METHOD AND DEVICE FOR THE PRODUCTION OF CONTINUOUS MULTIFILAMENTS HAVING A HIGH DEGREE OF COHESION

Filed July 1, 1969

Fig.1

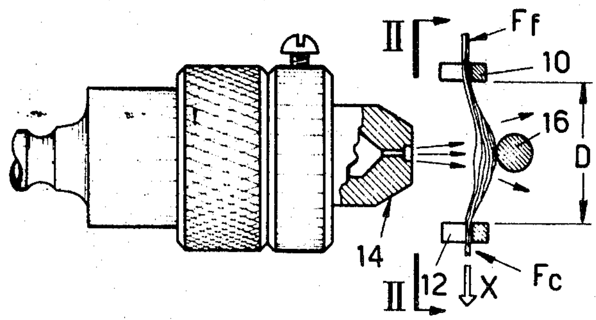


Fig.2

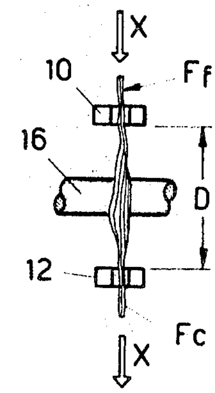


Fig.3

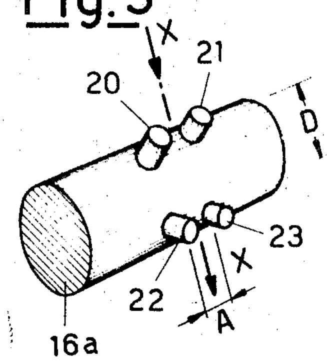


Fig.4

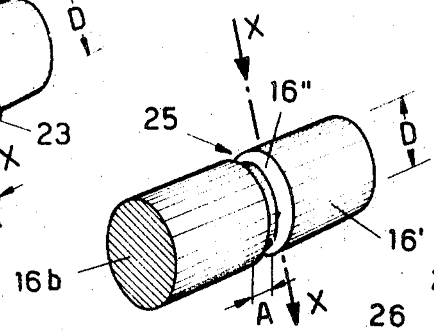


Fig.5

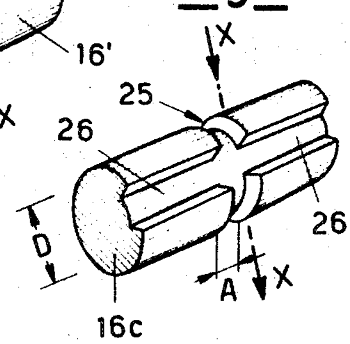


Fig.6

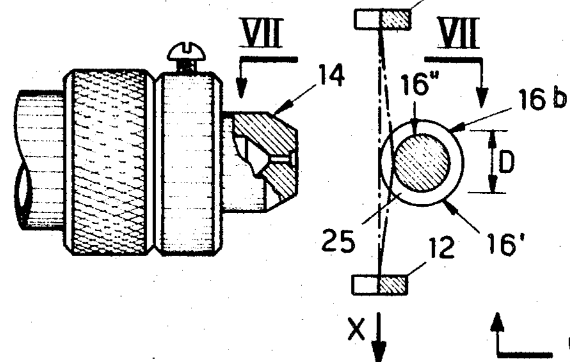
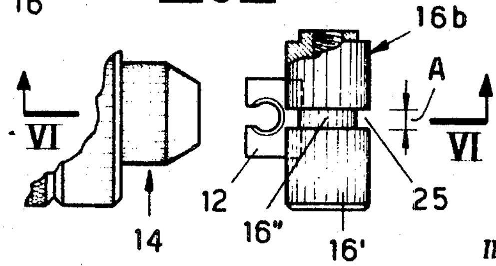


Fig.7



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BY [signature] ATTORNEY

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3,614,817
METHOD AND DEVICE FOR THE PRODUCTION OF CONTINUOUS MULTIFILAMENTS HAVING A HIGH DEGREE OF COHESION

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Int. Cl. D02g 1/16
U.S. Cl. 28—1.4 10 Claims

ABSTRACT OF THE DISCLOSURE

A method and a device are disclosed for improving the cohesion between individual monofilaments of a cohered yarn. The method consists in limiting the freedom of oscillatory movement of the individual filaments as exposed to the action of a cohering gas jet, and is carried out by providing a grooved or splined cylindrical surface in the area where the gas jet is active on the filaments. The dimensions, and the distances at which the cylindrical surface is placed with respect to the other component parts of the installation are critical.

This invention relates to an improvement in the methods and devices for the industrial production of the so-called "cohered continuous yarns" and more particularly of the yarns consisting of a plurality of thin monofilaments of either a man-made or a synthetic material, non-twisted or only limitedly twisted, but "cohered" to one another, or mutually interlocked or interlinked so as to form a multifilamentary yarn adapted to certain utilizations in the textile field, without any previous twisting treatments.

Said cohered filaments are well known in the art. A comprehensive disclosure thereof, of their advantages and the procedure by which the cohesion degree can be measured and defined, can be found in the technical and patent literature of the art, and especially in the joint U.S. Pat. No. 3,238,590, issued Mar. 8, 1966 in the names of Domenico Nicita, one of the present inventors, and of Piero Giacabone.

These multifilamentary cohered yarns have the principal technical and commercial advantage that they can be produced with methods which are much more rapid and economical than those employing twisting, that is, than the procedures conventionally adopted to obtain a coherent and unitary multifilamentary structure, to the ends of practical use. In addition, they remove the drawbacks inherent in the torsion which has been heretofore left in the filaments, said torsion, for example, decreasing the permeability of the filaments to the tinctorial agents. In addition, by observing a few critical conditions in the cohesion treatment, further advantages can be achieved, such as the formation of a comparatively labile cohesion layer, that is, a layer such as to ensure the mutual bond between adjacent continuous filaments to the degree and for the time which are necessary for their textile uses. This cohesive state is reduced, and even destroyed, after said use, and, typically, as a consequence of the weaving operations, thus encouraging the formation of a particularly homogeneous textile structure which is pliable and devoid of any local knots and irregular spots liable to compromise dyeing. These possibilities and the conditions which permit their attainment have bene disclosed, for example, in the U.S. Pat. No. 3,436,798, issued Apr. 9, 1969 in the name of the applicant, Nicita.

In the light of the foregoing, an object of the present

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invention is to provide improved methods and means adapted to permit the performance of such cohesion-imparting treatments with a great increase in output, that is of the commercial efficiency of the machines used, without prejudicing, and, conversely, exalting the quality and uniformity of the product.

It is also an object of this invention to provide improved methods and means by which the conditions of the treatment and the physical phenomena which are conductive to cohesion can be kept under rigorous control, both as regards the degree or magnitude of cohesion (which is empirically expressed, as is known and explained by the appertaining literature, in terms of "number of false or pseudo-knots per unit length of the filament") and as regards the conditions or power of such a cohesion to the end of its persistence or liability in the yarn.

The basic ideas of the subject improvement, along with the essential feature of the procedures and means provided by the invention, and the technical advancement over what was known heretofore, will become apparent from the ensuing detailed description aided by the accompanying drawings, wherein:

FIG. 1 corresponds to FIG. 1 of the already cited U.S. Pat. No. 3,238,590 to whose text reference is made for a better understanding of the background of the present invention. This figure is reported to facilitate a comparison with the prior art, concurrently with

FIG. 2, which is a partial showing of the device of FIG. 1, as viewed from the plane and in the direction shown by II—II of FIG. 1.

FIGS. 3, 4 and 5 show, in a perspective diagrammatical manner, embodiments of the essential and characteristic component part of the improved device.

FIG. 6 shows, partly in side elevation and partly in section taken along the plane VI—VI of FIG. 7, a device of the kind shown in FIG. 1, improved according to the invention with the use of a component of the kind shown in FIG. 4.

FIG. 7 is a partial view of the improved device of FIG. 6 as viewed in the direction and the plane indicated at VII—VII in FIG. 6.

By briefly recalling the conventional art, with reference to FIGS. 1 and 2, the formation of a cohered yarn Fc, starting from a bundle of continuous filaments Ff of a man-made, or preferably synthetic material, non-twisted or twisted only to a negligible extent, is carried out by feeding in the direction X—X the bundle of filaments between the two thread guides **10** and **12** which are aligned and spaced apart through an appropriate distance D, while the bundle is subjected to the action of a gas jet issuing from a nozzle **14** and directed in a direction which is perpendicular, or nearly so, relative to the bundle, at a point which is preferably midway of the gap D between said thread guides, so as to urge the filaments towards a convex surface whose generating lines are oriented in a direction which is, preferably, approximately perpendicular both to the path of the filaments between the thread guides **10** and **12**, and to the axis of the gas jet. To simplify the construction, the convex surface in question is the rear portion of an essentially cylindrical component **16**. This constructional approach has proven to be advantageous also for the end result, but the particular configuration of the cross-sectional shape of the component **16** has no criticality to the ends of the application of the prior art, inasmuch as it has been found sufficient to respect the conditions of substantial convexity of the surface against which the filaments are thrust by the areodynamic action of the gas jet and of the fact that the component **16** has such a shape and a volume as to allow the gas jet to flow easily along its sides after having impinged onto the filaments and flown past the filaments bundle.

By adhering to these conventional conditions, the bundle-forming filaments, deflected from their theoretically linear path as defined by a line joining the two thread guides, contact, randomly and temporarily, the convex surface and undergo individual displacements and oscillations in the plane of tangency with the convex surface and also transversally of the theoretical path aforementioned. It is assumed that, due to these individual movements, many straddlings are manifested among the individual filaments such as to give rise to the desired cohesion effect: the latter should be supported to be proportional to the degree of freedom of the movement.

It has been surprisingly ascertained by the applicant that, even adopting the most favourable conditions, sought for and checked by trial, and more particularly the conditions of velocity and cross-section of the gaseous jet, radius of curvature of the convex surface which opposes the deflection of the filaments under the action of the jet, distance between the nozzle **14** and said surface, a satisfactory cohesion cannot be obtained when the speed at which the material is caused to advance exceeds certain values. This fact, of course, implies a limitation to the output or production efficiency of the cohesion-imparting device.

It has been surprisingly ascertained that, whenever the freedom of movement of the individual filaments is drastically restricted in the treatment area, that is in the area where the filaments are thrust by the gaseous jet and are allowed to contact the confronting contrasting surface, but still without any substantial limitation of the freedom of flow of the gaseous jet beyond said area, there is a considerable increase in cohesion (expressed in terms of "number of false knots" per unit length) for the same speed of advance. Conversely, the possibility is afforded of considerably increasing the speed of advance of the material while obtaining a cohesion magnitude equal to the one obtained before at a much slower speed.

The validity of the assumption that the number of false knots is, as a rule, inversely proportional to the speed of the yarns has been confirmed.

The drastic limitation, as outlined above, of the freedom of movement in the treatment area, considerably neutralizes the detrimental effect of the speed of advance (that is, the potential output of the cohesion-imparting devices) on the cohesion magnitude.

Considering "a posteriori" the possible interpretations of the phenomena recalled above, which have been surprisingly ascertained, it can be realized that the inverse proportionality between the speed of advance and the degree of cohesion is a phenomenon which is consistent with the hypothesis that the straddlings and consequential formation of knots are the result of movements which are vibratory in nature, a hypothesis which is adopted, provisionally and not compulsorily, in the present disclosure, but which is however inadequate to explain completely the effects and results obtainable with the use of the subject improvement.

As a matter of fact, it has been seen that the dependency between the degree of cohesion and the distance between the thread guides, or, better to speak, the gap therebetween in which the filaments could be considered free to vibrate, in a plane essentially perpendicular to the axis of the gaseous jet and tangent to the contrast surface, is not gradual and does not correspond to the equation of the vibrating strings. In the second place, the hypothesis that the phenomenon is of a vibratory nature does not explain the importance, to the ends of the degree of cohesion, of the lateral limitation of the amplitude of the possible movements of the filaments, of the transversal distance relatively to the direction of advance, of the means which physically limit said amplitude. The vibratory hypothesis should not take said amplitude into account (it should be a function of the absorbed energy only) but only of the vibration frequency, or of the longitudinal interval between the members which physically limit the field in which the vibration takes place. It can be added, conversely, that to limit said amplitude, in the sense of limiting the transversal space where the filament bundle can open and the individual filaments are allowed to be individually displaced and to vibrate, should have been a detrimental circumstance to the ends of the cohesion. Conversely, it has been surprisingly ascertained that a drastic and positive limitation in this direction is favourable to the ends of the results of the invention and is a necessary and critical circumstance therefor.

Conversely, in a way, the vibratory hypothesis is consistent with the fact that to adopt jets having a higher kinetic energy, i.e. a higher speed when leaving the nozzle, is conducive to an increase in cohesion. According to the vibratory hypothesis, it should be assumed that the greater kinetic energy should lead to an increase of the vibration amplitude when the frequencies are equal, since the wavelength is limited by the means which physically limit the treatment area. The increase of the amplitude of the vibrations could explain the phenomenon owing to the fact that the undulations having a greater amplitude lead to an increase of the angle between the filaments which are crossed at the knots of these undulations and thus to a more vigorous straddling and crossing between the filaments of the cohered yarn.

On the other hand, it has been ascertained that the increase of kinetic energy has no influence above certain determined values (which, on the other hand, would be economically unacceptable to overcome due to the burden consequent to the supply of large amounts of highly pressurized air) and, in addition, the aforementioned necessary or critical limitation of the vibration amplitude, i.e. of the freedom of transversal displacement of the individual filaments, would nullify the effect of the increase of the kinetic energy to the end of the formation of undulations having a greater amplitude within the limits permitted to the parts which physically maintain said amplitude within a determined range.

In view of the foregoing, the improvement thus consists in providing guiding means for the filament bundle, which act over a distance longitudinally not higher than 20 mm. and, consistently and with this condition, in the order of the radius of curvature, or, stated alternatively, of the longitudinal extension of the surface against which the filaments are urged and with which they can be brought into contact by the kinetic energy of the gaseous jet.

Considering now that the contrast surface can be conveniently embodied by a cylindrical surface, so as to encourage the flow of the gaseous jet beyond the filament bundle downstream of the treatment area, this surface is preferably embodied by the rear surface of a cylindrical rod or body, a generating line of which intersects, preferably through a right angle, the axis of the gaseous jet and also preferably, through an approximately right angle, the direction of the filaments.

Assuming now that the filaments can contact said rear surface under the action of the gaseous jet through an arc having a comparatively small width, in the order of 60° (with a wide approximation), on taking into account the upper limit of the longitudinal distance of the guiding means, as recalled above, and of the advisability, as determined by trial, that the radius of curvature of the cylindrical surface is not too small, the radius is advantageously comprised between 1.5 mm. and 10 mm. These values are also the preferred limiting values for the distance between the guiding means.

In addition, it is advisable to adopt a cylindrical body or rod for providing said surface since the cylindrical rod or body provides a flow surface which can be easily gone past by the gaseous jet, which is spread thereby, without originating any appreciable whirling phenomena in the treatment area.

The size, in the direction of advance of the yarn, of the body which forms that surface, can lie with advantage in the range between 2 and 40 mm., and preferably between 5 and 20 mm., this size being advantageously selected by adopting a criterion of proportionality with the distance between the nozzle and the contrast surface since the spreading of the jet between the nozzle and the area of the treatment, is proportional to that distance.

Such a drastic limitation of the values in which the freedom of movement of the filaments is actually restricted, is physically obtained by providing thread guiding means which are structurally associated to the body which provides the contrast surface. Said means can consist of pairs of thread-guide-forming projections, upstream or downstream of the treatment area, or at the start and the end of the portion of the surface on which the gaseous jet impinges and with which the filaments can come into contact.

According to a particularly simple and advantageous embodiment of this invention, said means are embodied by a groove formed through the body, at least through the length of the portion concerned, the parallel and converging sidewalls of the groove providing, in themselves, the members which limit the freedom of movement of the filaments. The sidewalls can be wholly continuous, or they may contain discontinuities. For example, such a groove may intersect one or more transversal grooves arranged along generating lines of the convex surface of said body, so as to permit the outflow of a portion of the gas of the jet downstream of the treatment area, in a direction which is transversal relatively to the direction of advance of the filaments.

As exemplified by FIG. 3, a component part **16***a*, which, for simplicity of construction, can be a cylindrical body, has pairs of projections, **20**, **21** and **22**, **23**, respectively, acting as thread guides, placed at a short distance D, and having the twofold task of restricting to said interval the length of the free portion in which the filaments are allowed to vibrate individually, and of limiting the amplitude A of the lateral vibrations and oscillations upstream and/or downstream of the interval D.

FIG. 4 shows an embodiment of such component part, which is extremely simple and advantageous. In the example shown, the cylindrical body **16***b* has an annular groove **25** whose width and depth are adapted to limit both the transversal movements of the yarn being treated, and to restrict the length, D, of the interval in which the oscillations are allowed, to the extent which corresponds to the secant of the external surface **16′** of the body **16***b* and tangent to the bottom surface **16″** of the groove **25**.

The alternative embodiment of FIG. 5, a body **16***c*, corresponding to that shown in FIG. 4, is completed by a groove **26** in the longitudinal direction, that is, facing the gas jet and intersecting the circular groove **25** in the area where the filaments are being treated.

FIGS. 6 and 7 show an embodiment of the improved device, which generally corresponds to that of FIG. 1, but has a cylindrical grooved body **16***b* of the kind shown in FIG. 4. It should be observed that, in such case, the distance between the thread guides **10** and **12**, contributes, within certain limits, towards establishing the treatment conditions, in that the treatment area becomes limited, both in length and width, by the distance D through which the filaments travel in the groove **25** and by the width A of the groove **25**, respectively.

In actual practice, the thread guides **10** and **12** serve only to ensure that the filament bundle is positioned and maintained in front of the treatment area, i.e. the groove **25**. The distance between the thread guides can be, for example, in the range 20 mm. to 30 mm., the filaments engaging the groove only under the action of the gas jet issuing from the nozzle **14**.

As a rule, the width and depth of the groove are selected as a function of the overall denier rating of the yarn and the number of the filaments which form same. In practice, favourable results have been obtained by employing, in a device such as exemplified in FIGS. 6 and 7, a cylindrical body **16***b* having a diameter preferably between 5 mm. and 20 mm. with an annular groove whose depth is preferably comprised between 0.5 mm. and 4 mm. and whose width is between 0.5 mm. and 4 mm.

The device is preferably associate to a nozzle **14** having a diameter between 1 mm. and 3 mm. for a cylindrical bore having a length of between 4 mm. and 10 mm., fed by compressed air at a pressure between 1.5 atmospheres and 5 atmospheres.

A few practical examples of the invention method follow, performed with a device of the kind shown in FIG. 1 and equipped with means for counteracting and limiting the freedom of oscillatory movement of the filaments of the kind shown in FIG. 4.

EXAMPLE 1

A yarn having a total denier of 60 and comprising 18 polyamide filaments, of the nylon-6 kind, drawn on a conventional drawing frame at the speed of 450 meters a minute according to the conventional method of transferring the tensioned yarn from a slow roller to a swift roller, the surface speeds of the rollers being determined so as to give a draw ratio of 1 to 3.47.

Immediately downstream of the swift roller, the yarn has been caused to pass through the device. The latter comprised a grooved cylindrical body (of the type of FIG. 4) with its axis perpendicular to the plane of advance of the yarn, defined by the alignment of the inlet and outlet thread guides **10** and **12** (FIGS. 6 and 7), the cylindrical body having an outside diameter of 12 mm. and an annular groove with a depth of 1.5 mm. and a width of 1.5 mm.

Correspondingly to the area where the yarn was essentially tangent to the cylindrical body, it was thrust by a jet of compressed air at the relative pressure of 2 atmospheres, issuing from a nozzle **14** having a cylindrical bore of 1 mm. diameter and 6 mm. in length, the axis of the yarn (defined as outlined above by the alignment of the thread guides of an outlet portion) being at a distance of 2 mm. from the opening of the nozzle **14**.

Under the action of the jet, the yarn was deflected and forced to enter the groove, thus locally taking a trend which was approximately tangent to the groove bottom.

The thusly treated yarn was checked in order to ascertain the existence, the number and frequency of the false knots by the conventional method of fastening a thread section between two points, introducing a needle between the filaments and displacing the needle longitudinally along the yarn, the false knots being in those spots where the translational movement of the needle became hindered.

In the thusly treated yarn, it was ascertained that the stoppage of the needle took place at intervals between 5 mm. and 20 mm. Upon repeated checks, it was ascertained that the number of false knots per lineal meter of yarn was between 80 and 120, a value which gives an indication of the degree of cohesion.

On considering that the adopted speed of advance (450 meters a minute) was in the order of magnitude of the known and conventionally adopted treatment speeds (which can attain values of 700 meters a minute and over) it has been possible to ascertain that the treatment with the improved device according to this invention resulted in a very considerable increase of the degree of cohesion.

The comparison is conspicuous on taking into account the Example 5 of the U.S. Pat. No. 3,238,590 cited above, wherein, the yarn, drawing ratio and advance speed being the same, the formation of false knots was seen at distances between 15 mm. and 50 mm., so that the degree of cohesion obtained thereby was in the order of 30 to 35 false knots per lineal meter.

Virtually the same results were obtained by treating, under the same conditions, yarns having the same denier count and number of filament, but formed by Nylon-66 and commercial textile polyester (polyethylene terephthalate). It can thus be concluded that the physicochemical nature of the yarn involved has virtually no bearing on the result of the treatment, which is a function of the physical conditions under which the freedom of movement of the individual filaments is controlled under the effect of the gas jet issuing around the surface which opposes the deviation and controls the vibrations of the individual filaments.

EXAMPLE 2

A 150-denier yarn, made up of 32 nylon-6 monofilaments, drawn as described in Example 1 and completely untwisted (filaments parallel to the axis of the yarn) was treated in the device described in Example 1, but wherein the grooved body had a groove with the same depth of 1.5 mm. but a width of 2 mm. to allow for the higher denier and the greater number of filaments. The nozzle was fed with compressed air at a relative pressure of 3.8 atmospheres.

The treatment was carried out at an advance speed as high as 3,800 meters a minute, that is more than 8 times that adopted in the tests described in the previous example.

The thusly treated yarn, when subjected to check for ascertaining the degree of cohesion obtained, exhibited the formation of from 30 to 40 false knots per lineal meter.

The present example thus shows that the application of the improvement, the subject of this invention, affords a degree of cohesion in the order of the one obtainable with the prior art conventional devices, but at a speed which is at least 8 times as great, thus under conditions of commercial production which are considerably improved over the prior art.

Corresponding results were obtained by repeating the tests with yarns having the same denier count and number of filaments, formed by nylon-66 and polyester.

Tests and trials were carried out with yarns of a different nature and make-up, also under different conditions within the preferred field of application of the invention, that is:

EXAMPLE 3

An acetate yarn, having a denier of 75 and formed by 23 parallel monofilaments has been fed at a speed of 750 meters a minute in front of a cylindrical body of sintered ceramic material having an outside diameter of 18 mm. and annular groove 1 mm. wide and 1.5 mm. deep, under the action of an air jet issuing under a pressure of 2.5 atmospheres through a nozzle of 3 mm. dia. positioned at 5 mm. distance from the cylindrical body. The yarn was collected under a tension in the order of 3–4 gr.

The cohesion degree tests established the existence of false knots in a number which varied between a minimum of 25 and a maximum of 40 per lineal meter. The optical inspection showed that the appearance of the yarn was absolutely normal after the treatment and that the unaided eye could not discern virtually any modification, entanglement or others.

By adopting cylindrical bodies having different diameters and positioning the nozzle at different distances, within a reasonable range, no appreciable modifications of the degree of cohesion were obtained. In practice, it has been possible to ascertain that the adoption of a certain criterion of proportionality between the diameter of the cylindrical body and the distance of the nozzle from the yarn under treatment was advisable.

EXAMPLE 4

A yarn of viscose rayon having a denier of 120 and composed by 48 monofilaments, was produced under the conventional conditions on a continuous spinning machine and collected with no torsion, that is with the monofilaments parallel to each other. The treatment according to the invention was carried out between the drying device and the take-up reel, at the conventional spinning speed in the order of 70 meters a minute.

A device of the kind described above was used, but having a nozzle with a diameter of 1.5 mm. fed by compressed air under a relative pressure of 1.8 atmospheres, projected against a cylindrical body having an outside diameter of 5 mm. and an annular groove having 0.7 mm. width and 1 mm. depth. The distance between the yarn and the nozzle bore was 3 mm.

The degree of cohesion tests showed the presence of 40 to 50 false knots per lineal meter.

The effects of the treatment showed to be only scarcely influenced by variation, even comparatively wide ones, of the size of the cylindrical body and its groove. A certain advisability of adhering to a proportionality ratio between the diameter of the cylindrical body and the advance speed of the yarn was ascertained, and also to a certain proportionality between the width of the groove and the overall denier count and number of filaments of the yarn, to be treated.

These proportionality ratios are, generally, consistent with the hypotheses expressed hereinabove. As a matter of fact, the length of the portion where the filaments or monofilaments are constrained and their freedom of movement or vibration is limited, is proportional to the diameter of the cylindrical body, that is of the secant chord, of the outer cylindrical surface of the body in correspondence to the grooved area. Thus, such a factor of proportionality originates a substantial constancy in the frequency of the assumed vibrations.

What is claimed is:

1. An improved method for producing yarns composed of a plurality of continuous filaments cohered by advancing them along a basically rectilinear path and in front of a convex surface whose generatrix at one position extends at a right angle to the direction of said path while directing a gas jet at them in a direction substantially perpendicular to the direction of advance and to said generatrix so that said convex surface countracts deflection of the filaments from the rectilinear direction of advance of the filaments while permitting flow of the gas beyond said surface, which comprises limiting the amplitude and length of possible vibrations and oscillations of the individual filaments in a direction transverse both to the direction of advance and to the axis of the gas jet in the area in front of said convex surface and where the gas jet strikes the filaments, the advance being effected, in the area struck by the gas jet, in front of a groove in said convex surface whose length and width delimit the length and amplitude of said vibrations or oscillations.

2. An improved device for imparting coherence, by the agency of aerodynamical action, to yarns composed of a plurality of continuous filaments united in bundles, with small or no twist, comprising means for effecting essentially rectilinear advance of the bundle along a treatment area, means for projecting onto said bundle, in a direction essentially perpendicular to the direction of advance, a gas jet to deviate the filaments from their direction of advance, a body embodying a convex surface opposed to said jet and intersecting the axis of the jet and tangent to a plane perpendicular to the axis of said jet, and means on said body for delimiting the amplitude and length of the transversal oscillations of the individual filaments under the action of the jet and against said surface.

3. An improved device according to claim **2** wherein said surface is the bottom of a groove formed in said body and oriented in the direction of advance of the filaments and defining, by its length and width, the length and the amplitude, respectively, of the transversal oscillations of the filaments under the action of the gas jet.

4. An improved device according to claim **3**, wherein the bottom of the groove is convex.

5. An improved device according to claim **3**, wherein said body is cylindrical and has an annular groove.

6. A device according to claim 5, wherein said body has a second groove which is oriented perpendicularly to the first groove and intersects the latter at right angles in the area intersected by the jet axis.

7. A device according to claim 2, having means which delimit the treatment area and have a size between 1.5 mm. and 10 mm. in the direction of advance of the bundle and between 0.5 mm. and 4 mm. in a direction transversal to the former direction.

8. A device according to claim 2, wherein the radius of curvature of said convex surface is between 1.5 mm. and 10 mm.

9. A device according to claim 3, wherein the groove has a depth between 0.5 mm. and 4 mm., a width between 0.5 mm. and 4 mm. and the radius of curvature of the bottom wall of the groove is between 1.5 mm. and 10 mm.

10. A device according to claim 5, wherein the outside diameter of said body is between 5 mm. and 20 mm.

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U.S. Cl. X.R.

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