Aug. 5, 1969 GORO OZAWA ET AL 3,458,987

JET BUNDLE YARN

Filed Aug. 14, 1967 4 Sheets-Sheet 1

Fig. 1

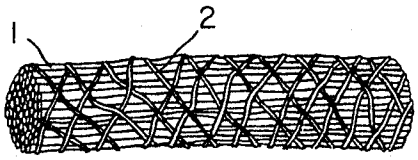


Fig. 2

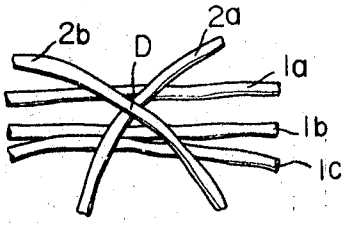


Fig. 3

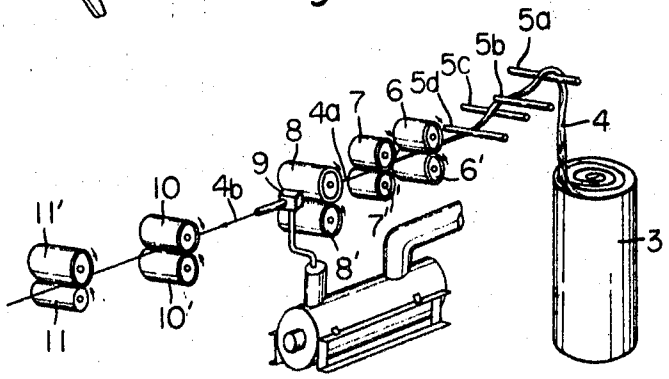


Fig. 4

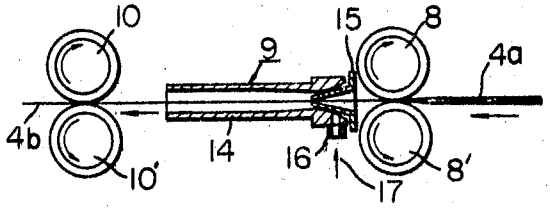


Fig. 5

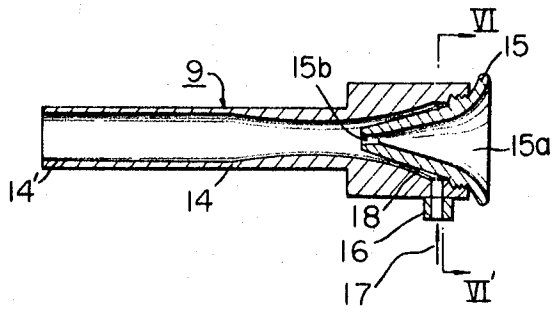


Fig. 6

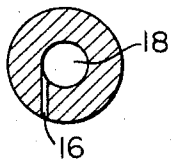


Fig. 7

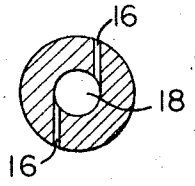


Fig. 8

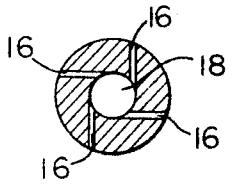


Fig. 9

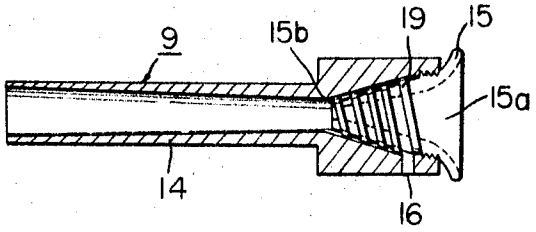
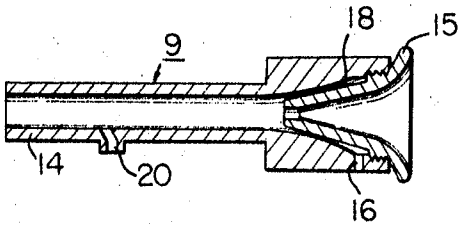


Fig. 10



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JET BUNDLE YARN

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Fig. 11

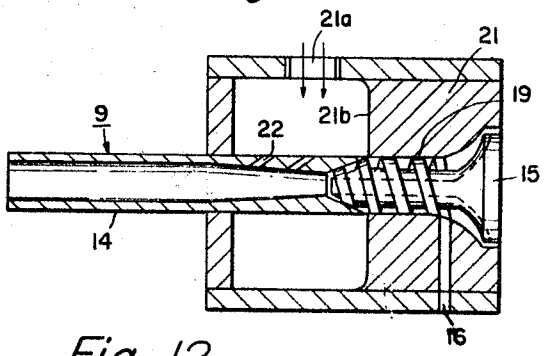


Fig. 12

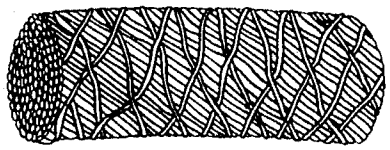


Fig. 13

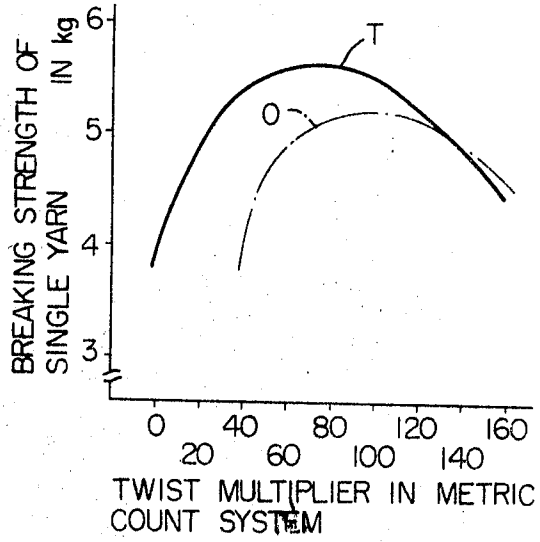


Fig. 14

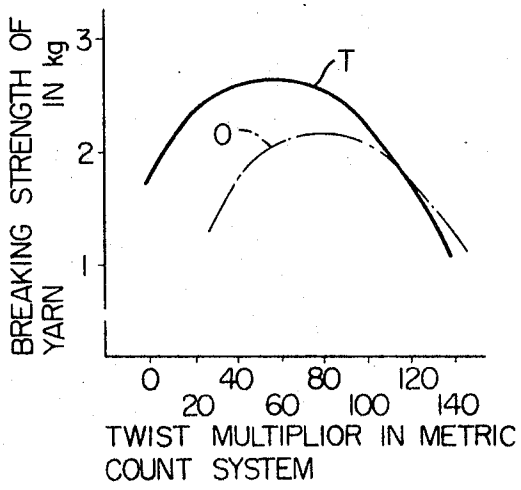


Fig. 15

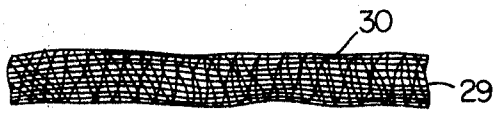
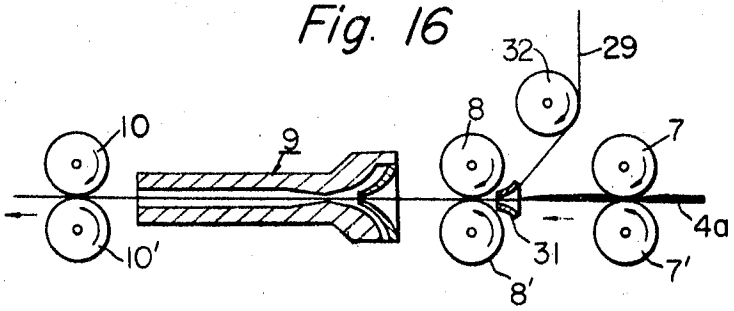


Fig. 16



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3,459,987

JET BUNDLE YARN

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Claims priority, application Japan, Dec. 29, 1966, 42/527; Feb. 8, 1967, 42/7,723; Feb. 13, 1967, 42/8,782; May 16, 1967, 42/30,582
Int. Cl. D02g 3/02
U.S. Cl. 57—140 10 Claims

ABSTRACT OF THE DISCLOSURE

A jet bundle yarn is composed of core portions having a relative alignment of staple fibers to that of the feed material and a circumferential portion composed mainly of continuous net-like structure composed of staple fibers fixed to each other at their crossing portions and at their ends. Some modified configurations of jet bundle yarns are disclosed.

This invention is a co-pending application in respect to our patent application for super high speed spinning method and apparatus for manufacturing jet bundle yarn, Ser. No. 660,301 filed Aug. 14, 1967. This invention relates to a jet bundle yarn, more particularly, to a novel and practical jet bundle yarn comprising a core portion having the similar relative alignment of staple fibers to that of the feed material and a circumferential portion mainly comprising a continuous net-like structure composed of the staple fibers which are fixed to each other at their crossing portions and at their ends.

In the conventional spinning process, the production speed of the spun yarn is limited to 100 m./min., practically, the main reason of the limitation of the production speed is due to the fact that it is quite difficult to produce practical yarns if the spinning speed is over 100 m./min., in other words, it is almost impossible to spin yarn by the conventional twisting and winding method, in the above-mentioned high speed condition.

Fluid twist yarn was made known by the Czechoslovakian Patent No. 91,208, issued in 1958, and disclosed in the technical information of Textilni Strojirenstvi, 1961 (pp. 156–160). According to the above-mentioned prior art, the relative fiber alignment of the fed material must be completely changed to a configuration by the draft action of the fluid stream for producing twisted yarn which has a configuration similar to the conventional spun yarn. However, the yarn strength of the fluid twist yarn is inferior to the conventional spun yarn at present and the practical counts of the fluid twist yarn is up to 40^s (English count system), moreover the appearance of the fluid twist yarn produced is fluffy. Therefore, the fluid twist yarn cannot be considered as being what is generally known as commercial yarn, as yet.

On the other hand, U.S. Patents No. 3,009,309 and No. 3,279,164, issued in 1961 and 1966, respectively, also disclosed the prior arts for producing fluid twisted yarn.

However, in the above-mentioned U.S. patents, the yarns produced are always fancy yarns such as sheaf-yarn. Therefore, the end use of the yarns produced by the above-mentioned U.S. patents are restricted to obtaining a fancy effect only, and it is known that the production speed of the yarn according to the above-mentioned U.S. patent is limited to 100 m./min.

An object of the present invention is to provide novel and practical jet bundle yarns having useful properties for industrial use, or woven or knitted cloth for garments.

A further object of the invention is to provide novel jet bundle yarns without the normal twist configuration and fluffy appearance, but having uniform thickness of yarn and practical properties not inferior to the conventional spun yarn, further having a crispy handling quality.

It is a still further object of the present invention to provide economical jet bundle yarns in high production efficiency.

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

FIG. 1 is a perspective view of an embodiment of the jet bundle yarn according to the invention,

FIG. 2 is an enlarged explanatory view for showing the surface of the jet bundle yarn shown in FIG. 1,

FIG. 3 is a perspective view of an embodiment of the apparatus for producing the jet bundle yarn of the invention,

FIG. 4 is a side view, partly section of the jet bundling member of the apparatus shown in FIG. 3,

FIG. 5 is an enlarged side view of the jet bundling member shown in FIG. 4,

FIGS. 6, 7 and 8 are the cross-sectional views of several embodiments of jet bundling member, taken along line VI–VI', shown in FIG. 5,

FIGS. 9, 10 and 11 are sectional side views of several embodiments of the jet bundling member of the invention, in which the jet stream of fluid passes through vortically to bestow the jet bundling effect to the fed material,

FIG. 12 is an enlarged perspective view of the jet bundle yarn in modified spinning conditions,

FIGS. 13 and 14 are comparative diagrams for showing the relation between the breaking strength of single yarn and twist multiplier of the yarn produced according to the invention and the conventional spun yarn, respectively,

FIG. 15 is an enlarged side view of the modified jet bundle yarn of the invention,

FIG. 16 is a schematic side view of the main portion of the apparatus for producing the modified jet bundle yarn shown in FIG. 15.

Referring to FIGS. 1 and 2, the typical jet bundle yarn produced by the jet bundling process according to the invention has a novel configuration, that is, the yarn of the invention comprises an inside element or a core portion 1 composed of staple fibers mainly aligned in the lengthwise direction of the yarn, a circumferential portion mainly comprising a continuous net-like structure 2 composed of the staple fibers which are fixed to each other at their crossing portions and their ends. Therefore, the core portion of the yarn of the invention does not have a twisted configuration, principally.

It has been disclosed by experimental results that the yarn of the invention has practical mechanical properties including tensile strength which is not inferior to those of the conventional twisted spun yarn having a twist multiplier of more than 40 in metric count system in spite of the above-mentioned particular configuration of the yarn.

To make clear the particular configuration of the jet bundle yarn of the invention, an apparatus and method for producing the jet bundle yarn is hereinafter explained.

Referring to FIG. 3, an apparatus for producing jet bundle yarn of the invention comprises, a container **3** for reserving the spinning material **4**, a guide members **5***a*, **5***b*, **5***c* and **5***d* for feeding the material **4** to the apparatus, a draft element composed of at least a pair of back rollers **6** and **6'** and a pair of front rollers **8** and **8'** which rotate at a high surface speed above 300 m./min., a pair of front rollers **8** and **8'** for feeding the drafted material into a jet bundling member **9** through which a heated vortical fluid stream is passed under a high pressure, a pair of take-up rollers **10**, **10'**, and a conventional winding device **11**.

The spinning material **4** composed of staple fibers is drafted by a draft element comprising the back rollers **6** and **6'** and the front rollers **8** and **8'**, then the drafted material **4***a* is fed to a jet bundling member **9** through which the heated vortical fluid stream is passing under high pressure, thereby the fibers positioned at the circumferential portion of the drafted material **4***a* are only twisted around the inside element, composed of the fibers of the drafted material, and then the material delivered from the nozzle shaped member is taken up by the take-up rollers **10** and **10'** positively, and wound in a package **11'**, at the speed of more than 300 m./min. In case of the material for yarn containing some thermoplastic synthetic fibers, and when the temperature of the vortical fluid stream is sufficiently high to melt the thermoplastic synthetic fibers, the synthetic fibers contained in the circumferential portion of the yarn shrink and are fixed to each other at the crossing portions and the end points. Consequently, a net-like configuration **2** of fibers is formed at the circumferential portion of the yarn which binds firmly the inside element or core portion **1** of the yarn, thus the novel jet bundle yarn is produced.

To fix the fibers of the circumferential portion of the yarn and to bind firmly the inside element of fibers of the yarn produced, it is necessary to bond the fibers of the circumferential portion. The above-mentioned manner of using some thermoplastic synthetic fibers is one method, when the vortical fluid stream is maintained at sufficiently high temperature to melt the synthetic fibers, the heated fluid can be used for this purpose.

However, the following method can be used when the fed material does not include thermoplastic fibers. That is, cotton fiber, rayon staple fibers, wool, acetate staple fiber, silk cut fiber, some mineral fibers etc., all kinds of materials for making yarn can be used for producing the jet bundle yarn according to the present invention. This requires that a suitable fixing or binding agent of fibers be included in the circumferential portion of the yarn produced by the invention, such as a fixing agent or bonding agents be included in the fluid stream or that certain thermoplastic agents be attached to the fed material.

The above-mentioned thermoplastic synthetic fiber is not restricted to a particular fiber, but means all kinds of fibers such as polyamide fiber, polyester fiber, acrylic fiber, polyolefin fiber, polyvinyl alcohol fiber, polyvinyl chloride fiber may be used and their blended fibers. Moreover, by our mill test, it is also possible to produce a practical yarn composed of a core portion of filament yarns and a net-like configuration of short fibers surrounding the core yarn by using the above mentioned apparatus.

Referring to FIG. 5, the jet bundling member **9**, which can be used for manufacturing the jet bundle yarn of the invention, comprises an aspirator type inlet **15** and a nozzle like fluid stream conduit pipe **14** and a heated stream supply inlet **16**. The inside end of the inlet **15** is converged considerably and the starting portion of the pipe **14** is diverged as shown in the drawing. As the fluid stream is fed through the inlet into the pipe **14** under pressure in such a way that the fluid is fed in a tangential direction of a conical narrow space **18** between the inside end portion of the aspirator type inlet **15** and the cylindrical inside wall of the pipe **14** surrounding the inlet **15**, the fluid stream assumes a supersonic condition or the like. As the fluid inlet offsets with the narrow conical space **18** in a tangential condition, the vortical stream is produced in the pipe and is ejected from the outlet portion **14'** of the pipe **14**. The pressure of the vortical stream in the pipe **14** is much lower than the pressure at the diverged portion **15***a* of the aspirator type inlet **15**. Consequently, the drafted material **4***a* is easily sucked into the aspirator type inlet **15**. The length of the pipe **14** should be sufficiently long so as to bestow a jet bundling motion to the fibers contained in the circumferential portion of the drafted material **4***a*. In the pipe **14**, the fibers forming the main portion of the drafted material **4***a* still maintain their configuration, while the complete separation of the individual fibers contained in the drafted material takes place in the fluid twisting device of the prior art of the Czechoslovakian Patent No. 91,208. In the prior arts of U.S. Patents Nos. 3,009,309 and 3,279,164, the fluid conduits through the tube wall intercept the passageway with the conduit axis offset with respect to the axis of the passageway for producing a fancy effect of produced yarn. However, in the apparatus of the present invention, the fluid inlet **16** which corresponds to the above-mentioned fluid conduits through tube wall does not intercept the passageway of the drafted material in the pipe **14** to prevent the irregular twisting of the fibers contained in the circumferential portion of the drafted material as clearly shown in FIG. 5.

The drafted material **4***a* sucked into the aspirator type inlet **15** and the pipe **14** is temporarily twisted by the vortical stream while passing through the pipe **14**.

The fibers contained in the circumferential portion of the drafted material **4***a* are twisted around the main portion of the drafted material **4***a* by a twisting action of the vortical fluid stream while passing the pipe **14**. Therefore, the above-mentioned twisted fibers form a net-like configuration **2** surrounding the main inside portion **1** of the drafted material **4***a* and thereby, the fibers contained in the main inside portion **1** of the material **4***a* are firmly bundled by the net-like configuration **2**. It is necessary to set the above-mentioned configuration while the drafted material **4***a* passes through the pipe **14** to form a stable configuration of yarn. When certain thermoplastic synthetic fibers are blended in the spinning material **4**, or the spinning material **4** is composed of certain thermoplastic synthetic fibers and the supplied fluid is maintained at a sufficiently high temperature to shrink and melt the synthetic fibers, the fibers forming the net-like configuration **2** shrinks and are partly melted, the fibers forming the net-like configuration **2** are fixed to each other at their crossing portions and their end points, consequently, a novel jet bundle yarn **4***b* having a stable configuration is produced while the drafted material **4***a* is passing through the pipe **14**.

In the drawings of FIGS. 1 and 2, the main inside element or core portion **1** of the jet bundle yarn **4***b* is firmly bundled by the net-like portion **2** which comprises bound fibers **2***a*, **2***b*, surrounding the fibers **1***a*, **1***b*, **1***c* etc. of the main inside element of the yarn in such a way that the bound fibers **2***a*, **2***b*, etc. are firmly fixed to each other at their crossing portion D and fixed to the fibers **1***a*, **1***b*, **1***c*, etc. of the inside element of the yarn **1** at their contact portions. The yarn **4***b* produced is taken up by the take-up rollers **10** and **10'** and then wound into a package **11'** by the winding device **11**. As

described above, the ends of fluffy fibers are almost eliminated from the surface of the drafted material 4*a*, therefore, yarn without fluffy fiber ends can be produced by the apparatus of the invention.

Referring to FIGS. 5, 6, 7 and 8, in the jet bundling member 9 comprising the aspirator type inlet 15, the nozzle like fluid stream pipe 14 and the fluid stream inlet 16, the inlet portion 15*a* of the aspirator type inlet 15 is diverged considerably toward the front rollers 8 and 8', and the inside portion 15*b* is inserted into the starting portion of the pipe 14 in such a way that the end of the starting portion is secured to the inlet portion 15*a* of the inlet 15 by thread engaging in such a way that the inside cylindrical wall surrounds the outside wall of the aspirator type inlet 15 so as to provide a conical narrow space 18 between the starting portion and the inlet 15 as shown in the drawing. Consequently, any combination of the aspirator type inlet 15 with the fluid stream pipe 14 can be easily obtained. To obtain an effective vortical stream in the pipe 14, several types of the fluid inlet 12 can be considered. In FIGS. 6, 7 and 8, a single fluid inlet, duplicate or quadruplicate fluid inlets 16 are respectively shown. Every fluid inlet 16 is offset with respect to the conical narrow space 18 in such a way that the fluid is fed tangentially to the conical narrow space 18 so as to produce a vortical fluid stream which is ejected from one end of the pipe 14. To obtain a more continuous vortical fluid stream in the pipe 14, the aspirator type inlet 15 is provided with a spiral groove 19 for restricting the passage of the fed fluid stream, as shown in FIG. 9.

In FIG. 10, a supplementary fluid inlet 20 which is offset with respect to the fluid passageway in the pipe 14 is provided. The fluid is also fed into the fluid passageway in the pipe 14 tangentially to the cylindrical inside wall of the pipe 14 so as to accelerate the vortical fluid stream without any intercepting action on the drafted material passing through the pipe 14.

In FIG. 11, another type of the jet bundling member which can be used for producing the jet bundle yarn of the invention, comprises a main portion of the member 9 and a supplementary jacket 21 surrounding the main portion 9. The main portion 9 has the same configuration as that of the embodiment shown in FIG. 9, with the exception that a plurality of supplementary fluid conduits 22 are disposed to the starting portion of the pipe 14 in such a way that the conduits 22 are disposed so as to feed the supplementary fluid stream in a tangential and forward direction to the inside wall of the pipe 14, as shown in FIG. 10.

The main fluid stream is supplied to the member through the inlet 16 and the supplementary stream is supplied into the fluid passage through the inlet 21*a* disposed to the jacket 21, which goes into space 21*b* formed by the inside wall of the jacket 21 and the pipe 14 and then passes through the supplementary conduits 22.

In the above-mentioned embodiments of the jet bundling members which can be used for manufacturing jet bundle yarn of the invention, the following condition should be considered, that is:

(1) The sucking force at the diverged inlet portion 15*d* should be sufficient to introduce the drafted material 1*a* so as to obtain easy starting of the operation and provide starting operation without yarn breakage.

(2) The jet bundling action in the pipe should be sufficient to form the net-like configuration of staple fibers surrounding the main portion of the yarn. In other words, the vortical stream in the pipe 14 must be sufficiently strong to form the net-like configuration.

(3) The relative position of fibers contained in the main portion of the drafted material 1*a* must be maintained while passing through the pipe 14.

(4) The fibers composed of the net-like configuration must be bonded to each other while or just after passing the pipe 14.

The arrangement of the elements of the jet bundling member described above are designed to conform with the above-mentioned necessary conditions.

The inside diameter of the pipe 14 is dependent upon the yarn count, but from 4 mm. to 20 mm. is preferable, the length of the pipe 11 must not be less than four times the inside diameter of the pipe 14, and it is preferable to provide a length from 10 times to 200 times, but less than 500 times of the inside diameter.

When the net-like configuration is coarse, the jet bundle yarn is provided with a low twist by the conventional twister after take-up the jet bundle yarn, thereby a yarn comprising a combination of jet bundle and conventional twist which is stronger than the conventional spun yarn can be produced. In FIG. 12, an enlarged configuration of the above-mentioned combination twisted yarn is shown. The preferable twist multiplier is less than 70 in the metric system. In FIGS. 13 and 14, the comparative diagrams showing the relation between the breaking strength of yarn and the twist multiplier of the yarn are shown. In the diagrams O designates the conventional yarn and T designates the combination yarn according to the present invention. The first case shown in FIG. 13 is for $1/10^s$ (metric count system) of polypropylene yarn composed of 2 den. fibers, and the second case shown in FIG. 14 is for $1/20^s$ (metric count system) of acrylic fiber yarn composed of 3 den. fibers. It is clear from these that the strength of the single yarn according to the present invention is superior in both cases. Further, by the after heat-treatment of the jet bundle yarn provided with the above-mentioned additional low twist at above 80° C., it is easy to obtain the yarn having at least the same breaking strength as conventional spun yarn, even though the yarn count and the spinning material are the same in both case.

In FIG. 15, a modified jet bundle yarn of the invention comprises a core portion 29 which is composed of a plurality of individual filaments, and a net-like configuration 30 surrounding the core portion 29 which is composed of a plurality of staple fibers. The net-like configuration 30 binds the core portion 29 firmly, when the fibers composing the net-like configuration 30 have shrinkable and meltable properties by heat and the yarn produced is further heated to shrink the fibers contained in the net-like configuration. In FIG. 16, a main portion of a modified embodiment for manufacturing the modified jet bundle yarn of the invention is shown, wherein, a multifilament 29 is fed to the pair of feed rollers 8 and 8' through a trumpet-like guide member 31, while a drafted material 4*a* is also fed to the feed rollers 8 and 8' through a trumpet like guide member 31, and then both spinning materials are sucked into the jet bundling member 9 through which a superposed vortical fluid stream is passing, and the yarn produced is taken up by the take-up rollers 10 and 10' by the same manner as described in the first embodiment for producing yarn of the invention. When the drafted material 4*a* composed of thermoplastic synthetic fibers, and the superposed vortical fluid stream is maintained at a sufficient high temperature to melt the synthetic fibers, the staple fibers of the drafted material forms a stable net-like configuration binding the core portion of yarn comprising the multi-filament 29. The modified yarn produced can be practically used as a commercial textile yarn.

Example 1

A polypropylene two (2 den./filament, total denier 360,000 D) is used as a material and sliver produced from the tow by a Perlok machine is fed to the jet bundling apparatus shown in FIG. 1, and several jet bundle yarns are produced, as shown by the following conditions.

Yarn count—$1/10^s$ metric count system

Draft element—Ambler system
Draft ratio between the back roller and the front roller—50
Jet bundling member (shown in FIG. 5):
Feed inlet of fluid stream—Single
Inside diameter of the pipe **14**—10 mm.
Length of the pipe **14**—400 mm.

The following table shows the comparative conditions of the jet bundling process.

No.	Surface speed, m./min. Front roller	Take-up roller	Working tension in g.	Fluid stream: Medium	Temp., °C.	Pressure in kg./cm.²	Yarn: Configuration	Breaking strength in g.
1	2,000	2,100	10	Steam	130	4.0	C	<50
2	2,000	2,100	15	Superheated steam	160	2.0	C	<100
3	2,000	2,100	25	do	230	1.5	B	2,200
4	2,000	2,100	25	do	230	2.0	B	2,600
5	2,000	2,100	30	do	230	3.0	A	4,800
6	2,000	2,100	30	do	280	2.0	A	4,900
7	3,500	3,675	15	do	180	2.0	C	<100
8	3,500	3,675	25	do	230	2.6	B	1,800
9	3,500	3,675	25	do	230	3.0	B	1,900
10	3,500	3,675	30	do	280	2.0	A	3,800
11	3,500	3,675	30	do	330	2.0	A	4,000

In the table, A designates the remarkably stable configuration of yarn, B designates the stable configuration of yarn, C designates the yarn configuration having less net-like configuration weak strength yarn. So, we can understand that the temperature and pressure of the vortical stream are important factors to produce practical yarn of the invention.

Example 2

A polypropylene tow (2-den./filament, total denier 360,000 D) is draft cut by the Perlok machine and the sliver produced of 5.0 g./m. weight is supplied to the apparatus shown in FIG. 3, under the following conditions.

Yarn count—1/10^s metric count system
Draft element—Ambler system
Draft ratio between the back roller and the front roller—50
Jet bundling member (shown in FIG. 5):
Fluid inlet of fluid stream—Double
Inside diameter of the pipe **14**—10 mm.
Length of the pipe **14**—200 mm.

The following table shows the comparative conditions of the jet bundling process.

No.	Surface speed, m./min. Front roller	Take-up roller	Working tension in g.	Fluid stream: Medium	Temp., °C.	Pressure in kg./cm.²	Yarn: Configuration	Breaking strength in g.
12	2,000	2,100		Air	20	4.0	D	
13	2,000	2,100		Steam	130	3.0	D	
14	2,000	2,100	15	Superheated	180	3.0	C	<100
15	2,000	2,100	25	do	230	1.5	B	2,200
16	2,000	2,100	35	do	230	2.0	B	2,600
17	2,000	2,100	35	do	230	3.0	A	4,800
18	2,000	2,100	25	do	280	2.0	A	4,900
19	3,500	3,675	25	do	230	1.5	C	<100
20	3,500	3,675	25	do	230	2.0	B	1,800
21	3,500	3,675	15	do	230	3.0	B	1,900
22	3,500	3,675	35	do	280	2.0	A	3,800
23	3,500	3,675	35	do	330	2.0	A	4,000

As shown in the table, almost the same result disclosed in Example 1 is obtained. In the table, D designates the failure to produce yarn.

Example 3

An acrylic fiber tow (3 den./filament, total denier 480,000 D) is supplied to the Turbo-stapler and a draft cut sliver having shrinkable property is produced, then the draft cut slivers are provided with a relaxation treatment under the following conditions.

No.	Relaxation treatment: Medium	Treating period	Shrinkage by steam of 130° C. in percent
24	130° C. steam	20 minutes	0
25	100° C. steam	do	2
26	70° C. steam	do	5
27	65° C. steam	do	10
28	60° C. steam	do	15
29			24

A spinning material of 2.0 g./meter **1***a* is produced by a gill-box from the above-mentioned relaxed sliver and several jet bundle yarns are produced under the following conditions:

Yarn count—1/20^s metric count system
Draft element—Double apron system
Draft ratio between the back roller and the front roller—50
Surface speed of the front roller—2,000 m./min.
Fluid used stream:
Temp. of super-heated steam 450° C.
Gauge pressure 2 kg./cm.²
Jet bundling member (shown in FIG. 5):
Fluid inlet—Single
Inside diameter of the pipe **14**—8 mm.
Length of pipe **14**—300 mm.
Effective temp. of the vortical fluid—320° C.
Stretch ratio between the front roller and the take-up roller—0.95–1.05

Note: When in the case of using normal fiber without shrinkable property is used, the stretch ratio is preferable more than 1%.

The following table shows the quality yarn produced of the example.

No.	Spinning condition	Configuration	Working tension in g.	Breaking strength in g.
24	Very poor	D		
25	do	C	20	200
26	Better	B	28	546
27	Best	A	30	750
28	do	A	30	764
29	do	A	30	785

The yarn produced designated by A has a very fine configuration and sufficient strength for practical use.

Example 4

The non-shrinkable sliver (designated by No. 24) and the shrinkable sliver (designated by No. 29) of Example 3 are blended by a gill-box in ratio of 80/20, 20/40, 40/60 respectively, and three blended slivers of 2.0 g./m. are prepared. The jet bundling is carried out under the same condition as that of the Example 3 by using the same jet bundling member. The jet bundle yarns are produced from the above-mentioned prepared slivers, as shown in the following table.

	Fiber composing prepared sliver		Spinning condition, working tension in g.	Yarn quality	
	Non-shrinkable fiber in percent	Shrinkable fiber in percent		Configuration	Breakng strengh in g.
No.:					
30----	80	20	28	B	529
31----	60	40	30	A	681
32----	40	60	30	A	763

Note: The spinning operation of No. 30 was carried out without any trouble, but those of the others were carried out in good condition.

As it is clearly shown in the above result, it is preferable to blend more than 20% of the shrinkable fiber in order to obtain the better results.

Example 5

A polypropylene tow (15 den./filament, total denier 450,000 D) is used as the material and is sliver produced from tow of these by a Perlok machine, heat shrinkage of this is 13.6% in steam of 130° C., and this is fed to the fluid twisting apparatus shown in FIG. 3, to produce several fluid twisted yarns under the following condition.

Yarn count—1/6's metric count system
Draft element—Conical fluid control system
Draft ratio between the back roller and the front roller—30
Surface speed of the front roller—1,500 m./min.
Surface speed of the delivery roller—1,515 m./min.
Fluid used stream:
Temp. of super-heated steam—300° C.
Gauge pressure—2.5 kg./cm.²
Fluid twisting member (see FIG. 10):
Fluid inlet—4
Dia. of yarn passage—75 mm.
Length of yarn passage—1,000 mm.
Heating temperature—300° C.

Effective temperature of vortical fluid stream—230° C.
Processing tension—35 g.

The jet bundle yarn thus produced has a breaking strength of 3,300 g. breaking extension of 7.5% and uniform appearance with little fluffs.

The following cloth is produced by using the jet bundle yarn produced by the above-mentioned method.

Structure: Plain weave
Yarn used:
Warp—1/6s metric count system
Filling—1/6s metric count system

Yarn density:
Warp—15 inch
Filling—13 inch

The weaving operation was operated without any preparatory treatment of yarn such as a sizing treatment, in an excellent condition. By the above-mentioned mill test, the excellent weaving quality of the jet bundle yarn without a sizing operation were noticed. The weight of the cloth produced was 195 g./m.², and the cloth produced has sufficient quality for using as a base fabric of carpet.

Example 6

The single yarn of 1/20s metric count system produced (designated by No. 29 in Example 3) is set in a restricted condition by steam of 130° C. for 20 min.

The single yarn treated has the following properties.

Breaking strength—870 g.
Breaking elongation—16.5%
Shrinkable property in the boiling water—2.5%

Next, the yarn is treated by the preparatory wet treatments comprising yarn dyeing (hank), softening treatment and sizing, and weaved and finished. The preparatory wet treatment, weaving and finishing were operated in the same manner as the conventional methods. The cloth having the following structure was easily processed in the same way as the conventional cloth made of the conventional yarn.

Structure of cloth:

Warp yarn—1/20s metric count system
Weft yarn—1/20s metric count system
Density—
Warp—48 inch
Weft—41 inch
Plain weave suitable for "Tweed"

The cloth produced has weight of 200 g./m.² and has an excellent handling quality with a suitable soft feeling and uniform appearance with little fluffs. Consequently, the cloth produced is a suitable material for ladies suits.

Example 7

The single yarns of 1/20s metric count system (designated by No. 31 in Example 4) are doubled by a conventional doubler and then twisted by a conventional twister to produce an S twist of 200 turns/meter, and made into hanks of twisted yarn. The weft knitted-cloth of plain knitting was made by the above-mentioned yarn, after high-bulk treatment by steam of 100° C. for 15 min., yarn dyeing, softening treatment, rewinding. The grey knitted-cloth is set by steam of 100° C. The above-mentioned treatments were operated without any troubles in the same way as the treatment for conventional spun yarns, and the knitting operation was performed by using hand knitting machine. The knit cloth produced has weight of 250 g./m.², and an excellent handling quality with a suitable soft feeling and uniform appearance with little fluffs. Consequently, the knitted-cloth produced is suitable material for ladies' or children's sweaters.

Example 8

A polypropylene tow (2 den./filament, total denier 420,000 D) is used as the material, and sliver produced from the tow by a Perlok machine with a cutting ratch of 200 mm. is fed to the drawing machine and the roving machine to produce roving yarn having weight of 0.5 g. Roving yarn thus produced with heat shrinkage of the component fiber 14.3% in steam of 130° C., is then fed to a jet bundling apparatus shown in FIG. 3, and several jet bundle yarns are produced under the following condition.

Yarn count—1/80s metric count system
Draft element—Double apron system
Draft ratio between the back roller and the front roller—40
Surface speed of the front roller—2,000 m./min.
Surface speed of the delivery roller—2,060 m./in.
Fluid used:
Temp. of super-heated steam—200° C.
Gauge pressure—1.7 kg./cm.²
Jet bundling member (see FIG. 10):
Fluid passage—2
Dia. of yarn passage—6 mm.
Length of yarn passage—200 mm.
Effective temperature of vortical fluid stream—200° C.
Processing tension—25 g.

The manufactured jet bundle yarn has a breaking strength of 430 g. and breaking elongation of 7.0%, with uniform appearance having little fluffs, and superior handling quality of crispness.

Example 9

A high shrinkage polyester tow (3 den. x 152 mm.) is used as the material, and the sliver produced from the tow by a roller card is fed to the gill-box for doubling and drafting to produce a sliver having the weight of 2.0 g./m. The sliver thus produced, whose component fiber having heat shrinkage of 25% in steam of 130° C., is then fed to the jet bundling apparatus shown in FIG. 3, and several jet bundle yarns are produced under the following condition.

Yarn count—1/20's metric count system
Draft ratio between the front roller and the back roller—40
Surface speed of the front roller—2,000 m./min.
Surface speed of the delivery roller—2,000 m./min.
Fluid used:
Temp. of super-heated steam—320° C.
Gauge pressure—2.0 kg./cm.²
Jet bundling member (see FIG. 10):
Feed inlet of fluid stream—2
Dia. of yarn passage—8 mm.
Length of yarn passage—300 mm.
Effective temperature of vortical fluid stream—240° C.
Processing tension—27 g.

Jet bundle yarn produced has a breaking strength of 1,650 g., an excellent durability suitable for processing in weaving and knitting and with uniform appearance having less fluffs. On the other hand, jet bundle yarn produced from non-heat-shrinkage polyester fiber has a breaking strength of 560 g. and a weaker twisting condition.

Example 10

A draft cut sliver from a polyvinyl alcohol fiber (2 den./filament, total denier 200,000 D) is produced by a Perlok machine and a sliver of 2.0 g./meter is prepared by a drawing machine from the draft cut sliver. The sliver thus prepared has a shrinkage of 37% in 130° C. superheated steam. This material is fed to the apparatus shown in FIG. 3 and a jet bundle yarn is produced under the following condition.

Yarn count—1/20 metric count system
Draft element—Pressure draft system
Draft ratio between the back roller and the front roller—40
Surface speed of the front roller—2,000 m./min.
Surface speed of the take-up roller—1,970 m./min.
Fluid used:
Temp. of super-heated steam—400° C.
Gauge pressure—2.0 kg./cm.²
Jet bundling member (shown in FIG. 11):
Fluid inlet—Single
Inside diameter of the pipe 14—8 mm.
Length of the pipe 14—300 mm.
Effective temp. of the fluid stream—270° C.
Working tension—30 g.

The yarn thus produced has a single breaking strength of 2,550 g., good and beautiful appearance and soft handling quality. Therefore, the yarn produced can be used as a practical yarn for weaving and knitting.

Example 11

A draft cut sliver is produced by a Perlok machine from a polypropylene tow (3 den./filament, total denier 480,000 D). The staple length of fibers was 150 mm. and the staple fiber produced has shrinkage of 13.7% in 130° C. steam. The sliver produced by the above-mentioned process is blended with a sliver of merino wool having 66's spinning quality by the blending ratio of 30% polypropylene sliver with 70% merino wool sliver, by using the gill-box, and the blended sliver having 2.0 g./m. weight was produced. The above-mentioned blend-sliver is fed to the apparatus shown in FIG. 3 and the blend yarn is produced under the following spinning condition.

Yarn count—1/20 metric count system
Draft element—Double apron system
Draft ratio between the back roller and the front roller—40
Surface speed of the front roller—2,000 m./min.
Surface speed of the take-up roller—2,000 m./min.
Fluid used:
Temp. of super-heated steam—300° C.
Gauge pressure—2.0 kg./cm.²
Jet bundling element (shown in FIG. 11):
Fluid inlet—5
Inside diameter of the pipe 14—8 mm.
Length of the pipe—300 mm.
Effective temperature of vortical fluid stream—220° C.
Processing tension—30 g.

The yarn thus produced has a tensile strength of 680 g. and a softness suitable for weaving and knitting operation.

Example 12

A sliver with cut length 150 mm. and the heat shrinkage of whose component fiber is 13.7% in steam of 130° C., is produced from a polypropylene tow (3 den./filament, total denier 480,000 D). 70% of the above-described polypropylene sliver is blended with 30% of viscous rayon sliver (3 den. x 120 mm.) of a gill-box to produce a blended sliver having a weight of 5 g./m., the sliver produced is fed to the jet bundling apparatus shown in FIG. 3, and several jet bundle yarns are produced under the following condition.

Yarn count—1/10's metric count system
Draft element—Ambler system
Draft ratio between the front roller and the back roller—50
Surface speed of the front roller—2,000 m./min.
Surface speed of the delivery roller—2,050 m./min.
Fluid used:
Super-heated steam temp.—300° C.
Gauge pressure—2.0 kg./cm.²
Jet bundling member (shown in FIG. 11):
Feed inlet of fluid stream—4
Dia. of yarn passage—8 mm.
Length of yarn passage—300 mm.
Effective temperature of vortical fluid stream—220° C.
Processing tension—27 g.

The yarn thus produced has a breaking strength of 1,580 g. and an excellent durability suitable for processing in weaving and knitting, with uniform appearance having little fluffs, and further having a crispy handling quality.

Example 13

A draft cut sliver is produced by a Perlok machine from a polypropylene tow (3 den./filament, total denier 480,000 D) and spinning material of sliver having 2.0 g./m. weight is prepared by a drawing machine from the draft cut sliver and the sliver is then treated with a fiber setting machine in a 120° C. stream for 20 minutes, and a sliver of 4.5 g./m. weight is prepared by a drawing machine. The sliver produced has a shrinkage of 3.5% in 130° C. steam. The sliver produced is fed to the apparatus shown in FIG. 3 and yarn produced under several spinning condition.

Yarn count—1/9 metric count system
Draft element—Bottom apron system
Draft ratio between the back roller and the front roller—40.5

Surface speed of the front roller—1,000 m./min.
Fluid used:
Temp. of super-heated steam—250° C.
Gauge pressure—2 kg./cm.²
Jet bundling element (shown in FIG. 5):
Fluid inlet—Double
Inside diameter of the pipe **14**—10 mm.
Length of the pipe **14**—200 mm.

The following table shows the oter spinning conditions.

No.:	Surface speed of take-up roller, m./min.	Stretch ratio in percent	Working tension in g.	Breaking strength of yarn	Yarn appearance
41	1,000	----------	15	3.0	Bulky.
42	1,010	1.0	28	4.3	Do.
43	1,050	5.0	37	5.5	Tight but soft handling.
44	1,075	7.5	40	6.3	
45	1,100	10.0	50	7.2	Yarn breaks easily.

NOTE.—The breaking strength of the conventional yarn is about 6-8 kg.

As it is clear from the table, the breaking strength of the yarn produced increases with increase in the stretch ratio, the yarn forming becomes difficult in the over stretch ratio.

Example 14

A polypropylene tow (2 den./filament, total denier 360,000 D) is used as the material and the sliver produced having a weight of 5.0 g./m. from the tow by a Perlok machine is fed to the jet bundling apparatus shown in FIG. 3 under the following condition and then twisted further under the condition shown in the following table.

Yarn count—1/10^s metric count system
Draft element—Conical tube system
Draft ratio between the front roller and the back roller—50
Surface seed of the front roller—2,500 m./min.
Surface speed of the delivery roller—2,550 m./min.
Fluid used:
Temp. of super-heated steam—350° C.
Gauge pressure—2 kg./cm.²
Jet bundling member (shown in FIG. 9):
Feed inlet of fluid stream—2
Dia. of yarn passage—70 mm.
Length of yarn passage—200 mm.
Processing tension—30 g.

The following table shows the twisting condition.

No.:	Twist/meter	Twist multiplier	Breaking strength ing.	Breaking elongation in percent
46	0	5	3,846	13.6
47	16	5	4,144	13.9
48	31	10	4,417	14.5
49	63	20	4,903	14.4
50	95	30	5,209	15.1
51	158	50	5,598	15.3
52	220	70	5,707	15.0
53	315	100	5,498	14.3
54	410	130	5,031	13.2
55	504	160	4,455	13.4

It is evident from the results shown in the above table that the stress-strain property of fluid twisted yarn can be improved remarkably by providing them low twist and the maximum strength is obtained by making the twist multiplier about 70.

It is possible to obtain a fluid twisted yarn having same handling quality and appearance as those of conventional spun yarns by making the twist multiplier lower than 71.

Example 15

A sliver having high shrinking property is produced by a Turbo-stapler from an acrylic fiber tow (3 den./filament, total denier 480,000 D) and a spinning material in a sliver from having 5 g./m. weight is prepared by a gill-box. The spinning material is fed to the apparatus shown in FIG. 14 under the following condition.

Yarn count—1/10^s metric count system
Draft element—Double apron system
Draft ratio between the back roller and the front roller—50
Surface speed of the front roller—1,000 m./min.
Surface speed of the take-up roller—1,050 m./min.
Fluid used:
Temp. of super-heated steam—400° C.
Gauge pressure—2 kg./cm.²
Jet bundling member (shown in FIG. 5):
Fluid inlet—Single
Inside diameter of the pipe **11**—10 mm.
Length of the pipe **11**—400 mm.
Working tension—30 g.
Rotation speed of the pot—50,000 r./min.
Theoretical number of twist:
47.6 T/M
Twist multiplier 15.1

The yarn produced is rewound to cheese form and treated with steam of 130° C. for 15 minutes, by which the finished yarn has a breaking strength of 2,230 g., and breaking elongation of 13.0%, which are superior qualities suitable for practical use.

Example 16

A draft cut sliver is produced by a Perlok machine from a polypropylene tow (3 den./filament, total denier 480,000 D). The staple length of fibers was 150 mm. and the staple fiber produced has shrinkage of 13.7% in 130° C. steam. The sliver produced by the above-mentioned process is blended with a sliver or merino wool having 66's spinning quality by the blending ratio of 30% polypropylene with 70% merino wool sliver, by using the gill-box, and the blended sliver having 2.0 g./m. weight was produced. The above-mentioned blend-sliver is fed to the apparatus shown in FIG. 3 and the blend yarn is produced under the following spinning condition.

Yarn count—1/20 metric count system
Draft element—Double apron system
Draft ratio between the back roller and the front roller—40
Surface speed of the front roller—2,000 m./min.
Surface speed of the take-up roller—2,000 m./min.
Fluid used:
Temp. of super-heated steam—300° C.
Gauge pressure—2.0 kg./cm.²
Jet bundling element (shown in FIG. 10):
Fluid inlet—2
Inside diameter of the pipe **14**—8 mm.
Length of the pipe **14**—300 mm.
Effective temperature of vertical fluid stream—220° C.
Bonding agent contained in the vortical fluid stream—Acrylic resin emulsion
Processing tension—30 g.

Fibers contained in the net-like configuration of the above-mentioned yarn are bonded firmly by the bonding agent contained in the fluid stream. The yarn thus produced has a breaking strength of 690 g. and an excellent practical property for weaving knitting.

Example 17

In Example 12, the jet bundling member shown in FIG. 10 was used. A fluid stream containing 5% weight ratio of acrylic resin emulsion was fed into the fluid passage of the pipe **14** through inlet **20** to bond the fibers composing the net-like configuration of the yarn while passing through the pipe **14**.

The yarn produced had better properties than the yarn explained in Example 12, because the fibers composing the net-like configuration were fixed firmly by the bonding agent of the acrylic resin.

Example 18

A polypropylene tow (3 den./filament, total denier 480,000 D) is draft cut by the Perlok machine and the sliver produced of 200 mm. staple length is fed to a drawing frame and a sliver of 2.0 g./m. was prepared.

A polypropylene multifilament (900 den./180 filaments) is also prepared.

The polypropylene multifilament was fed to the apparatus shown in FIG. 19 while the prepared sliver was drafted by the draft element of the apparatus under the following condition.

Yarn count—1/10 metric count system
Draft element—Double apron system
Draft ratio between the back roller and the front roller—40
Surface speed of the front roller—3,500 m./min.
Surface speed of the take-up roller—3,570 m./min.
Fluid used:
Super-heated steam—330° C.
Gauge pressure—3.0 kg./cm.^{2}
Jet bundling member (shown in FIG. 9):
Feed inlet of fluid stream—Double
Inside diameter of the pipe **14**—10 mm.
Length of the pipe **14**—400 mm.
Effective temperature of vortical fluid stream—230° C.
Processing tension—30 g.

The yarn produced comprising a core portion of multifilament yarn without twist and a net-like configuration of short fibers surrounding the core yarn. The yarn has an excellent handling quality and has practically sufficient properties for weaving or knitting operation. The yarn has a breaking strength of 5,200 g. and a breaking elongation of 15%.

What is claimed is:

1. A jet bundle yarn comprising an inside element of yarn having a plurality of staple fibers aligned in the general longitudinal direction of said yarn and movable relative to one another, and a net-like configuration of staple fibers wound helically around the inside element in opposite directions and continuously binding said inside element of yarn, said staple fibers composing said net-like configuration fixed to each other at their crossing portions.

2. A jet bundle yarn according to claim **1**, wherein said net-like configuration of staple fibers comprises thermoplastic synthetic fibers fixed to each other at their crossing portions by heat.

3. A jet bundle yarn according to claim **1**, wherein said net-like configuration of staple fibers comprises thermoplastic synthetic fibers fixed to each other at their crossing portions and fixed to outside fibers of said inside element of yarn at their contact portions by partial fusion of said thermoplastic synthetic fibers.

4. A jet bundle yarn according to claim **1**, wherein said net-like configuration of staple fibers comprises shrinkable fibers which are shrunk around said inside element for firmly binding the fibers of said inside element of yarn together.

5. A jet bundle yarn according to claim **1**, wherein said net-like configuration of staple fibers are fixed to each other at their crossing portions by a bonding agent.

6. A jet bundle yarn according to claim **1**, wherein said net-like configuration of staple fibers are fixed to each other at their crossing portions by a plasticizer.

7. A jet bundle yarn according to claim **3**, wherein said net-like configuration of staple fiber contains at least 20% of shrunk fiber.

8. A jet bundle yarn according to claim **1**, wherein said inside element of yarn has a low twist not exceeding 70 in the metric count system.

9. A jet bundle yarn comprising an inside element of multifilament and a net-like configuration of staple fibers continuously and tightly binding said multifilament, said staple fibers being fixed to each other at their crossing portions.

10. A jet bundle yarn comprising an inside element of staple fibers and a net-like configuration of multifilament continuously and tightly binding said inside element of staple fibers, filaments of said multifilament being fixed to each other at their crossing portions.

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