Oct. 18, 1966 MAGOICHI SAKAI ETAL 3,279,024

METHOD AND APPARATUS FOR MAKING BULKY CONTINUOUS FILAMENT YARN

Filed Sept. 24, 1964 3 Sheets-Sheet 1

Fig. 1

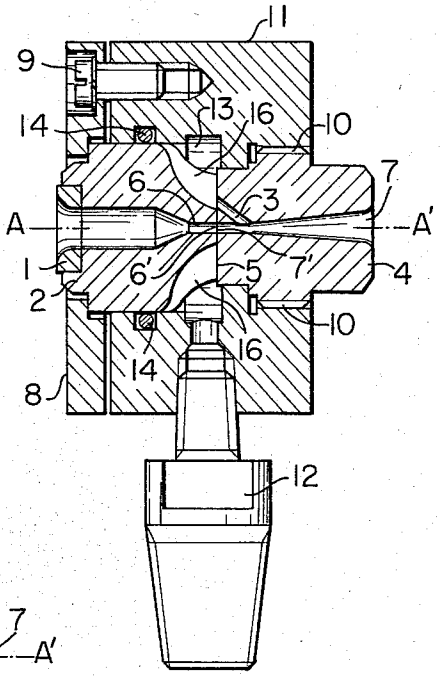
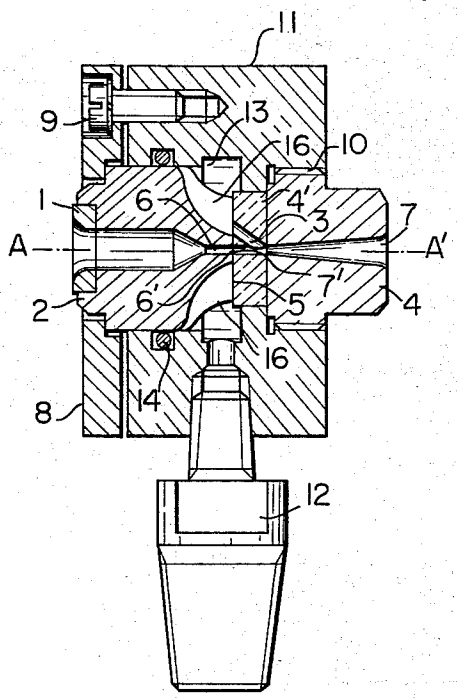


Fig. 2



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Fig. 3

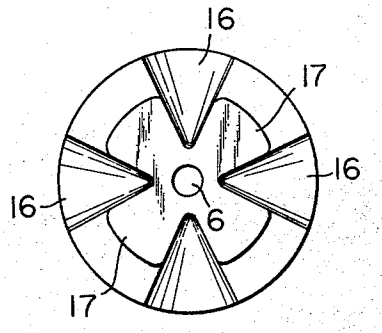


Fig. 4

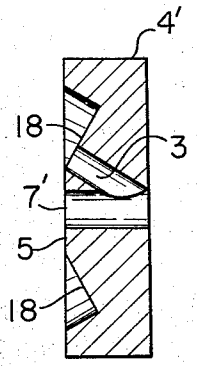
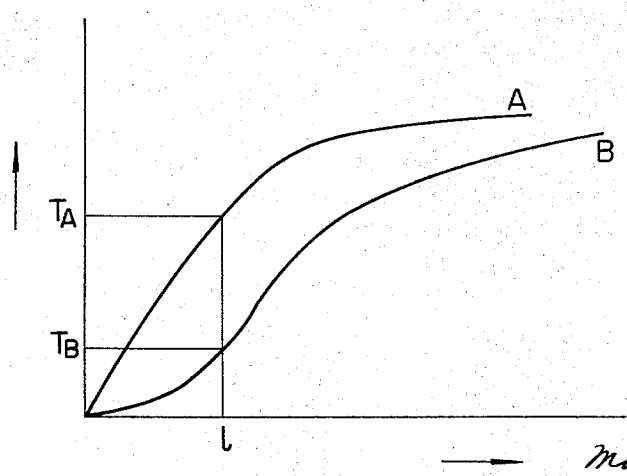


Fig. 5



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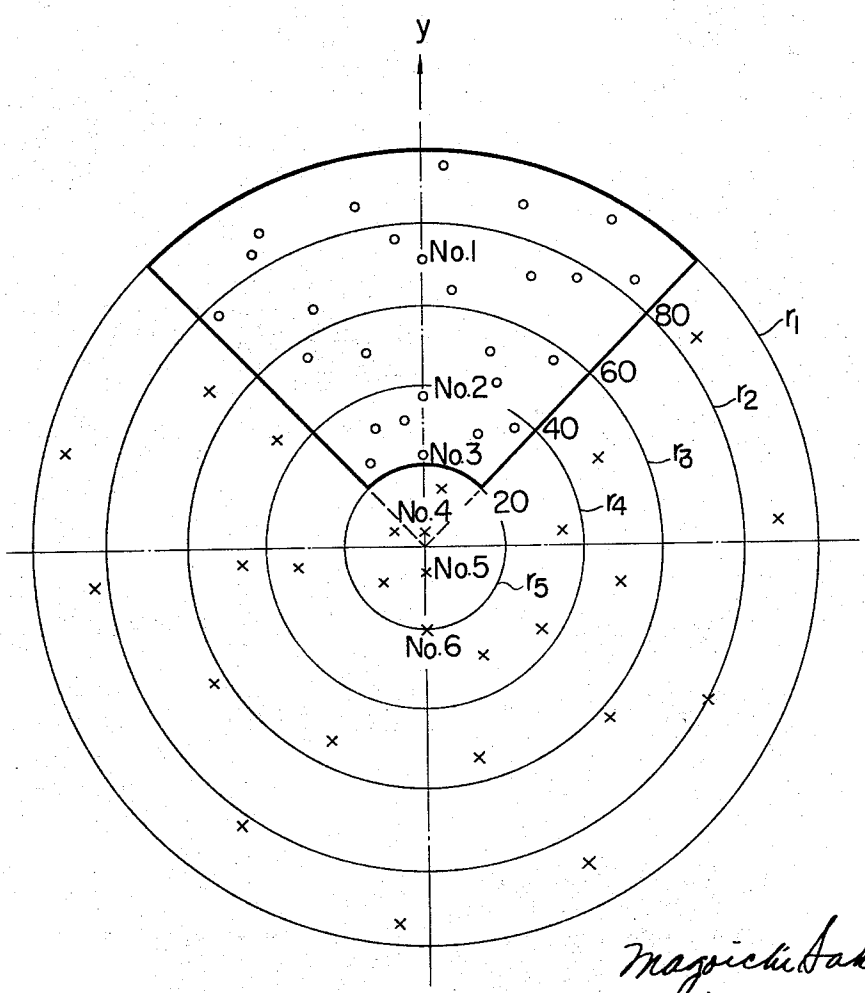
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METHOD AND APPARATUS FOR MAKING BULKY CONTINUOUS FILAMENT YARN

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Fig. 6



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METHOD AND APPARATUS FOR MAKING BULKY CONTINUOUS FILAMENT YARN

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4 Claims. (Cl. 28—1)

This invention relates to improvements in an apparatus for making bulky continuous filament yarn and to a method of using such an apparatus to produce high grade bulky continuous filament yarn having bulkiness of high quality as well as great stability. More particularly, the invention relates to an apparatus wherein, in the conventional apparatus for making bulky continuous filament yarn comprising a venturi member having a venturi throat adapted to create a turbulent zone and at least one fluid jetting passage for supplying a fluid to said throat and a guide member having a yarn guide passage for introducing a filament yarn to said venturi throat, the apparatus is characterized in that the juncture of said guide member and said venturi member are rendered fast so as to be air-tight at their respective yarn guide passage exit surface and venturi throat entry surface by means of a surface-to-surface contact, said exit and entry are disposed concentrically, and the diameter of said exit is at least as great as said entry. The invention also relates to a method of using such an apparatus and producing bulky continuous filament yarn wherein, in the conventional method therefor which comprises the steps of guiding a bundle of filaments substantially lineally from its guide zone into a turbulent zone of fluid, discharging the bundle into said turbulent zone by releasing it in the vicinity of the entry to said zone, jetting the fluid against said bundle with sufficient force to separate the filaments and to form the filaments individually into convolutions, and thereafter taking out said bundle from said turbulent zone; the released end of said bundle released into the foregoing turbulent zone from said guide zone is positioned in a zone defined by the circumference of a circle resulting from the intersection of the peripheral wall of the turbulent zone with a plane including said end and perpendicular to the axial line of said turbulent zone, and a concentric circle having a radius 20% of that of the foregoing circle; and further within a zone defined by lines radiating at an angle of 45 degrees from center of said circles to the left and right of a line resulting from the projection on said perpendicular plane of a line along which said bundle is taken out at a certain angle with respect to the exit surface of said turbulent zone.

Numerous methods and apparatus have been proposed in the past for making bulky continuous filament yarns.

All of these prior art methods have been unsatisfactory for one reason or another, such as insufficient bulkiness, unsatisfactory distribution of stress bearing portions of the filaments, undesirable modification of fiber properties, impermanence of form, or complexity and expense of operations.

For improving on these disadvantages, known are the methods and apparatus, such as those of British Patent 762,630 and U.S. Patent 2,852,906, in which bulky continuous filament yarns are made by introducing a bundle of filaments into a turbulent zone of fluid to form in the individual filaments coils, loops or whorls at random intervals along their length.

The present invention in directed to improvements in such an apparatus and to a method of using such an improved apparatus to make stably a bulky yarn whose stability of bulkiness is especially remarkable.

The foregoing improved prior art methods can be roughly classified into two types; namely, the method, as shown in British Patent 762,630, in which the yarn is introduced from a direction obliquely of the nozzle and a method, as illustrated in U.S. Patent 2,852,906, wherein the yarn is guided substantially lineally from the point of its entry to its exit. Of these two methods, the latter is to be preferred however, since in the former method not only the wear and tear of the needle end inside the nozzle at which the yarn is released is terrific, but also the fluffing of the yarn by means of its bending is great.

As a result of extensive researches in regard to the method of producing bulky yarns by the latter method, we found that although the relative positions of the component members for making up the turbulent zone or the position of the bundle of filaments in the turbulent zone were adjusted in the prior art apparatus employing the latter method to control the processing conditions in such an apparatus, the range of such adjustments was considerably extensive and that even though adjustments were made within this range, there still occurred unforeseeable irregularities. Hence, no matter how much caution was exercised, there were delicate variations in the bulkiness of the yarn obtained which would frequently cause fatal defects to occur in making this yarn into fabrics. While this variation in the bulky yarn is usually not noticeable in its yarn state, the difference can be distinguished functionally when woven into, say, a fabric. Further, this becomes still more noticeable when the fabric is dyed to become a serious defect in its quality.

As a result of our researches for overcoming this defect of the prior art methods which could not be avoided no matter how much care was exercised in carrying out the aforementioned adjustments, we found that the conditions of the juncture of the guide member having a yarn passage for guiding the bundle of filaments to the venturi throat constituting the turbulent zone and the venturi member having a venturi throat adapted to create a turbulent zone and at least one fluid jetting passage for supplying a fluid to said throat, and the configuration of the passage resulting from this juncture had a very serious bearing on the quality of the bulky yarn obtained. Further, it was found that the unforeseeable troublesome and delicate variations ascribable to the inability to control the adjustments, as hereinbefore mentioned, could not be avoided so long as the prior art methods were used.

In addition, we found that for avoiding the defects of the hitherto proposed methods the juncture of the guide member and the venturi member had to be rendered fast so as to be air-tight at their respective yarn guide passage exit surface and venturi throat entry surface by means of a surface-to-surface contact, and that in this instance the diameter of the foregoing exit must be at least equal to, if not greater than, the diameter of the foregoing entry and the two openings must be disposed concentrically, it being found that the hereinbefore defects could not be avoided under conditions in which the yarn prior to its being submitted to the action of the essential turbulent zone is subjected in another turbulent zone to a stream of air sucked in from the aforesaid yarn guide passage in accompaniment with the flow of fluid in said first-mentioned essential turbulent zone, i.e., by a passage in which the diameter of the aforesaid throat entry is smaller than that of the aforesaid yarn guide passage exit.

Further, we found that by making up the venturi member so that it consists of at least of two parts, i.e., a jet passage part including the fluid jetting passage and a venturi part including a greater part of the venturi throat, and also by machining the entry portion of the fluid jetting passage of the venturi member at right angles to

the axis of said jetting passage, such an apparatus could be readily provided with good precision and to great advantage from the standpoint of its fabrication and use.

It was further found that in producing bulky continuous filament yarn by using the so improved invention apparatus a bulky yarn having very excellent stability could be stably obtained by operating so that the released end of the bundle of filaments discharged into the turbulent zone from the guide is positioned within a specific zone in a plane perpendicular to the axial line of the turbulent zone and including said end.

Accordingly, it is an object of this invention to provide an apparatus which can satisfactorily overcome the delicate and unforeseeable instability in quality that was unavoidable by means of the apparatus heretofore proposed and also to provide a method by which an especially excellent bulky yarn is stably produced by using such an apparatus.

Other objects and advantages of the invention will become apparent from the following description.

The invention apparatus is more particularly described below in connection with the accompanying drawings, wherein:

FIG. 1 is an explanatory vertical sectional view of an embodiment of the invention apparatus in which those parts other than the set screw and the elbow for introduction of the fluid have been cut away through the axial line of the venturi throat and the yarn passage.

FIG. 2 is a sectional view similar to FIG. 1 of another embodiment.

FIG. 3 is a plan view of the guide member as seen from the direction of its juncture with the venturi member.

FIG. 4 is a sectional view similar to FIG. 2 illustrating another embodiment of the fluid jetting passage part.

FIG. 5 is a graph for explaining the stability of the bulky continuous filament yarn obtained by the invention method.

FIG. 6 is an explanatory chart showing the released end zone and is for explaining the method of obtaining stably a yarn whose stability is especially remarkable when producing a bulky yarn by using the invention apparatus.

Referring more specifically to FIG. 1, an apparatus is shown which has a guide member and a venturi member, the former consisting of an adapter **2** having an eyelet **1**, a yarn guide passage **6** drilled therein, and a canal **16** cut away for conducting a fluid, say, air from a fluid-filled chamber **13** to a fluid jetting passage **3**; and the latter consisting of a venturi throat **7** adapted to create a turbulent zone and a venturi body **4** having at least one fluid jetting passage **3** for supplying a fluid to said throat **7**. Passage **3** can be provided in a suitable number of two or more, as required. Further, passage **3** is disposed obliquely at a suitable angle facing the exit of venturi throat **7**. Needless to say, these members are secured to a suitable body **11**. In FIG. 1 the venturi member is secured detachably to body **11** by means of a threaded portion **10**, while the guide member is secured detachably to body **11** by means of a setting plate **8** and set screw **9**. Body **11** is also provided with an elbow **12** for introduction of air by which air is fed to fluid-filled chamber **13**. In addition, this embodiment has an O ring **14** provided for preventing the leakage of fluid from between the surfaces of contact of the body and adapter **2** of the guide member.

The means by which the venturi and guide members are secured to body **11** is not limited in this invention to that illustrated but is capable of being modified variously.

According to the invention however, juncture **5** of the foregoing venturi member and guide member must be made fast by a surface-to-surface contact of the yarn guide exit **6'** and that of the venturi throat entry **7'** so as to ensure that substantial air-tightness is maintained. Further, it is necessary that the diameter of said exit **6'** is at least as great as that of said entry **7'** and that they are disposed concentrically. The terminology "substantial air-tightness," as here used, denotes the state in which the entry of the gas from the juncture to the passage is substantially impossible. Although the embodiment shown in FIG. 1 shows the instance of one where the diameters of the exit and entry parts are the same, the use of an exit **6'** with a somewhat greater diameter is permissible.

The diameter of the venturi throat entry **7'** must however not be greater than that of the yarn passage exit **6'**. If such be the case, the objects of the invention cannot be achieved. In such a case, in accompaniment with the stream of air which, upon being jetted from the fluid jetting passage, forms a turbulent zone to be then jetted from throat **7**, the stream of air that is sucked in from yarn passage **6** forms at the foregoing entry **7'** another turbulent zone which is instable and irregular. Thus the bundle of filaments is subjected to a very instable and irregular action prior to its entry to the turbulent zone at which it is to be submitted to the desired action, with the consequence that it becomes impossible to obtain stably a uniform quality bulky yarn of excellent stability.

For instance, in using in such an apparatus the needle that is conventionally used in guiding the yarn, the needle is fitted into the entrance of the venturi throat. From the standpoint of the fabrication, this is a difficult operation, and even though it were possible to attain substantial airtightness in fitting in the needle, the diameter of the communicating passage there formed would increase abruptly at the tip of the needle so that the setting up of a troublesome second turbulent zone could not be avoided.

Further, according to this invention, the yarn passage exit surface **6'** and the venturi throat entry surface **7'** are secured together so as to be substantially air-tight by a surface-to-surface contact, it being necessary to ensure that the exit and entry are disposed concentrically. When not concentric, the formation of another troublesome turbulent zone intermediate of this point and the point where the fluid for formation of the turbulent zone is jeted into throat **7** cannot be avoided, thus rendering the achievement of the objects of the invention impossible.

In the conventional nozzle of this type it was the usual practice to provide an annular clearance between the tip of the yarn tube or needle and the yarn outlet through which the fluid was jetted. In this case, however, since the tip of the needle and the surrounding cavity is fabricated by machining, the errors are great. Hence, the development of processing irregularities between the spindles and within the spindles could not be avoided.

On the other hand, according to the present invention, as the fluid jetting passage is provided in the venturi member, there is no such a clearance at all. Moreover, as previously described, the juncture is by means of a substantially air-tight surface-to-surface contact. Hence the difficulties of fabrication as described above and the setting up of a troublesome second turbulent zone are completely done away with.

FIG. 2 illustrates one of the preferred modifications of the invention apparatus. Shown is one in which the venturi body **4** of the venturi member is composed of two parts, i.e., a fluid jetting passage part **4'** including the fluid jetting passage **3** and a venturi part **4** including a greater part of the venturi throat.

As the wall of the venturi throat is susceptible to abrasion by means of the turbulent action of the yarn, a material of great hardness must be used in the fabrication of this part, hence making its drilling an exceedingly difficult operation. If however the venturi is divided into two parts as in this embodiment, it becomes possible to use a material of lesser hardness for the jetting passage part to facilitate its drilling since the turbulent action of the yarn does not take place at this part. It is also easier

to discover those in which the drilling is defective. In addition, since it suffices to discard only this part in those cases of defective drilling, the fabrication cost of the nozzle can be reduced.

FIG. 3 shows a plan view, as viewed from the venturi member side, of the guide member surface which makes a surface-to-surface contact with said venturi member. It is especially desirable according to the present invention that the area of contact between the guide member and the venturi member be made large for attaining a substantially air-tight surface-to-surface contact and for maintaining this contact stably. For this purpose, the parts other than parts **16** which communicate with the fluid passage **3** provided in the venturi member, i.e., parts **17** which make the surface-to-surface contact, should preferably be designed to have a great area of contact by being extended outwardly as much as possible, as shown in FIG. 3.

Further, according to the invention, by machining the entry part of fluid jetting passage **3** of the venturi member at juncture **5** of the two members making the surface-to-surface contact, at right angles to the axis of said fluid jetting passage to form a surface **18**, the drilling precision of said passage **3** can be enhanced very easily. In this case, this is carried out to greatest advantage from the fabrication standpoint, if, as shown in FIG. 4, the venturi member is made into two parts as illustrated in FIG. 2 and then the foregoing machined surface **18** is formed in the fluid jetting passage part **4'**, followed by drilling the passage **3**. Furthermore, since the drilling of the passage is done after a part has been machined away, not only is the drilling simplified but also the precision with which the drilling is accomplished can be enhanced.

The method of making a bulky continuous filament yarn using the invention apparatus will be described below with reference to FIG. 1.

The compressed fluid for effecting the turbulent action, such as air, is conducted via elbow **12** to fluid-filled chamber **13** made up of body **11** and adapter **2** from whence it is conducted via canal **16** to jetting passage **3** to be jetted into venturi throat **7** where it contacts a bundle of filaments introduced in the axial direction A–A' via eyelet **1** and yarn passage **6**, whereby the bundle of filaments is imparted a textured effect by being subjected to the turbulent action of the air to result in the imparting of bulkiness.

When carrying out the method of producing a bulky continuous filament yarn by employment of the invention apparatus and using such a conventional method which comprises conducting a bundle of filaments substantially lineally from its guide zone to a turbulent zone of fluid, discharging the bundle into the turbulent zone by releasing it in the vicinity of the entrance thereof, jetting a fluid against said bundle with sufficient force to separate the filaments and to form the filaments individually into convolutions, and thereafter taking out the bundle from the turbulent zone; by operating particularly so as to position the released end of the bundle of filaments in a specific zone when released, the production stably of a bulky yarn excelling in stability can be accomplished with great advantage.

This specific zone is a zone defined by the circumference of a circle resulting from the intersection of the peripheral wall of the turbulent zone with a plane including the aforesaid released end and perpendicular to the axial line of said turbulent zone, and a concentric circle having a radius 20% of that of the foregoing circle; and further within a zone defined by lines radiating at an angle of 45 degrees from the center of said circles to the left and right of a line resulting from the projection on said perpendicular plane of a line along which said bundle is taken out at a certain angle with respect to the exit surface of said turbulent zone.

The term "released end," as used herein, is to be understood as representing that position immediately before the spot at which the bundle of filaments makes entry into the essential turbulent zone, normally a position immediately before the location of the exit of the fluid jetting passage to the venturi throat. If a needle has been provided in throat **7**, then of course, it is the tip of the needle, but since the use of a needle is not desirable according to this invention, it should be understood as being the position defined above.

The hereinbefore mentioned specific zone will be described in greater detail below in connection with the operation using the invention apparatus.

Of the bulky yarns A and B made by utilizing a jetted fluid and having the stress-strain curves such as shown in FIG. 5 (in the figure the vertical axis represents stress and the horizontal axis, strain), yarn A having a higher Young's modulus can be regarded as being a more stable yarn than yarn B whose Young's modulus is lower. Hence, the stresses T_A and T_B of a yarn when subjected to a given strain l can be used as the index of the stability of said yarn. Further, the value calculated from a measurement of the residual elongation of a bulk yarn taken out after having been subjected to a given load for a given period of time is referred to as the stability index, and this also becomes an index of the stability of the filaments. In this case, the greater the foregoing stress or the smaller the value of the foregoing stability index, the greater is the stability of the bulky yarn obtained.

In Table I, below is shown the relationship between the stress and stability index of the bulky yarn obtained and deflection (percent) in the specific zone of the aforementioned released end of the bundle of filaments when deflected in the direction in which the yarn is being taken out along the aforesaid projected line of the take-out line of the yarn.

TABLE I

Experiment	Deflection, Percent	Stress, gr.	Stability Index, Percent
1	70	17	0.1
2	38	12	0.3
3	20	10	0.5
4	4	4	2.0
5	−7	1.5	5.0
6	−20	0.5	8.0

The stability index used in the above table was measured and calculated in the following manner.

A load of 0.05 g./d. is hung for 30 seconds from a bulky yarn having a length l_0 (100 mm.) made by the invention apparatus. Thirty seconds after removing the load, the length l_1 was measured. The stability index S was then calculated as follows:

$$S=\frac{l_1-l_0}{l_0}\times 100 \text{ (percent)}$$

The fiber used was a 150-denier polyester, and the overfeed in this case was 22%. Those shown in the table with deflections of minus value are those whose take-out directions were opposite with respect to the center of the circle to those taken out along the aforesaid projected line of the take-out line.

Further, in FIG. 6 are shown numerous instances of the deflection of the released ends, including those of Experiments Nos. 1–6 shown in Table I. The 0 marks in the figure indicate the deflection points at which were obtained bulky yarns of excellent stability whose stress was not less than 10 g. and stability index was also low. On the other hand, the x marks indicate the points at which the bulky yarns obtained were unstable, the stress being below 10 g. and the stability index being also high.

Generally speaking, a bulky yarn of this type whose stress is not less than 10 grams is not only stable but possesses good appearance and handle as well. For example, a bulky yarn having a stress of the order of four

grams is easily stretched and deformed by the tension it is subjected to during its handling when being woven or knitted. Hence, it cannot be regarded as being a desirable bulky yarn.

Further, the r_1 in the figure indicates the circle resulting from the intersection of the peripheral wall of the turbulent zone with a plane including the aforesaid released end and perpendicular to the axial line of said turbulent zone; and r_5 indicates the concentric circle having a radius 20% of that of the foregoing circle, R_2, R_3 and R_4 are circles described between the foregoing two circles and having radii which are respectively 80%, 60% and 40% of the radius of r_1. The zone defined by the thick line in the figure is the aforementioned specific zone and *y* indicates the aforesaid projected line of the take-out line of the yarn (according to the invention method, the yarn is taken out at a certain angle with respect to the exit surface of the turbulent zone). The take-out direction is indicated by the arrow.

According to the invention method, while a needle or other suitable means can also be used as a support means for positioning the released end of the yarn in the aforesaid specific zone, the introduction of the yarn to the guide member and the position from which the yarn is taken out from the turbulent zone can be readily adjusted by means of suitable rollers, pins and other known guides. In this case, either the wall of eyelet **1**, the entrance wall of guide passage **6** or the exit wall of venturi throat **7** can be used as suitable support points.

As the starting yarn which can be used in the invention, included are, for example, the synthetic fibers such as polyesters and polyamides, the semisynthetic fibers such as acetate and rayon, the regenerated fibers, the inorganic fibers, such as glass fibers, and also the natural fibers such as silk and wool. Further, the form of the fiber does not matter, it being possible to use staples, spun fibers or continuous filament fibers.

Although particularly preferred embodiments of the invention apparatus and method of making a bulky yarn by using such an apparatus have been described, the invention is possible of variation and modifications without departing from the spirit of the invention and scope of the appended claims.

What we claim is:

1. In an apparatus for making bulky continuous filament yarn comprising a venturi member having a throat adapted to create a turbulent zone and at least one fluid jetting passage for supplying a fluid to said throat and a guide member having a yarn guide passage for conducting a filament yarn to said venturi throat, the improvement wherein the juncture of said guide member and said venturi member are rendered fast so as to be air-tight at their respective yarn guide passage exit surface and venturi throat entry surface by means of a surface-to-surface contact, said exit and entry are disposed concentrically, and the diameter of said exit is at least as great as that of said entry.

2. An apparatus according to claim **1** wherein venturi member consists of at least two parts, one being the fluid jetting passage part including said fluid jetting passage and the other being the venturi part including a greater part of the venturi throat.

3. An apparatus according to claim **1** wherein the entrance portion of the fluid jetting passage at said juncture is machined with a surface perpendicular to the axis of said fluid jetting passage.

4. In a method of making bulky continuous filament yarn involving the steps of introducing a bundle of filaments from the guide zone thereof substantially lineally to a turbulent zone of a fluid, discharging said bundle into the turbulent zone by releasing it in the vicinity of the entrance to said zone, jetting the fluid against said bundle with sufficient force to separate the filaments and to form the filaments individually into convolutions, and thereafter taking out said bundle from said turbulent zone, the improvement which comprises rendering fast said guide zone exit and said turbulent zone entry so as to be air-tight by means of a surface-to-surface contact and such that the two zones are in communication, said exit and entry being concentrically disposed and the diameter of said exit being at least as great as that of said entry, and placing the released end of said bundle to be released into said turbulent zone from said guide zone in a zone defined by the circumference of a circle resulting from the intersection of the peripheral wall of the turbulent zone with a plane including said end and perpendicular to the axial line of said turbulent zone, and a concentric circle having a radius 20% of that of the foregoing circle; and further within a zone defined by lines radiating at an angle of 45 degrees from the center of said circles to the left and right of a line resulting from the projection on said perpendicular plane of a line along which said bundle is taken out at a certain angle with respect to the exit surface of said turbulent zone.

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