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[54] **FIBRILLATION PROCESS**

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[*] Notice: The portion of the term of this patent subsequent to Mar. 13, 1988, has been disclaimed.

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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.** .... **57/167,** 28/DIG. 1, 57/34 B, 57/157 F

[51] **Int. Cl.** **D02g 3/06,** D02g 1/16

[58] **Field of Search** .... 57/34, 34 B, 77.3–77.45, 57/140, 157, 157 F, 167; 28/DIG. 1, 1 F, 72 CS

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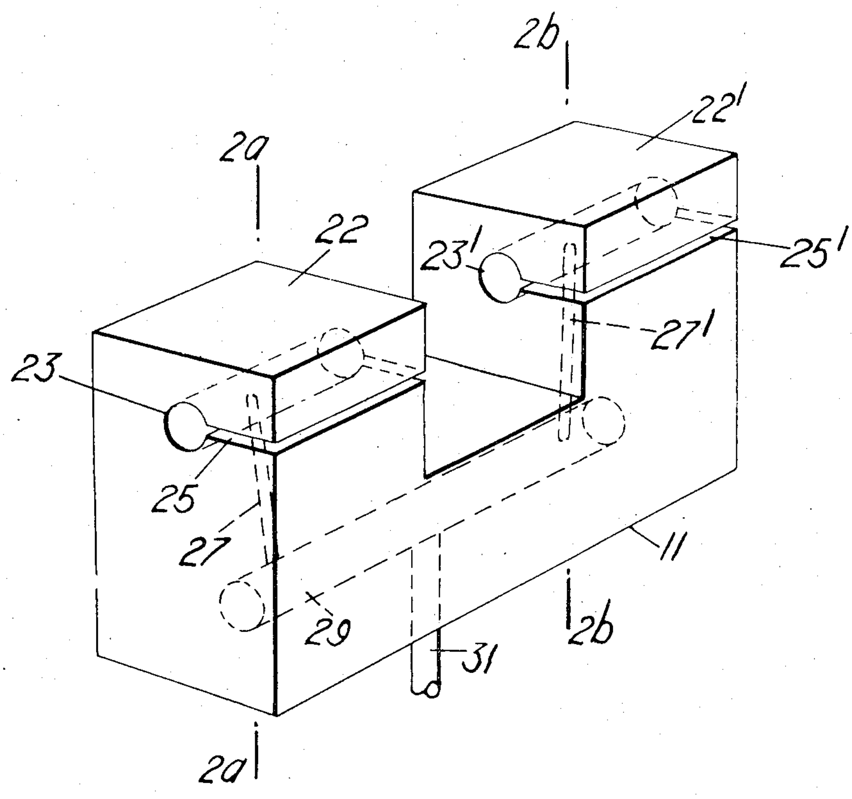
[57] **ABSTRACT**

A method of fibrillating ribbon or tape, by subjecting the material to at least two fluid false-twisting means such that the direction of twist imparted to the material is completely reversed between adjacent false-twisting means. The material may be polyamide, polyester or mixture of these two and it may be heated prior to passing into the false-twist means and relaxed after passing therethrough.

7 Claims, 4 Drawing Figures



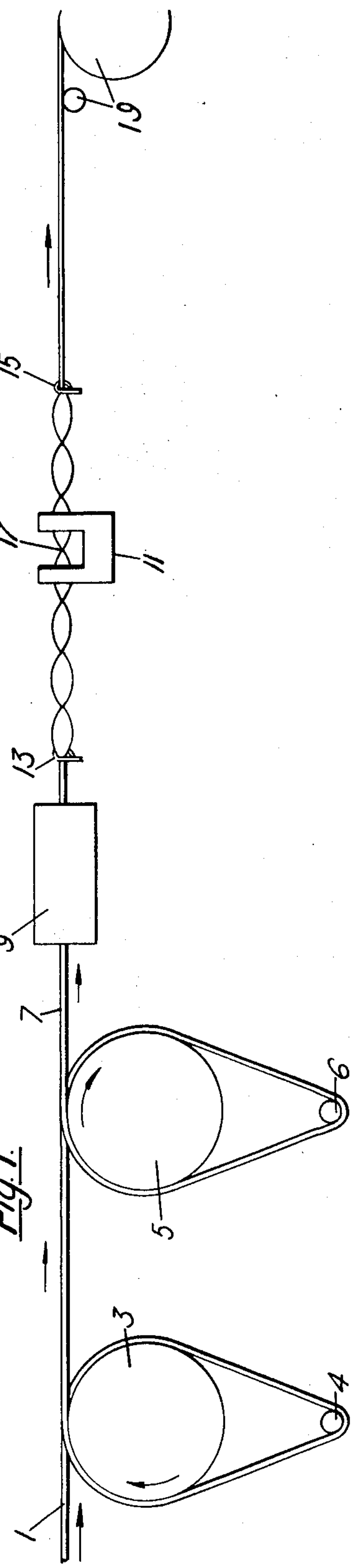


Fig. 1.

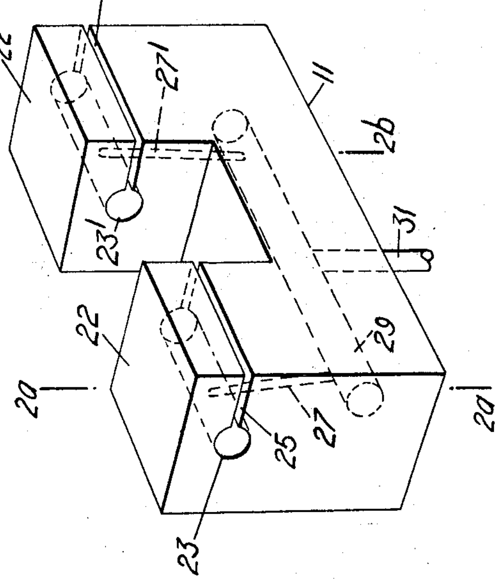


Fig. 2.

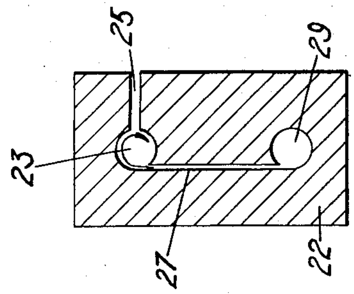


Fig. 2a.

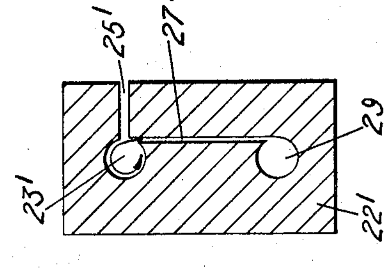


Fig. 2b.

FIBRILLATION PROCESS

The present invention concerns improvements in or relating to filamentary materials and their production and particularly to yarns, threads, cords or other filamentary articles which are made by fibrillation techniques.

It is known to produce filamentary articles from longitudinally oriented fibrillatable synthetic polymeric tapes or films by subjecting them to beating or twisting actions to cause them to fibrillate. One such known method of fibrillating involves subjecting a fibrillatable tape or film strip to the beating action of fluid flowing in a highly turbulent stream at high velocity whilst the material is kept slack or under very low tension but this method suffers from the disadvantage that control of fibrillation is poor because of the difficulty of maintaining the low tension at a relatively uniform level. This poor control over fibrillation leads to variable products, which also have more free fibril ends and fibril loops than is desirable for many end uses. Other known methods of fibrillation involve brushing or slitting fibrillatable strands, which severe mechanical actions, give products having many free fibril ends and loops and also reduce the physical properties of the strand. Acoustic and electrostatic means, optionally associated with a mechanical action, have been proposed but such methods necessitate costly apparatus. Still other known methods involve twisting the fibrillatable film strip, for instance by means of a ring-spinning machine or a mechanical false twister, so that it undergoes a substantial reduction in its transverse dimension and, in the case of the false twisting process, is then subjected to a sudden change in direction. Such methods necessitate slow processing speeds to produce sufficient fibrillation for many purposes.

It is an object of the present invention to provide a method for fibrillating a fibrillatable ribbon or tape which does not suffer from the disadvantages of the aforesaid prior art methods.

According to the present invention, there is provided a method for fibrillating a fibrillatable ribbon or tape which comprises subjecting a travelling fibrillatable ribbon or tape under tension to the action of a series of at least two fluid false-twisting means such that the direction of twist imparted to the strand is completely reversed between adjacent false-twisting means. Preferably there is substantially no change in longitudinal direction of movement of the strand between the first and second false-twisting means.

We believe that the complete reversal of twist in the material between adjacent false-twisting means imposes intense stressing and shearing forces which causes very effective fibrillation.

The term ribbon as used herein means an elongated structure wider than it is thick which is produced by extrusion of a melt of a thermoplastic polymer or a solution thereof through a slot or a number of slots in a spinneret or die and the term tape is used herein to denote an elongated structure of ribbon form but which is produced by extruding or casting the thermoplastic polymer into a film which is longitudinally slit before or after orientation into a number of narrower widths. As is well known a high degree of longitudinal orientation, preferably uniaxial orientation is necessary to produce a fibrillatable tape or ribbon.

We have found that insertion of false-twist into the ribbon or tape by means of contra-rotating fluid streams gives more effective fibrillation of a ribbon or tape than insertion by mechanical false twisting means, due to an undefined secondary action of the fluid which augments the fibrillation caused by the complete reversal of twist in the strand and produces enhanced uniformity of fibrillation. In addition the spacing of consecutive fluid jets has little effect upon the fibrillation produced.

The fibrillatable ribbons or tapes used in the present invention may be made from any polymeric substance capable of producing such ribbons or tapes and particularly useful substances are polypropylene, polyamides, polyesters and melt blends of incompatible polymers. Tapes and films of enhanced fibrillation tendency comprising a plurality of spaced parallel striations longitudinally aligned with the axis of orientation and thinner webs integral with and extending between the striations are also suitable for use in the present invention. Likewise fibrillatable, conjugate ribbons or tapes which comprise two or more superposed layers of film adhered together which films may have different shrinkage propensities may be used in a method according to this invention. In certain cases fibrillation may be affected by heating the fibrillatable ribbon or tape. One particular effect of heating a ribbon or tape, that is before passing it through contrarotating fluid jets and allowing twist to run back into the heating means, is described hereinafter. in another case, wherein heating precedes fluid jet treatment and twist is not allowed to run back into the heating means, fibrillation of less easily fibrillatable ribbons may be enhanced. Finally, heating of a ribbon or tape may be effected between stages of false twisting, which has the effect of somewhat reducing the fibrillation. In general, however, heating between stages is not desirable. The dimensions of the ribbons or tapes used may vary depending upon the apparatus used and the product desired and can be chosen accordingly. Thus for thicker ribbons or tapes a higher fluid pressure and/or a lower speed of movement of a ribbon or tape through the fluid twisting means would be used. Also to further enhance the fibrillating effect twist stopping guides may be positioned upstream and downstream of the fluid twisting means to confine the false twist effects within a shorter length. Alternatively treatment in a series of two or more pairs of contrarotating fluid jets may be used, preferably arranged to produce alternating directions of twist throughout the whole series of fluid jets.

Air is the preferred fluid for use in a process according to this invention but other fluids, as for example steam, which do not have a deleterious effect on a ribbon or tape being treated, may be used.

Ribbons or tapes treated according to the present invention may be used directly, for example in the production of cords or textile articles or a certain amount of true twist may be inserted before such use of the fibrillated materials. The usefulness of the treated materials may be enhanced by carrying out a treatment according to the invention in a manner which imparts a tendency to contract to a bulky, elastic structure.

Thus according to a further aspect of the invention we provide a process as hereinbefore described wherein the twist imparted by the first fluid false-twisting means is allowed to run back over a hotplate or into a heating zone positioned before the false-twisting means. Carrying out the process in this way allows at least a part of the first inserted twist to be heat set into the ribbon or tape, this set twist being temporarily removed, reversed and removed again in the following false-twisting devices. A ribbon or tape treated in this way when allowed to relax partly or completely will tend to return to the set twisted condition and in doing so will develop bulk and elasticity. The bulk so developed may be set in and the elastic properties modified by a further heat treatment under controlled tension or partial relaxation conditions at an elevated temperature, usually higher than the first heat setting temperature. Heat treatments as described may be applied in continuous manner by suitably positioned heating and relaxing means or the second heat treatment may be applied to a package of fibrillated material which has been wound up at a lower speed than the speed or delivery from the last false-twisting device, i.e., which has been overfed to the winding unit, such over-feeding providing the necessary tension relaxation.

As stated hereinbefore the method of the present invention produces very good fibrillation of enhanced uniformity, and this is shown by the low fibril deniers and ratios of fibril width to fibril thicknesses obtained in the fibrillatable products. Also fewer free fibril ends and fibril loops may be obtained and the product of the ratio of fibril width to fibril thickness and free fibril ends per cm. for the products produced by the method of this invention may be considerably lower than in the prior art products because of the inherently better control possible in the present invention. Free fibril ends in this context include all ends and loops which protrude from the product at least 1 mm.

The invention will now be described in more detail by way of Example and with reference to the accompanying drawings, of which FIG. 1 shows an arrangement of apparatus for fibrillating fibrillatable structures according to the invention, FIG. 2 shows a device for producing two contra-rotating fluid vortices and FIGS. 2*a* and 2*b* are cross-sections through the device of FIG. 2.

Detailed construction of a device which applies reversing false twist by means of contra-rotating fluid vortices is shown in FIGS. 2, 2*a* and 2*b* wherein the device 11 is a U-shaped member through the parallel limbs 22, 22' of which are coaxial bores 23, 23' the axes of which bores coincide.

Bores 23, 23' are provided with radially aligned parallel-sided slots 25, 25' which facilitate the stringing-up of the device. Manifold bore 29 is provided in the interior of the device, and is axially parallel with coaxial bores 23, 23'. Manifold bore 29 is connected to a pressurized fluid supply (not shown) by means of connector 31. From manifold bore 29 fluid passageways 27, 27' pass and enter bores 23, 23' tangentially and perpendicularly to the axes of said bores 23, 23'. The exit orifices from passageways 27, 27' are positioned in the walls of bores 23, 23' so as to produce fluid vortices rotating in opposite directions in limbs 22,22'.

In operation, pressurised fluid enters manifold bore 29 and passes therefrom by way of fluid passageways 27, 27' into coaxial bores 23, 23' whereby fluid vortices which are contra-rotating with respect to each other are generated in bores 23, 23'. A travelling fibrillatable ribbon or tape passes through coaxial bores 23, 23' and is false-twisted in each bore by action of the contra-rotating fluid vortices. The direction of the false-twist imparted to the ribbon or tape is reversed at a point substantially mid-way between parallel limbs 22, 22' whereat intense traverse shearing forces and stresses are induced in the ribbon or tape causing it to fibrillate and to form many fine fibrils. In the following Examples the diameters of passages 25 and 25' and 27 and 27' are respectively 4.8 and 1.6 mm.

We have found that more regular products are obtained when the twist-reversal point in the strand is maintained substantially stationary in spaced and the apparatus of FIG. 2 is particularly useful in this connection.

EXAMPLE 1

As shown in FIG. 1, an undrawn tape 1, consisting of a melt blend of polymers of composition 95.5 percent polyhexamethylene adipamide and 4.5 percent polypropylene, having a denier of 4,860, a width of 9.5 mm and a thickness of 0.055 mm is drawn and fibrillated by the following route. The tape 1 is first drawn between two rollers, 3 and 5, with associated idler rollers 4 and 6 arranged so that the tape follows a helical path on the roller assemblies having different peripheral speeds in the ratio of 1 : 5, to produce drawn, oriented tape 7 having a denier of 975, a width of 5.0 mm and a thickness of 0.028 mm. The drawn tape 7 is immediately and continuously fed at a speed of 18 metres per minute to a heating zone 9 and it is then passed at a tension of 49 grams through two contra-rotating air vortices produced by the jet device 11 shown in detail in FIG. 2, operating at a line-pressure of 10.2 kg/cm^2 gauge. Pigtail guides 13 and 15 are placed before and after the fibrillating device 11 in a position which allows the jet device 11 to generate a swirling balloon in the tape, having 6 nodes, with a node 17 positioned halfway between the contra-rotating fluid vortices generated by the device 11. After fibrillation the fibrillated tape is wound up on a constant tension winder 19.

The fibrillated tape has the following properties:

Denier of product	1035
Mean denier of fibrils	12
Fibril width to thickness ratio (W)/(T)	2.4
Fibril free ends/cm	1.5
(W)/(T) × free ends	3.6
Tenacity (grams per denier)	1.6

The fibrillated tape is a compact bundle of substantially rectangular (the narrow ends of some fibril cross-sections being somewhat rounded) cross-section fibrils having little longitudinal variation in the number of fibrils and showing few free ends or loops.

EXAMPLE 2

An undrawn tape of the same size as used in Example 1 but consisting wholly of polyhexamethylene adipamide is drawn in the same way to produce tape of 1,034 denier which is fibrillated as in the foregoing Example to produce a product having the following properties:

Denier	1059
Mean fibril denier	14
W/T ratio	2.7
Free fibril ends/cm.	4.0
W/T × free ends	10.8
Tenacity (g./den.)	0.8

EXAMPLE 3

Apparatus according to FIG. 1 slightly modified is used to draw, fibrillate and impart bulk to a tape of polyethylene terephthalate (intrinsic viscosity measured in o-chlorphenol at 25° C. of 0.67) measuring 6 mm wide and 0.044 mm thick in the undrawn condition. The FIG. 1 apparatus is modified by providing means to heat feed roll **3** to a surface temperature of 100° C., a hotplate 20 cm long and of surface temperature 200° **C. between rolls **3** and **5** and dispensing with the guide **13** which allows the twist to run back through the heating zone **9** which is also a hotplate 20 cm long of surface temperature 220° C.

The tape is drawn between rolls **3** and **5** to draw ratio of 5.8:1 at a draw speed of 61 metres per minute giving a drawn tape 2.5 mm wide and 0.013 mm thick. The device producing two contra-rotating fluid vortices is supplied with air at a line pressure of 5.6 kg per square centimetre and the fibrillated tape is wound up at a tension of 40 g and a speed of 61 metres per minute.

The bulky fibrillated product had a denier of 600 (compared with a denier of 400 for the drawn unfibrillated tape) a number of free fibril ends and a network structure when unravelled with the means fibril denier being **10.**

EXAMPLE 4

A tape of polyethylene terephthalate, having an intrinsic viscosity of 0.65 and a thickness of 0.023 mm is drawn with the apparatus described in Example 3 omitting the heating zone **9** and using feed roll and intermediate hotplate surface temperatures of 90° C and 220°C a draw ratio of 6.24:1 and a draw speed of 65 m. per minute, giving a drawn tape 3.4 mm wide and 0.009 mm thick (380 denier). The drawn tape is fibrillated as in Example 3 to produce a fibrillate of 390 denier having fibrils of mean denier 5.3.

EXAMPLE 5

A tape of polyethylene terephthalate as used in Example 3 is drawn as in that Example using an electrically heated oven operating at 180° C in place of the hotplate **9** to give a drawn tape measuring 2.4 × 0.009 mm (270 denier) which is fibrillated as in Example 3 and heat treated at 200° C in the relaxed state producing a bulky material of 348 denier and 4.0 mean fibril denier.

EXAMPLES 6–9

In these Examples a series of four air jets is used to fibrillate a polyethylene terephthalate tape as used in Example 4, each jet causing a twist counter to that of the immediately preceding jet, all being supplied with compressed air at a pressure of 5.6 Kg/cm^2. With this arrangement for the same overall consumption of air, 0.23 cubic metres per minute, as used for two jets a markedly improved fibrillation is produced as the following table, wherein processing speed is varied, shows :

Example	Speed (m./min.)	Mean fibril denier Four jets	Two jets
6	500	4.2	4.9
7	750	4.7	6.5
8	1000	5.0	8.6
9	1250	4.5	7.5

The use of four jets enables either a higher speed or an economy of air consumption to be used or a finer fibrillation to be obtained. In fact fibrillation is almost independent of processing speed with a plurality of jets.

EXAMPLES 10–13

In these Examples two contra-rotating air jets are used to fibrillate a polyethylene terephthalate tape as used in Example 4 and the distance between the two jets is varied. This as shown in the following Table has only a small effect on the extent of fibrillation produced:

	Distance between jets (cm.)	Mean fibril denier
10	2.5*	5.3
11	5	5.3
12	18	5.8
13	33	6.0

* the spacing used in Examples 1–9.

COMPARATIVE EXAMPLES A AND B

A drawn polyethylene tape as used in Example 4 is fibrillated by means of a series of two non-fluid mechanical false twisting heads. In Example A false twist tapes wherein the yarn is caused to change direction suddenly within the tube are used and in Example B two false twist bushes as described in U.K. Pat. specification No. 797,051 are used. In both cases each device is operated so as to reverse the direction of twist applied to the tape in its passage therethrough and are spaced 3.5 cm. apart; other processing conditions and the mean fibril denier of the products are given in the following Table:

	Comparative Example A	Comparative Example B
Pretension (go)	4	17
Post tension (g.)	60	20
Twister speed (r.p.m.) 4000		6000
Tape speed (m./min.)	15	15
Mean fibril denier	23	22

From the Table it can be seen that the mechanical false twisting means are both slow and inefficient fibrillation means.

EXAMPLE 14

A conjugate tape 5 mm. wide and 0.032 mm. thick is prepared by casting a thin film of polyethylene terephthalate (intrinsic viscosity 0.65) on top of a thin simultaneously cast film of a polyester comprising 80 moles percent ethylene terephthalate and 20 moles percent of ethylene isophthalate and longitudinally slitting into 5 mm. tapes. A cast conjugate tape is then drawn to a draw ratio of 6.96:1 as in Example 3 (feed roll surface temperature 80° C.) giving a drawn tape of 275 denier measuring 1.9 × 0.012 mm. which is fibrillated as in that Example. The fibrillated product on heat relaxation at 80° C develops increased bulk. The relaxed material has a total denier of 503 and a mean fibril denier of 8.8.

EXAMPLE 15

An isotactic polypropylene tape is produced with longitudinal parallel striations interspersed with thinner integral webs by melt extrusion through a shaped die and is oriented by drawing to a draw ratio of 7:1. The drawn tape of 1,830 denier and 6.5 mm width is fibrillated in a device producing two contra-rotating air vortices operated at an air pressure of 4.6 Kg. per sq.cm., the yarn speed being 150 m. per minute and the winding tension 183 g. A coarse, open network product results having an average fibril denier of 53.

What we claim is:

1. A method for fibrillating a fibrillatable ribbon or tape which comprises subjecting a travelling fibrillatable ribbon or tape under tension to the action of a series of at least two fluid false-twisting means such that the direction of twist imparted to the strand is completely reversed between adjacent false-twisting means.

2. A method according to claim **1** wherein there is substantially no change in longitudinal direction of movement of the strand between the first and second or succeeding false-twisting means.

3. A method according to claim **1** wherein the twist imparted by the first false-twisting means is allowed to run back over or into a hotplate or heating zone positioned before the false-twisting means.

4. A method according to claim **3** wherein the material after passage through the false-twisting means is allowed to relax at least partially.

5. A method according to claim **1** wherein the ribbon or tape is heated in the absence of twist before passing into a fluid false-twisting means.

6. A method according to claim **1** wherein the fluid is air.

7. A method according to claim **1** wherein a ribbon or tape is composed of polypropylene, a polyamide, a polyester or mixtures of any of these polymers.

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