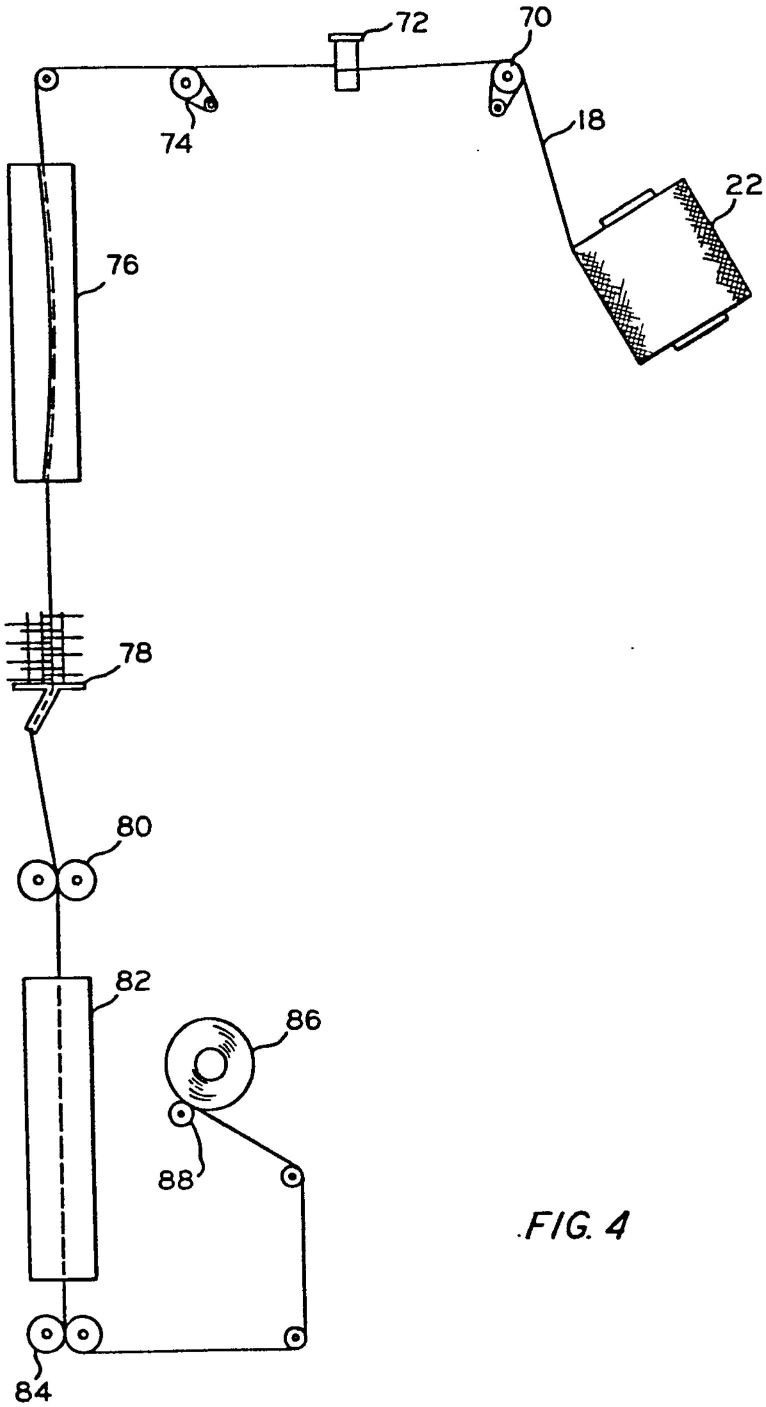

FIG. 4

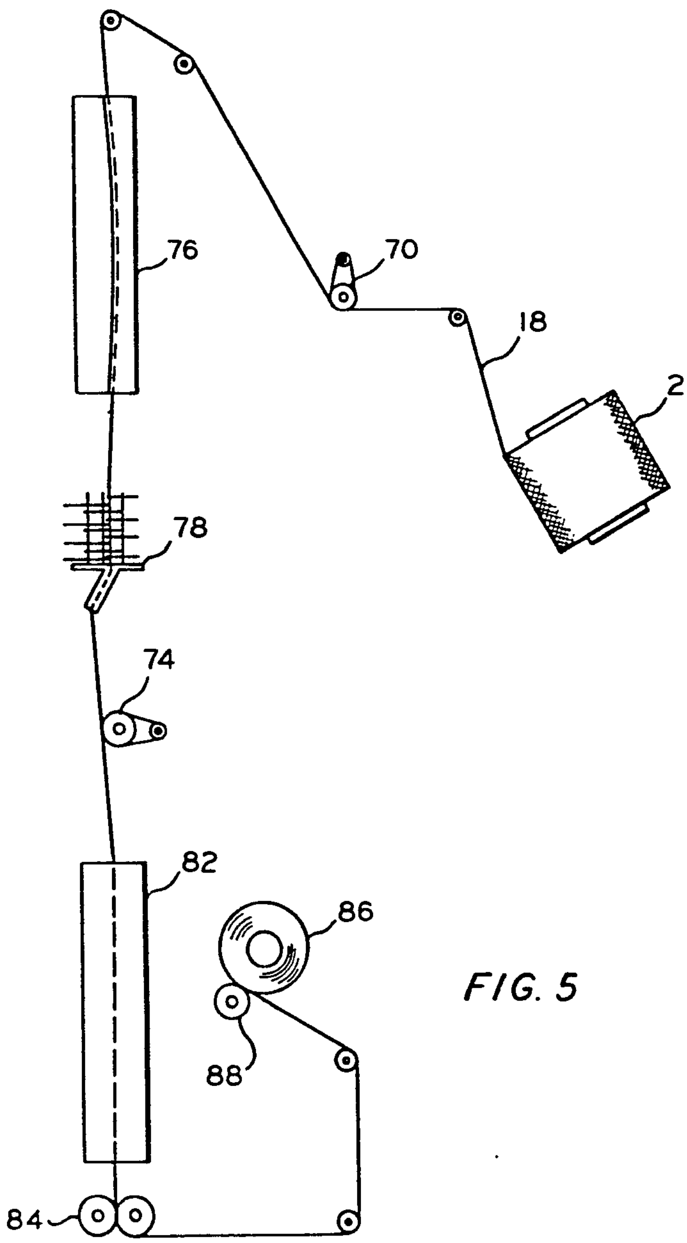

FIG. 5

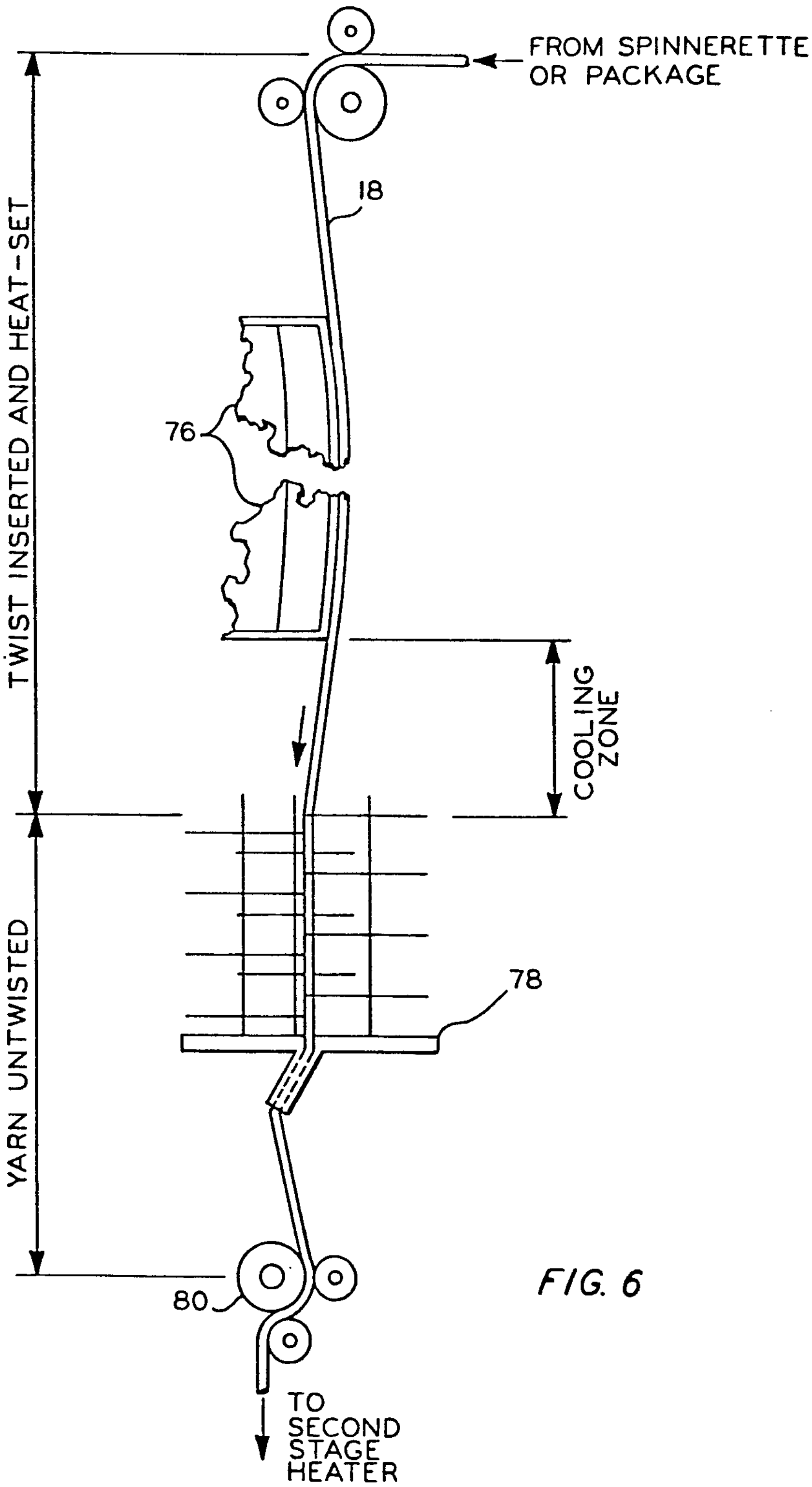
FROM SPINNERETTE OR PACKAGE
18
TWIST INSERTED AND HEAT-SET
76
COOLING ZONE
YARN UNTWISTED
78
80
TO SECOND STAGE HEATER

FIG. 6

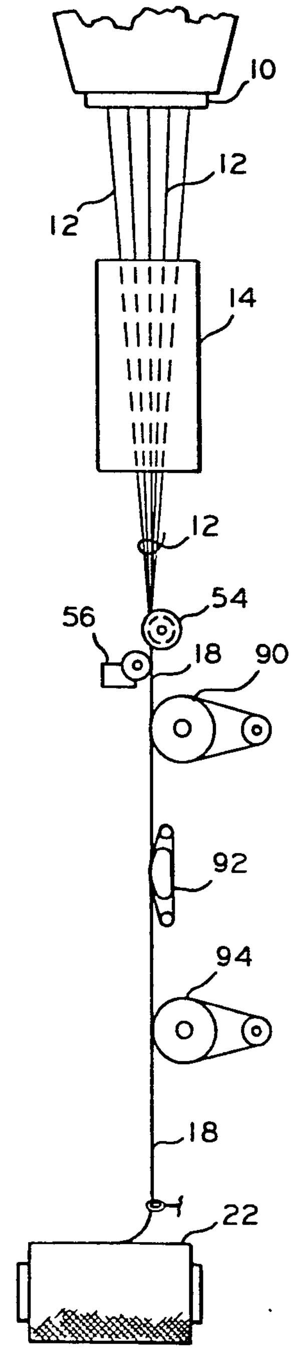

FIG. 7

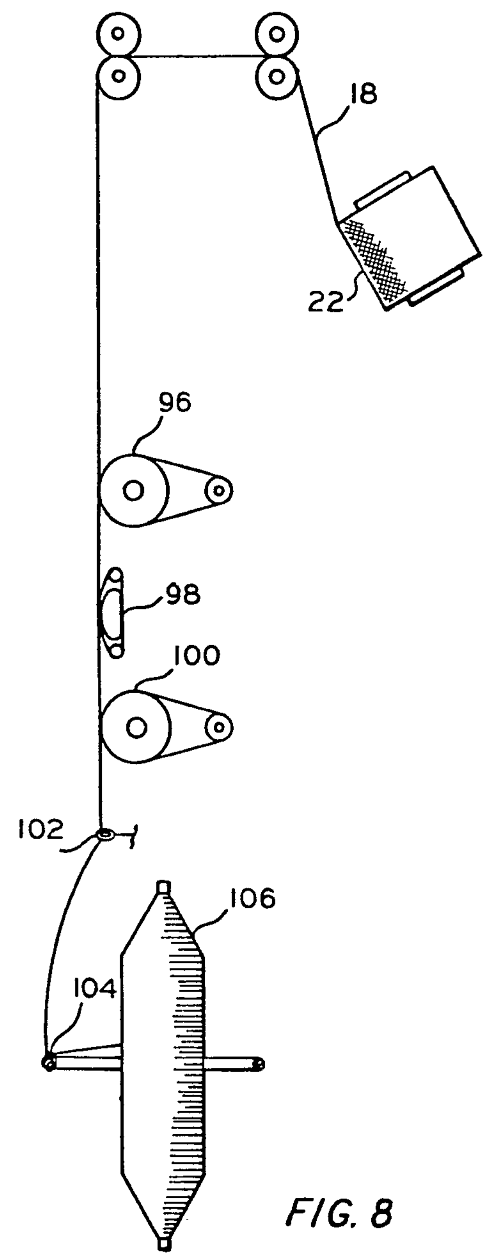

FIG. 8

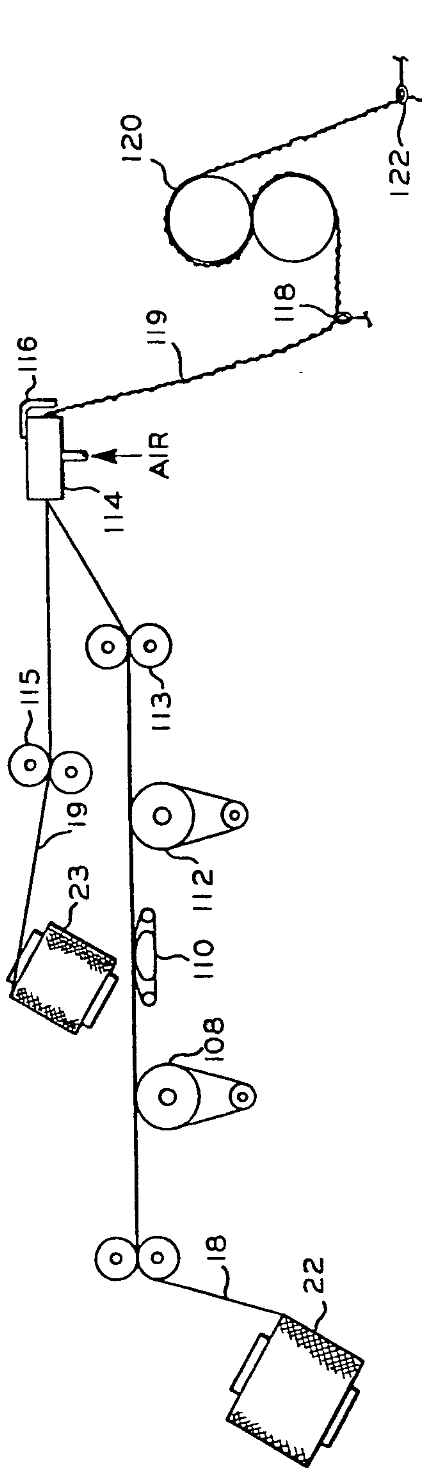
116
119
118
120
122
124
AIR
114
115
113
19
23
112
110
108
18
22

FIG. 9

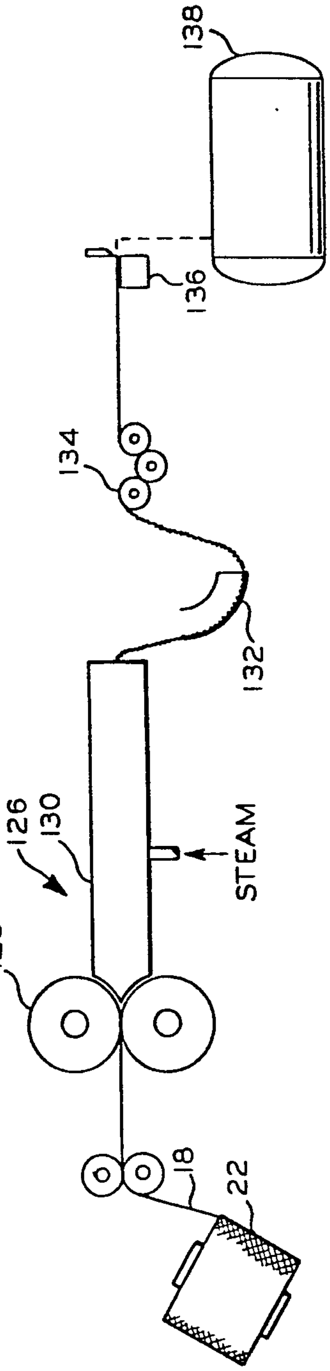
138
136
134
132
126
130
128
STEAM
18
22

FIG. 10

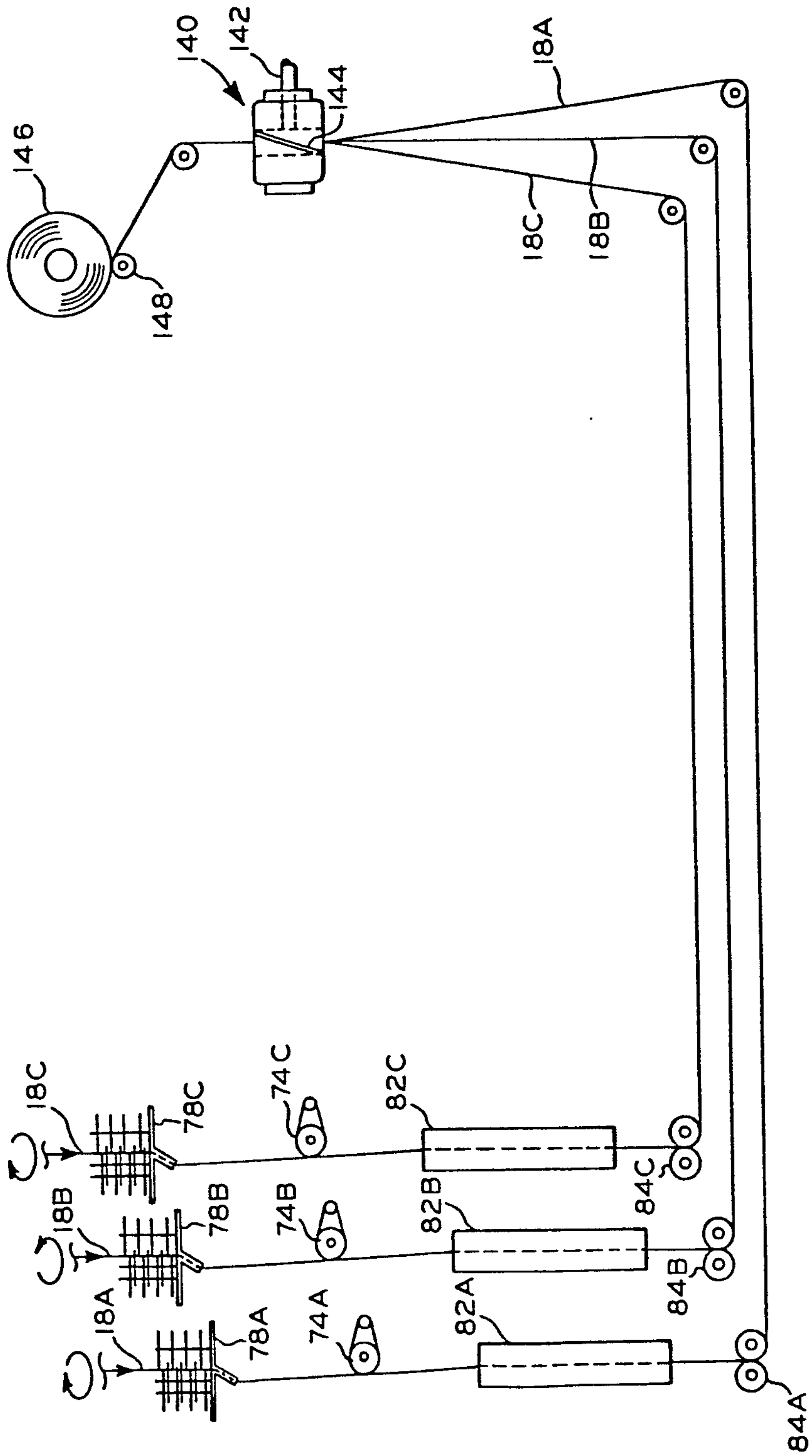
140
142
144
146
148
18A
18B
18C
78C
74C
82C
84C
78B
74B
82B
84B
78A
74A
82A
84A

FIG. 11