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(54) **CELLULOSE ACETATE TOW BAND FOR USE IN CIGARETTE FILTERS, CIGARETTE FILTER, TOW BAND PRODUCTION APPARATUS, AND TOW BAND PRODUCTION METHOD**

(57) A cellulose acetate tow band for use in a cigarette filter, in which a filament denier is not less than 5.0 denier, a Feret area of a filament is not less than 0.5, and/or a ratio S/L of a cross-sectional area S of the filament to a cross-sectional peripheral length L of the filament is not less than 5. The filament denier may be not more than 10 denier. The Feret area may be not more than 0.9. The ratio S/L may be not more than 9. In an apparatus for or a method of manufacturing a tow band, round-shaped spinning holes (10) each with a diameter of not less than $50 \mu\text{m}$ are used. The diameter of each round-shaped spinning hole (10) may be not more than $100 \mu\text{m}$.

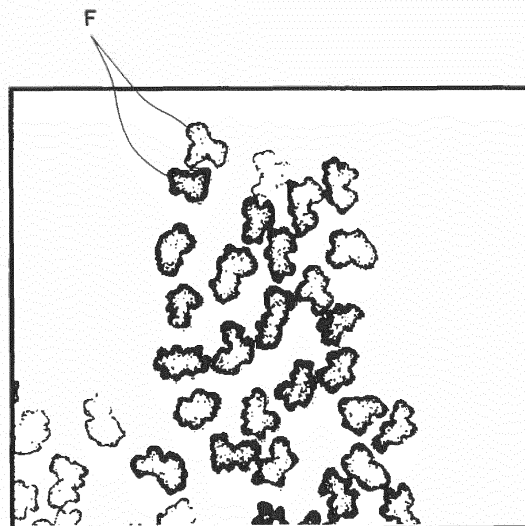


Fig. 3

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Description**Technical Field**

5 **[0001]** The present invention relates to a cellulose acetate tow band, a cigarette filter manufactured from the tow band, and an apparatus for and a method of manufacturing the tow band.

Background Art

10 **[0002]** A cellulose acetate tow band is well known as a material of a cigarette filter. In manufacturing the tow band, cellulose acetate is dissolved in an organic solvent and thereby a spinning dope is prepared. A spinning machine includes a plurality of spinning cabinets. Each spinning cabinet has a spinneret having a large number of spinning holes. Each spinning cabinet extrudes the spinning dope from the large number of spinning holes, and thereby a large number of filaments are formed. The large number of filaments are collected together to form a yarn. The tow band is manufactured
15 by bundling the yarns from all the spinning cabinets together and crimping those yarns. In manufacturing a cigarette filter, a filter rod is manufactured from such a tow band. The filter rod is manufactured in the following manner: open or "bloom" the tow band; add a plasticizer such as triacetin to the tow band, which has been opened; form the tow band into a cylindrical shape; and rolling the cylindrical tow band in rolling paper. The cigarette filter is manufactured by cutting the filter rod to a predetermined length.

20 **[0003]** In the description herein, the term "filament" refers to a single fiber (monofilament) pushed out of one spinning hole. The term "yarn" refers to one fiber bundle (a mass of monofilaments) that is obtained by bundling a large number of filaments formed by one spinning cabinet together. The term "tow band" refers to a fiber bundle that is obtained by bundling together all the yarns, the number of which is the same as the number of spinning cabinets, i.e., a fiber bundle obtained by bundling all the filaments formed by the spinning machine together. The term tow band, in the narrow sense,
25 refers to a mass of a large number of crimped filaments. In a description of conventional art, the fiber bundle or mass thus defined may be occasionally referred to not as a "tow band" but as a "filter tow" or simply a "tow".

[0004] The term "filament denier" indicates the fineness of a filament in terms of a mass (g) per unit length (9000 m). In the description below, the term "filament denier" may be abbreviated as "FD". That is, the FD of a tow band indicates the fineness of each filament forming the tow band. The term "total denier" indicates the fineness of a tow band in terms
30 of a mass (g) per unit length (9000 m). In the description below, the term "total denier" may be abbreviated as "TD". The term "packing amount" refers to the net weight of a tow band packed in one filter rod.

[0005] Conventionally, a Y-shape or other deformed shape has been preferred for the cross-sectional shape of the filament. For example, Patent Literature 1 discloses: forming an H-shaped filament by use of a spinneret with a rectangular orifice; and using a bundle of the H-shaped filaments in a cigarette filter or the like.

35 **[0006]** In recent years, thin cigarettes called "slim type" or "super slim type" have been put on the market. If the filter of such a slim cigarette is manufactured by using a conventional material such as one disclosed in Patent Literature 1, the pressure drop becomes too high. In recent years, cigarettes with a filter in which capsules encapsulating a flavor component are embedded are also put on the market. These capsules cause an increase in the pressure drop. As the pressure drop increases, it becomes less easy for the smoker to smoke the cigarette. Therefore, there is a demand for
40 a material that makes it possible to reduce the pressure drop even when applied to such a cigarette filter as above.

[0007] For example, Patent Literature 2 discloses a slim-rolled cigarette. The cigarette includes: a filter including a filter member and rolling paper rolled around the filter member; and tipping paper adhered to a cigarette rod and the filter in a manner to connect the cigarette rod and the filter. Through-holes are formed in a manner to extend through the tipping paper and the rolling paper such that air is allowed to flow in during smoking. The filter member includes a
45 tow, and the tow has a FD more than 8.0 denier and a TD less than 15000 denier. These settings, together with the through-holes, are intended to reduce the pressure drop. Moreover, it is presumed that the pressure drop is reduced by reducing the packing amount.

Citation List

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Patent Literature**[0008]**

55 PTL 1: U.S. Patent No. 2825120
PTL 2: International Publication No. WO 2013/042609

Summary of Invention

Technical Problem

5 [0009] The pressure drop can be reduced by reducing the packing amount. In this case, however, the hardness of the cigarette filter is also reduced. As a result, the cigarette filter tends to be easily deformed during the smoking. Consequently, it becomes less easy for the smoker to smoke the cigarette. Moreover, the amount of air flowing in through the through-holes increases, while the amount of air flowing in through the cigarette tip decreases instead. This causes a decrease in the amount of tar generated from the smoking.

10 [0010] In Patent Literature 2, the TD is set to be low in order to provide a volume suitable for a super slim type, and the FD is set to be high in order to reduce the pressure drop, which increases when the cigarette is made slim. As a result, the number of filaments forming the tow decreases inevitably. However, if the TD is low and the number of filaments is small, it is difficult to evenly crimp the tow in its length direction and width direction, and thus it is difficult to stabilize the quality of the tow. If the crimping is not made constant, the pressure drop of the cigarette filter varies. As a result, it is difficult to stabilize the quality of the cigarette filter.

15 [0011] In view of the above, an objective of the present invention is to provide: a cigarette filter capable of reducing its pressure drop and a variation in the pressure drop while keeping its hardness; a cellulose acetate tow band that produces such a functional advantage when used as a cigarette filter; and an apparatus for and a method of manufacturing the tow band.

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Solution to Problem

[0012] A cellulose acetate tow band for use in a cigarette filter according to one aspect of the present invention is a tow band in which a plurality of filaments extruded from a plurality of respective spinning holes are bundled together and crimped. In the cellulose acetate tow band, a filament denier is not less than 5.0 denier, and a Feret area of each of the filaments is not less than 0.5.

25 [0013] The "Feret area" is an index that can be utilized for evaluating deformation of a filament cross section. The Feret area is derived in a manner described below. A filament is cut at any point perpendicularly to the longitudinal direction of the filament to obtain a cross section. An imaginary parallelogram circumscribing the cross section is assumed (see FIG. 5). The imaginary parallelogram is formed by two pairs of opposite sides. One pair of opposite sides is formed by two parallel lines that circumscribe the cross section, and the inter-line distance between these two lines has a maximum inter-line distance value (i.e., maximum Feret diameter). The other pair of opposite sides is formed by the other two parallel lines that circumscribe the cross section, and the inter-line distance between these two lines has a minimum inter-line distance value (i.e., minimum Feret diameter). The Feret area is an area ratio calculated by dividing the cross-sectional area of the filament by the area of the imaginary parallelogram, i.e., the occupancy ratio of the cross section of the filament to the imaginary parallelogram.

30 [0014] The technical significance of the Feret area of a filament in the field of cigarette filters is described below. In general, inside a cigarette filter, the longitudinal direction of the filaments is substantially perpendicular to the flow of the mainstream smoke of the cigarette (see FIG. 6). The mainstream smoke is blocked by the filaments thus arranged, and droplets contained in the mainstream smoke collide with and are captured by the filaments. In light of the cross flow, the blocking capacity of each filament can be considered to be substantially the same as the blocking capacity of an imaginary filament whose cross-sectional shape is the imaginary parallelogram that is assumed for deriving the Feret area. That is, if the Feret area is small, it means that the blocking capacity of the filament relative to its cross-sectional area is high. The cross-sectional area of the filament indicates a positive correlation with the mass of the tow band (tow packing weight). Therefore, if the Feret area is small, it means that the mainstream smoke can be largely blocked by a small tow band mass.

35 [0015] For example, in the case of a filament with a perfect circle cross section, the imaginary parallelogram is a square, and the length of each side of the square is equal to the diameter of the perfect circle cross section. Accordingly, the Feret area is $\pi r^2/4r^2$, i.e., about 0.785 (r is the radius of the perfect circle cross section). Conventionally, however, such a filament has been considered to be an inefficient material whose capturing capacity is insufficient considering the mass, and attempts have been made to reduce the Feret area as much as possible. One of these attempts was to deform the cross section, and as described above, a deformed spinning hole and a deformed cross section have been preferred. For example, in the case of a filament with a Y-shaped cross section, which filament is formed by using a triangular spinning hole or a Y-shaped spinning hole, the Feret area of the filament is less than 0.5 because the Y-shaped cross section corresponds to a shape that is obtained by partially deforming a triangle in a contracting manner. As mentioned above, the Feret area becomes small when the degree of deformation of the cross section becomes significantly high.

40 [0016] In order to achieve the aforementioned objective, the inventors of the present invention conducted the devel-

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opment of a cellulose acetate tow band for use in a cigarette filter. During the development, the inventors arrived at an idea that is in the opposite direction to the conventional development idea. The idea the inventors arrived at was as follows: if the tow band is formed by filaments with a relatively large Feret area, the tow band is capable of reducing the blocking capacity compared to a conventional tow band formed by filaments with a deformed cross section even if both the tow bands are under the same mass condition; and owing to the reduced blocking capacity, the pressure drop can also be reduced.

[0017] According to the tow band of the above, which is one aspect of the present invention, the pressure drop can be reduced since the filament denier is not less than 5.0 denier, which is relatively high. In addition, the Feret area of each filament is not less than 0.5, and is larger than the Feret area of a conventional generally-used filament having a Y-shaped or H-shaped cross section. Accordingly, the degree of deformation of each filament is reduced compared to such conventional generally-used filaments. Therefore, when the tow band is actually used as a cigarette filter, the pressure drop can be reduced relative to the mass (i.e., even if the tow packing weight is increased). Moreover, when the tow band is used as a cigarette filter, air smoothly flows along the outer surface of each filament inside the cigarette filter, and thereby the pressure drop is reduced. Since the pressure drop is reduced, the number of filaments can be kept large.

[0018] As described above, by using the filaments each with a relatively large Feret area, when the filaments are used as a cigarette filter, the pressure drop is reduced. Therefore, it is not necessary to reduce the packing amount, and thereby the hardness of the cigarette filter can be kept high. In addition, it is not particularly necessary to reduce the total denier. Therefore, the number of filaments forming the tow band need not be reduced, which makes a stable crimping process of the tow band possible. This makes it possible to improve the quality and productivity of the tow band. When a cigarette filter is manufactured by using such a tow band as a material of the cigarette filter, the pressure drop and a variation in the pressure drop can be reduced while keeping the hardness high.

[0019] The filament denier may be not more than 10 denier. The Feret area may be not more than 0.9.

[0020] In the cellulose acetate tow band, a total denier may be not less than 14,000 denier. The total denier may be not more than 22,000 denier. Preferably, the total denier is in the range of 15,000 to 21,000 denier. More preferably, the total denier is in the range of 15,000 to 20,000 denier.

[0021] A cellulose acetate tow band for use in a cigarette filter according to another aspect of the present invention is a tow band in which a plurality of filaments extruded from a plurality of respective spinning holes are bundled together and crimped. A filament denier is not less than 5.0 denier. In a case where an area of a cross section of each of the filaments is S and a peripheral length of the cross section is L , a ratio S/L of the area to the peripheral length is not less than 5.

[0022] Similar to the Feret area, the "ratio S/L " is also an index that is utilized for evaluating deformation of a filament cross section. If the droplets contained in the mainstream smoke are perceived as aerosol, it can be considered that the surface of the filament captures the droplets. In this case, the less the ratio S/L , the higher the capturing capacity relative to the cross-sectional area of the filament, i.e., relative to the tow packing weight. The ratio S/L is reduced if the cross section of the filament is deformed significantly. The inventors of the present invention have found out that the ratio S/L can be controlled to be in a suitable range by setting the filament denier to be in a particular range.

[0023] According to the above-described tow band of the other aspect of the present invention, the pressure drop can be reduced since the filament denier is not less than 5.0 denier, which is relatively high. Since the filament denier is in such a range, the ratio S/L can be controlled to be in a suitable range, i.e., not less than 5. Since the ratio S/L is not less than 5, when the tow band is used as a cigarette filter, the pressure drop can be reduced relative to the tow packing weight. Accordingly, it is not necessary to reduce the packing amount, the total denier, and the number of filaments. Therefore, the productivity of the tow band can be increased. When a cigarette filter is manufactured from such a tow band, the pressure drop and a variation in the pressure drop can be reduced while keeping the hardness high.

[0024] The filament denier may be not more than 10 denier, and the ratio S/L may be not more than 9.

[0025] A cigarette filter according to yet another aspect of the present invention is manufactured from the above-described tow band. The cigarette filter has a circumferential length of 14 to 18 mm. Preferably, the circumferential length is in the range of 14 to 17 mm. More preferably, the circumferential length is in the range of 14 to 15 mm. Accordingly, even if the cigarette filter is used for a slim cigarette, the pressure drop of the cigarette filter and a variation in the pressure drop can be reduced while keeping the hardness of the cigarette filter high.

[0026] A cigarette filter cellulose acetate tow band manufacturing apparatus according to yet another aspect of the present invention is an apparatus for manufacturing a cellulose acetate tow band for use in a cigarette filter, in which a plurality of filaments extruded from a plurality of respective spinning holes are bundled together and crimped. The apparatus includes a spinneret including the plurality of spinning holes. Each spinning hole has a round shape, and a diameter of the spinning hole is not less than 50 μm .

[0027] A method of manufacturing a cellulose acetate tow band for use in a cigarette filter, according to yet another aspect of the present invention, includes: forming a plurality of filaments by extruding a spinning dope through each of a plurality of spinning holes; and forming a tow band by bundling the plurality of filaments together and crimping the

filaments. Each spinning hole has a round shape, and a diameter of the spinning hole is not less than 50 μm .

[0028] When each spinning hole has such a size, the filament denier and a degree of the change in the cross-sectional shape increase. However, since each spinning hole has a round shape, a filament with a filament denier of not less than 5.0 denier, the filament having a relatively smooth cross-sectional shape with a Feret area of not less than 0.5 and/or a ratio S/L of not less than 5, can be formed.

[0029] Each spinning hole may have a round shape, and the diameter of the spinning hole may be not more than 100 μm . This makes it possible to form a filament whose filament denier is not more than 10 denier, whose Feret area is not more than 0.9, and/or whose ratio S/L is not more than 9.

Advantageous Effects of Invention

[0030] The present invention makes it possible to provide: a cigarette filter capable of reducing its pressure drop and a variation in the pressure drop while keeping its hardness; a cellulose acetate tow band that provides such a functional advantage when used as a cigarette filter; and an apparatus for and a method of manufacturing the tow band.

Brief Description of Drawings

[0031]

FIG. 1 is a conceptual diagram illustrating an apparatus for and a method of manufacturing a cellulose acetate tow band for use in a cigarette filter according to one embodiment.

FIG. 2 is a bottom view of a spinneret according to the embodiment.

FIG. 3 shows a cross section of a filament according to the embodiment.

FIG. 4A is a diagram for describing an index for evaluating deformation of a filament cross section, showing one example of the cross section of the filament according to the embodiment.

FIG. 4B is a diagram for describing an index for evaluating deformation of a filament cross section, showing a comparative example.

FIG. 5 illustrates the method of deriving a Feret area.

FIG. 6 shows examples of a flow of mainstream smoke of a cigarette inside its cigarette filter.

Description of Embodiments

[0032] Hereinafter, one embodiment of the present invention is described with reference to the drawings. In the drawings, the same or corresponding elements are denoted by the same reference signs, and repeating the same descriptions is avoided below.

[0033] FIG. 1 is a conceptual diagram showing an apparatus for and a method of manufacturing a cellulose acetate tow band TB for use in a cigarette filter according to the embodiment. As shown in FIG. 1, a tow band manufacturing apparatus 1 includes a mixer 2, a filter 3, a spinning machine 4, a crimper 5, a dryer 6, and a baler 7. In manufacturing the tow band, a spinning dope (which may hereinafter be simply referred to as a "dope") is prepared (dope preparation process). In the dope preparation process, cellulose acetate is dissolved in an organic solvent such as acetone in the mixer 2 to prepare a solution with a required concentration (e.g., a weight concentration of not less than 20 wt % and not more than 30 wt %, preferably 26 wt %). Then, the solution is filtered by the filter 3. The filtrate is used as a spinning dope.

[0034] After the dope preparation process, the cellulose acetate tow band TB is manufactured from the spinning dope by using the spinning machine 4, the crimper 5, and the dryer 6 (spinning process). The tow band TB is compressed and baled by the baler 7 (baling process).

[0035] A cigarette filter is manufactured by using the tow band TB as a raw material although the manufacturing is not shown in detail in the drawings. In manufacturing the cigarette filter, a filter rod is manufactured as an intermediate product. Specifically, the tow band TB is opened or bloomed, and a plasticizer such as triacetin is added thereto. The tow band TB to which the plasticizer has been added is formed, by using a plug winding machine, into a filter rod having a cylindrical shape in conformity with an intended cigarette size (i.e., a diameter and a circumferential length), and rolling paper is wrapped around the filter rod. The filter rod thus manufactured is cut to a predetermined length suitable for an intended cigarette. In this manner, a plurality of cigarette filters are manufactured from one filter rod.

[0036] The tow band TB according to the present embodiment is suitable as a material of a cigarette filter attached to a thin cigarette, such as a so-called slim type or super slim type cigarette. For example, the cigarette filter has a circumferential length of not less than 14 mm and not more than 18 mm (the circumferential length is preferably 14 to 17 mm, and more preferably, 14 to 15 mm or less).

[0037] Hereinafter, the spinning process and the machines 4 to 6 used in the spinning process are described. The spinning machine 4 includes a plurality of spinning cabinets 11 and a plurality of spinnerets 12 corresponding to the

respective spinning cabinets 11. Each spinning cabinet 11 is a cylindrical body elongated in the vertical direction, and each spinneret 12 is provided at the upper end of a corresponding one of the spinning cabinets 11. Each spinneret 12 includes a plurality of spinning holes 10 (see FIG. 2).

5 [0038] The spinning dope is fed into the plurality of spinnerets 12 by a spinning pump 13. The spinning dope is extruded downward into each spinning cabinet 11 through the plurality of spinning holes of its spinneret 12, and a plurality of filaments F are formed from the spinning dope by a dry spinning method. The more the plurality of filaments F move downward, the closer the filaments F come to each other. As a result, a single yarn Y is formed. The yarn Y is discharged downward from the bottom of the spinning cabinet 11. In the spinning machine 4, a plurality of yarns Y are discharged from the plurality of respective spinning cabinets 11.

10 [0039] Each yarn Y is supplied with an oil emulsion, containing textile oil and water, from an oiling device 14, passes around a godet roller 15, and is fed to the crimper 5. The plurality of yarns Y are bundled together while being fed from the godet rollers 15 to the crimper 5, and thereby the tow band TB is formed. The crimper 5 is of a known stuffing box type, for example. The tow band TB is fed into a crimper box (stuffer box) while being pushed by a pushing roll. In this manner, wavy crimping is imparted to the tow band TB. The crimped tow band TB (the tow band in the narrow sense) is fed from the crimper 5 to the dryer 6. In the dryer 6, the residual solvent and moisture are removed from the tow band TB.

15 [0040] Hereinafter, a process of forming a cellulose acetate filament by a dry spinning method is described. The spinning dope, after being extruded through a spinning hole, runs downward inside the spinning cabinet 11 until the spinning dope as a filaments is discharged from the spinning cabinet 11. At a point when the dope starts running (i.e., at a point when the dope is extruded through the spinning hole), the dope is in a liquid phase. While the dope is running, the solvent evaporates from the dope, and thereby a filament is formed and the dope transforms from a liquid phase into a solid phase. The solvent starts evaporating from the dope surface immediately after the dope starts running.

20 [0041] The cross-sectional shape of the filament is characterized by a relationship between an evaporation speed and a diffusion speed, the evaporation speed being a speed at which the solvent evaporates from the dope surface, the diffusion speed being a speed at which the solvent diffuses from the dope center to the dope surface. The evaporation speed depends on, for example, the following factors: (1) the solvent retentivity of the cellulose acetate; (2) the vapor pressure of the solvent at an ambient temperature; (3) the degree of saturation of ambient gas by solvent vapor at each of running points; (4) the extrusion speed of the spinning dope; and (5) the area of the evaporation surface. The diffusion speed accords with Fick's second law.

25 [0042] Immediately after the dope starts running, the speed of the diffusion from the dope center is slower than the speed of the evaporation from the dope surface. As a result, the surface layer of the dope solidifies, and thereby a skin is formed. When the skin is formed, the cross-sectional peripheral length of the filament is roughly determined. The solvent at the dope center diffuses inside the formed skin and evaporates. Accordingly, after the skin is formed, the volume inside the skin (i.e., the cross-sectional area of the filament) decreases, and thereby the skin is deformed in the radial direction. As a result, the cross section of the filament has a shape that is deformed from the shape of the spinning hole.

30 [0043] The inventors of the present invention have found the following facts. That is, in a case where the diameter of the spinning hole is small, a large part of the solvent at the dope center diffuses inside the skin and evaporates during the skin being formed. As a result, the cross-sectional shape of the filament does not greatly differ from the shape of the spinning hole. For example, if the spinning hole has a round shape, the cross section of the filament has a substantially round shape and its deformation is small. If the deformation of the cross section is small, it is difficult to obtain sufficient filtration performance. Conventionally, filtration performance has been assured, by adopting a deformed shape for the spinning hole and thereby adopting a deformed cross sectional shape of the filament such as a Y shape or H shape.

35 [0044] Almost all of the factors (1) to (4) mentioned above are determined by the processes. Specifically, the factor (1) depends on the solvent to be used; the factor (2), i.e., the ambient temperature, depends on the drying temperature in the process; the factor (3) is determined by the flow rate of the drying air; and the factor (4) is determined by the production capacity such as the spinning speed. Regarding the factor (5), if the diameter of the spinning hole is large, the cross section of the filament is large and the area of the evaporation surface is large. If the area of the evaporation surface is large, the evaporation speed increases and the cross section of the filament is deformed to a greater degree. In addition, if the diameter of the spinning hole is large, the volume of the solvent confined inside the skin is large. Also for this reason, the cross section of the filament is deformed to a greater degree.

40 [0045] In view of the above, by setting the diameter of the spinning hole within a specific range and forming the shape of the spinning hole to be round, the deformation of the cross section of the filament can be controlled to obtain certain filtration performance. Specifically, in a case where the diameter of the spinning hole is to be small, by using a round spinning hole whose diameter is within a specific range, a suitable degree of deformation of the cross section of the filament can be caused without using a conventionally preferred Y-shaped or H-shaped deformed spinning hole cross section. The pressure drop can be suitably controlled by a filament with such deformation and a specific FD.

45 [0046] FIG. 2 is a bottom view of the spinneret 12 according to the embodiment. As shown in FIG. 2, the plurality of spinning holes 10 are open at a bottom surface 12a of the spinneret 12, facing the inside of the spinning cabinet 11. As

one example, the bottom surface 12a may have a round shape, and the plurality of spinning holes 10 may be arranged in an annular manner on the bottom surface 12a. However, the shape of the bottom surface 12a and the arrangement of the spinning holes 10 may be changed as necessary. Each spinning hole 10 has a round shape, and the diameter thereof is not less than 50 μm and not more than 100 μm . More preferably, the diameter of the spinning hole 10 is not

less than 50 μm and not more than 90 μm .
[0047] FIG. 3 shows a cross section of the filament F according to the embodiment. The cross section can be obtained by cutting the filament F perpendicularly to the longitudinal direction of the filament. The FD of the filament F is not less than 5.0 denier and not more than 10 denier, and more preferably, not less than 5.5 denier and not more than 9.0 denier. By using the above-described spinning hole 10, the FD of the tow band TB can be set within this numerical value range.

[0048] Since the diameter of the spinning hole 10 is within the above specific range, the deformation of the cross-sectional shape of the filament F extruded through the spinning hole 10 is controlled to be within a suitable range. Although the cross-sectional shape of the filament F is not a perfect circle, the degree of its deformation is less than the degree of the deformation of a Y-shaped cross section or H-shaped cross section, and the cross-section of the filament F shows a shape approximate to a circle.

[0049] FIGS. 4A and 4B are diagrams each for explaining an index for evaluating deformation of a filament cross section. FIG. 4A shows one example of the cross section of the filament F according to the embodiment. FIG. 4B shows, as a comparative example, one example of the cross section of a Y-shaped filament Fy that is formed by using a spinneret with a triangular or Y-shaped spinning hole. The index is, for example, "Ferret area" or "ratio S/L".

[0050] The "Ferret area" is the ratio of an area S to an area SVP (S/SVP), where S is the area of the cross section of the filament F, and SVP is the area of an imaginary parallelogram VP circumscribing the cross section. The imaginary parallelogram is formed by two pairs of opposite sides. One pair of opposite sides is formed by two parallel lines that circumscribe the cross section, and the inter-line distance between these two lines is the maximum Ferret diameter. The other pair of opposite sides is formed by the other two parallel lines that circumscribe the cross section, and the inter-line distance between these two lines is the minimum Ferret diameter. Accordingly, if the cross section of the filament F is taken at any point and the Ferret area of the cross section is obtained, the Ferret area is value that does not depend on the orientation of the cross section around the normal line. If the cross section is a perfect circle, the Ferret area is 0.785[-], and if the cross section is a triangle, the Ferret area is 0.5[-] or less.

[0051] The cross section of the filament F is very small. However, by processing electronic image data captured by a microscope by using a known image processing technique or by performing manual calculation based on the captured image, the imaginary parallelogram VP circumscribing the cross section of the filament can be set, and the cross-sectional area S, the area SVP, and a cross-sectional peripheral length L can be measured.

[0052] As shown in FIG. 4B, in the cross section of the Y-shaped filament Fy according to the comparative example, a region obtained by eliminating an inscribed circle ICy from the cross section prominently protrudes outward from a plurality of (three) points on the circumference of the inscribed circle ICy, and these points are prominently away from each other in the circumferential direction. Meanwhile, an imaginary parallelogram VPy needs to be set such that the imaginary parallelogram VPy circumscribes this region. For this reason, the imaginary parallelogram VPy is away from the inscribed circle ICy in the radial direction, and the size of the imaginary parallelogram VPy is significantly greater than that of the inscribed circle ICy. The region merely occupies a small part of a space that is obtained by eliminating the inscribed circle ICy from the imaginary parallelogram VPy. Accordingly, the Ferret area of the Y-shaped filament according to the comparative example is a small value. Since the Y shape is a result of contracting the triangular shape of the spinning hole, the Ferret area is less than 0.5. Moreover, the outer edge of the cross section is rugged to a great degree. Consequently, the cross-sectional peripheral length L is great relative to the cross-sectional area S, and the ratio S/L is a small value.

[0053] On the other hand, as shown in FIG. 5A, the filament F according to the present embodiment is formed by using a round spinning hole, and the outer edge of the cross section is rugged to a small degree. In the cross section of the filament F, a region obtained by eliminating an inscribed circle IC from the cross section is formed substantially fully circumferentially. The amount of outward protrusion from the inscribed circle IC does not vary greatly when seen in the circumferential direction of the inscribed circle IC. Accordingly, the imaginary parallelogram VP is close to the inscribed circle IC in the radial direction. As thus described, in the case of the filament F according to the embodiment, the deformation of the cross-sectional shape is reduced. Therefore, the Ferret area is a relatively large value; the outer edge of the cross section protrudes and is recessed to a small degree; and the ratio S/L is a large value.

[0054] In the present embodiment, the spinning hole 10 whose diameter is 40 μm or more is used, and the FD of the tow band TB is 5.0 denier or more, which is higher than a conventional general value. Since the FD is thus increased, when the tow band TB is used as a cigarette filter, the pressure drop can be reduced.

[0055] Moreover, in the present embodiment, the round spinning hole 10 is used, and the Ferret area of the filament F is not less than 0.5 and not more than 0.9. The ratio S/L is not less than 5 and not more than 9. Since the deformation of the cross section of the filament is reduced, when the tow band TB is used as a cigarette filter, the pressure drop can be reduced even through the TD is high.

[0056] As previously described, the deformation is prominent when the diameter of the spinning hole 10 is excessively large and the FD of the tow band TB is excessively high. When the FD of the tow band TB is excessively high, it is necessary to reduce the number of filaments forming the tow band TB in order to adjust the TD of the tow band TB.

[0057] For the above reason, the diameter of the spinning hole 10 is set to be 100 μm or less, and the FD of the tow band TB is set to be 10 denier or less. It is more preferable for the diameter of the spinning hole 10 to be not less than 50 μm and not more than 90 μm . It is also more preferable for the FD of the tow band TB to be not less than 15,000 denier and not more than 22,000 denier. By adopting these settings, the Feret area can be made not less than 0.6 and not more than 0.8, and also, the ratio S/L can be made not less than 5.5 and not more than 8.0.

[0058] As described above, in the present invention, by restricting the FD within a certain value range to reduce the deformation, an increase in the pressure drop can be reduced. In addition, in the present invention, even if the packing amount of the filter is increased, the pressure drop increases to a relatively small degree. Accordingly, a variation in the pressure drop of the cigarette filter due to a variation in the packing amount of the cigarette filter can be reduced. This makes it possible to increase the packing amount of the cigarette filter and keep the hardness of the filter. Accordingly, a manufacturer of cigarette filters is allowed to manufacture the cigarette filters without having to change the manufacturing conditions in accordance with each cigarette type. This improves the productivity of the cigarette filters.

[0059] Moreover, in the present invention, the TD of the tow band TB can be kept high. For example, the TD of the tow band TB can be set to be not less than 14,000 denier and not more than 22,000 denier. Preferably, the TD of the tow band TB can be set to be not less than 15,000 denier and not more than 21,000 denier. Even if the TD is kept high in this manner, the pressure drop can be reduced when the tow band TB is used as a cigarette filter. In addition, since the TD of the tow band TB is kept high, the volume of a tow T to be fed into the crimper 5 per unit time is also large. This makes it possible to stably feed the tow T into the crimper box and readily crimp the tow T. Accordingly, in the present invention, a variation in the pressure drop due to a variation in the number of crimps of the tow band TB can also be reduced.

[0060] The tow band TB according to the present embodiment is formed such that the FD satisfies the aforementioned numerical value range and such that the Feret area and/or the ratio S/L satisfies the aforementioned numerical value range(s). This makes it possible to favorably reduce a variation in the pressure drop due to a variation in the packing weight. Specifically, a variation in the pressure drop of a cigarette filter (a plug) in which the tow band TB according to the present embodiment is used can be made not more than 4.0 %, preferably not more than 3.8 %, more preferably not more than 3.5 %, and yet more preferably not more than 3.2 %.

[0061] As described above, when the tow band TB is used as a cigarette filter, the pressure drop can be reduced while keeping the hardness of the cigarette filter without requiring strict production control, and the tow band TB can be manufactured with reduced variation in the TD and in the number of crimps. By manufacturing a cigarette filter with use of the tow band TB, the hardness of the cigarette filter can be kept high, and also, a variation in the pressure drop can be reduced. In particular, the cigarette filter can be suitably adopted as a cigarette filter of a "slim type" cigarette and of a "super slim type" cigarette, which are on the market in recent years, or as a cigarette filter in which capsules are to be embedded.

Working Examples

[0062] Hereinafter, working examples are described. It should be noted that the present invention is not limited to the working examples described below. In the working examples and comparative examples, the Feret area, the ratio S/L, the pressure drop, variation values of the pressure drop, and the filter hardness were measured by a method described below.

(Feret area)

[0063] A pencil-like filament sample was fabricated from a tow band according to a working example or a comparative example. Specifically, a fiber bundle was partially extracted from the tow band, and the extracted fiber bundle was wrapped by paraffin such that the fiber bundle was disposed at a position corresponding to the lead of a pencil. The filament sample thus fabricated was sliced by a microtome to have a thickness of 1 μm to 10 μm , and thereby a sample segment was obtained. The sample segment was observed by an optical microscope ("BX-51" manufactured by Olympus Corporation), and an image captured from the observation was loaded into an image processor. The image processor was used to: set an imaginary parallelogram VP circumscribing one filament cross section contained in the image; and measure the cross-sectional area of the filament and the area of the imaginary parallelogram VP. The Feret area was calculated by dividing the cross-sectional area of the filament by the area of the imaginary parallelogram.

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(Ratio S/L)

5 [0064] The above sample segment was observed by the above optical microscope. An image captured from the observation was loaded into an image processor. The image processor was used to measure the cross-sectional area and the peripheral length of one filament cross section contained in the image. The ratio S/L was calculated by dividing the cross-sectional area by the peripheral length.

(Pressure Drop)

10 [0065] A filter rod sample was fabricated from a tow band according to a working example or a comparative example. Specifically, a tow band was bundled up by an existing manufacturing apparatus to have a predetermined diameter, and the tow band was fixed by rolling paper by means of a filter winding machine. In this manner, a filter rod sample with a predetermined length and a predetermined packing amount (net tow weight) was fabricated. Air with a temperature of 22 ± 1 °C and a humidity of 60 ± 10 % was passed through the filter rod sample at a flow rate of 17.5 cc per second. At 15 the time, a pressure difference [mmWG] (millimeter water gauge) between the pressures at both ends of the filter was measured. It should be noted that, in all of the working and comparative examples, the filter rod sample has no through-hole extending through the rolling paper.

(Variation Values of Pressure Drop)

20 [0066] One in fifteen filter rod samples was sampled, and thereby 300 filter rod samples were sampled in total. From pressure drop measurement values of the respective 300 filter rod samples, variation values were obtained, which were indicated by percent.

25 (Filter Hardness)

[0067] The filter hardness of a filter rod sample that was formed to have a plug length of 120 mm, a circumference of 16.70 mm, and a pressure drop of 350 mmWG was measured by using a hardness meter ("QTM7" manufactured by Filtrona). At the time of measuring the filter hardness, a load of 300 g was perpendicularly applied to the side surface 30 of the filter rod sample. The filter hardness was calculated by using an equation below.

$$\text{Filter hardness [\%]} = d / d_0 \times 100$$

35 [0068] In the equation, d represents the diameter of the filter rod sample in the load-applied direction after the filter rod sample was deformed due to the applied load, and d₀ represents the diameter of the filter rod sample before being deformed. If there is no deformation, it means that the hardness is 100 %. The closer the hardness is to 100 %, the harder the filter rod sample is.

40 (Working Examples 1 and 2)

[0069] A tow band according to Working Example 1 was manufactured in the following manner. Specifically, cellulose diacetate with an average acetylation degree of 55.2 % was dissolved in acetone, and thereby a spinning dope with a concentration of about 25 mass % was prepared. The spinning dope with a temperature of 50 to 60°C was fed to each 45 spinneret. Each spinning hole had a round shape whose diameter was 71 μm. The spinning dope was extruded into the spinning cabinets through the respective spinnerets, and thereby filaments each with a FD of 8.6 denier were formed. Inside each spinning cabinet, heated air with a temperature of 120 to 150°C was applied to the filament in order to evaporate acetone. An oil emulsion is supplied to each of bundled masses (yams) discharged from the respective spinning cabinets, and then the yarns were wound up around the respective godet rollers. The yarns were bundled 50 together to form a tow band with a TD of 21,000 denier. The tow band was crimped, and dried by the dryer. A tow band according to Working Example 2 was manufactured in the same manner as in Working Example 1 except the following point: in Working Example 2, filaments each with a FD of 6.0 denier were formed by using round spinning holes each with a diameter of 59 μm.

55 (Comparative Examples 1 to 7)

[0070] A tow band according to Comparative Example 1 was manufactured in the same manner as in Working Example

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1 except the following point: in Comparative Example 1, filaments each with a FD of 2.0 denier were formed by using triangular spinning holes, each triangular spinning hole having sides, each of which was about 45 μm . A tow band according to Comparative Example 2 was manufactured in the same manner as in Working Example 1 except the following point: in Comparative Example 2, filaments each with a FD of 3.0 denier were formed by using triangular spinning holes, each triangular spinning hole having sides, each of which was about 55 μm . A tow band according to Comparative Example 3 was manufactured in the same manner as in Working Example 1 except the following point: in Comparative Example 3, filaments each with a FD of 6.0 denier were formed by using triangular spinning holes, each triangular spinning hole having sides, each of which was about 80 μm . A tow band according to Comparative Example 4 was manufactured in the same manner as in Working Example 1 except the following point: in Comparative Example 4, filaments each with a FD of 7.0 denier were formed by using triangular spinning holes, each triangular spinning hole having sides, each of which was about 85 μm . A tow band according to Comparative Example 5 was manufactured in the same manner as in Working Example 1 except the following point: in Comparative Example 5, filaments each with a FD of 8.6 denier were formed by using triangular spinning holes, each triangular spinning hole having sides, each of which was about 95 μm . A tow band according to Comparative Example 6 was manufactured in the same manner as in Comparative Example 3 except the following point: in Comparative Example 6, the TD was 17,000. A tow band according to Comparative Example 7 was manufactured in the same manner as in Working Example 1 except the following points: in Comparative Example 7, filaments each with a FD of 8.0 denier were formed by using triangular spinning holes, each triangular spinning hole having sides, each of which was about 95 μm ; and the TD was 15000.

[0071] From each of the tow bands according to Working Examples 1 and 2 and Comparative Examples 1 to 7, a filter rod sample with a plug length of 120 mm, a circumference of 16.70 mm, and a tow packing weight of 0.35 g/rod was fabricated, and the fabricated filter rod samples were stored under controlled humidity for 24 hours in an air-conditioned room where the temperature was set to 20°C and the humidity was set to 65 %.

[0072] The pressure drop and its variation value of each obtained sample were measured by the above-described measurement method. Also, the filter hardness of each of the samples according to Working Example 1 and Comparative Example 7 was measured by the above-described measurement method. Table 1 shows the measurement results.

[Table 1]

	Spinning Hole	TD [D]	FD [D]	Feret Area [-]	S/L [m]	Pressure Drop [mmWG]	Pressure Drop Variation [%]	Plug Hardness [%]
Working Example 1	Round	21,000	8.6	0.71	7.7	280	4.0%	90%
Working Example 2	Round	21,000	6,0	-	-	360	4.0%	-
Comparative Example 1	Y shape	21,000	2.0	0.41	2.4	850	3.2%	-
Comparative Example 2	Y shape	21,000	3.0	0.41	2.9	770	3.2%	-
Comparative Example 3	Y shape	21,000	6.0	0.42	3.9	560	3.8%	-
Comparative Example 4	Y shape	21,000	7.0	0.41	4.3	510	3.8%	-
Comparative Example 5	Y shape	21,000	8.6	0.42	4.8	430	3.8%	-
Comparative Examples 6	Y shape	17,000	6.0	0.42	3.9	570	3.8%	-
Comparative Example 7	Y shape	15,000	8.0	-	4.8	530	4.5%	80%
(Plug length: 120 mm, Circumference: 16.70 mm, Tow packing weight: 0.35 g/rod)								

[0073] From each of the tow bands according to Working Examples 1 and 2 and Comparative Examples 1 to 5, a filter rod sample with a tow packing weight of 0.33 g/rod was also fabricated. From the tow band according to Comparative

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Example 6, a filter rod sample with a tow packing weight of 0.33 g/rod and a filter rod sample with a tow packing weight of 0.28 g/rod were also fabricated. From the tow band according to Comparative Example 7, a filter rod sample with a tow packing weight of 0.33 g/rod, a filter rod sample with a tow packing weight of 0.28 g/rod, and a filter rod sample with a tow packing weight of 0.24 g/rod were also fabricated. The pressure drop of each obtained sample was measured by the above-described measurement method. Table 2 shows the measurement results.

[Table 2]

		Tow Packing Weight [g/rod]			
		0.35	0.33	0.28	0.24
Pressure Drop [mmWG]	Working Example 1	280	250	-	-
	Working Example 2	360	320	-	-
	Comparative Example 1	850	710	-	-
	Comparative Example 2	770	640	-	-
	Comparative Example 3	560	470	-	-
	Comparative Example 4	510	430	-	-
	Comparative Example 5	430	360	-	-
	Comparative Example 6	570	530	380	-
	Comparative Example 7	530	480	360	260

[0074] It is clear from the comparison of Working Example 1 (8.6 R 21000) and Comparative Example 5 (8.6 Y 21000) that, in the case of triangular spinning holes, when the TD is 21,000 denier, even if the FD is increased to 8.6 denier, the pressure drop achieved by the plug length of 120 mm and the circumference of 16.70 mm is about 430 mmWG.

[0075] If it is desired to achieve a pressure drop of about 300 mmWG in the case of triangular spinning holes, the TD needs to be reduced. As is understood from Comparative Example 7 (8.0 Y 15000), in a case where the TD is 15,000 denier and the FD is 8.0 denier, the pressure drop is 530 mmWG. Accordingly, it is necessary to reduce the pressure drop by reducing the packing weight. If the packing weight is between 0.25 g and 0.28 g, a pressure drop of about 300 mmWG can be achieved. However, as shown in Table 2, the hardness decreases in accordance with a decrease in the packing weight (Comparative Example 7).

[0076] Meanwhile, by forming each spinning hole in a round shape and increasing the filament denier, filaments each with a large Feret area can be obtained. In the case of such a tow band, even if the total denier is kept high, the pressure drop will not be high.

[0077] As is clear from the comparison of Working Example 1 and Comparative Example 7, in a case where the total denier is kept high, the degree of variation in the pressure drop of the plug can be reduced in Working Example 1.

[0078] In addition, in Working Example 1, a variation in the pressure drop due to a variation in the weight is less than in Comparative Example 7, and as is clear from Working Example 1, even if the packing weight varies, the degree of variation in the pressure drop is small.

[0079] Therefore, for example, in the case of a tow band with a high TD, the tow band including filaments that are formed by using round spinning holes and that have a high FD and a large Feret area, the pressure drop can be reduced by about 30 % while keeping the packing weight. This makes it possible to reduce the possibility of the occurrence of a hardness problem, and reduce a variation in the pressure drop due to a packing weight variation occurring at the time of plug winding.

Industrial Applicability

[0080] The present invention is useful when applied to a cellulose acetate tow band for use in a cigarette filter.

Reference Signs List

[0081]

F filament
TB tow band

- 1 tow band manufacturing apparatus
- 4 spinning machine
- 5 crimper
- 10 spinning hole
- 5 11 spinning cabinet
- 12 spinneret

Claims

- 10 1. A cellulose acetate tow band for use in a cigarette filter, in which a plurality of filaments extruded from a plurality of respective spinning holes are bundled together and crimped, wherein a filament denier is not less than 5.0 denier, and a Feret area of each of the filaments is not less than 0.5.
- 15 2. The cellulose acetate tow band for use in a cigarette filter according to claim 1, wherein the filament denier is not more than 10 denier.
- 20 3. The cellulose acetate tow band for use in a cigarette filter according to claim 1 or 2, wherein the Feret area is not more than 0.9.
- 25 4. The cellulose acetate tow band for use in a cigarette filter according to any one of claims 1 to 3, wherein a total denier is not less than 14,000 denier.
- 30 5. The cellulose acetate tow band for use in a cigarette filter according to claim 4, wherein the total denier is not more than 22,000 denier.
- 35 6. A cellulose acetate tow band for use in a cigarette filter, in which a plurality of filaments extruded from a plurality of respective spinning holes are bundled together and crimped, wherein a filament denier is not less than 5.0 denier, and in a case where an area of a cross section of each of the filaments is S and a peripheral length of the cross section is L, a ratio S/L of the area to the peripheral length is not less than 5.
- 40 7. The cellulose acetate tow band for use in a cigarette filter according to claim 6, wherein the filaments denier is not more than 10 denier, and the ratio S/L is not more than 9.
- 45 8. A cigarette filter manufactured from the tow band according to any one of claims 1 to 7, the cigarette filter having a circumferential length of 14 to 18 mm.
- 50 9. An apparatus for manufacturing a cellulose acetate tow band for use in a cigarette filter, in which a plurality of filaments extruded from a plurality of respective spinning holes are bundled together and crimped, the apparatus comprising a spinneret including the plurality of spinning holes, wherein each spinning hole has a round shape, and a diameter of the spinning hole is not less than 50 μm .
- 55 10. The apparatus for manufacturing a cellulose acetate tow band for use in a cigarette filter, according to claim 9, wherein each spinning hole has a round shape, and the diameter of the spinning hole is not more than 100 μm .
- 11. A method of manufacturing a cellulose acetate tow band for use in a cigarette filter, the method comprising:
 - forming a plurality of filaments by extruding a spinning dope through each of a plurality of spinning holes; and
 - forming a tow band by bundling the plurality of filaments together and crimping the filaments, wherein
 - each spinning hole has a round shape, and a diameter of the spinning hole is not less than 50 μm .

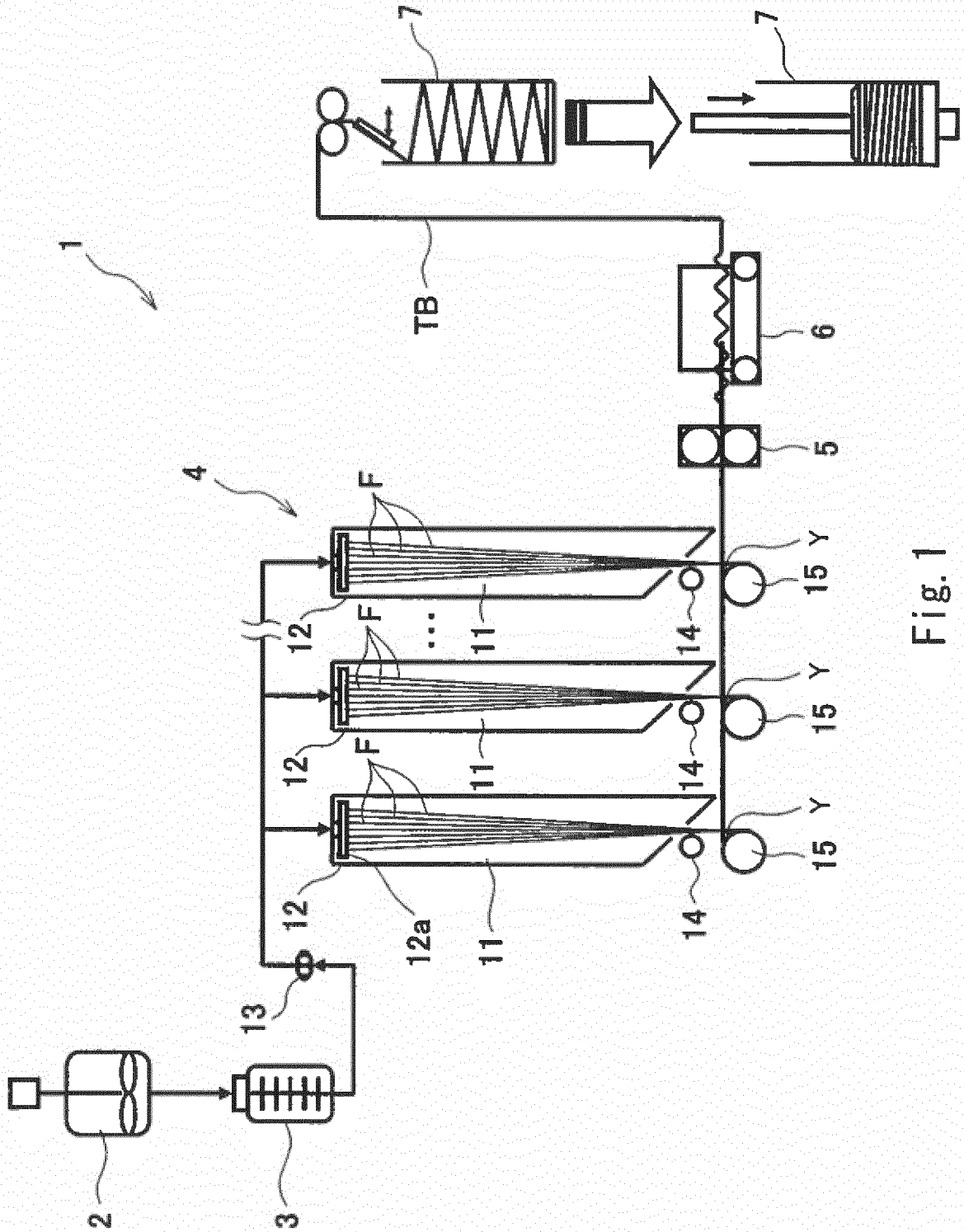
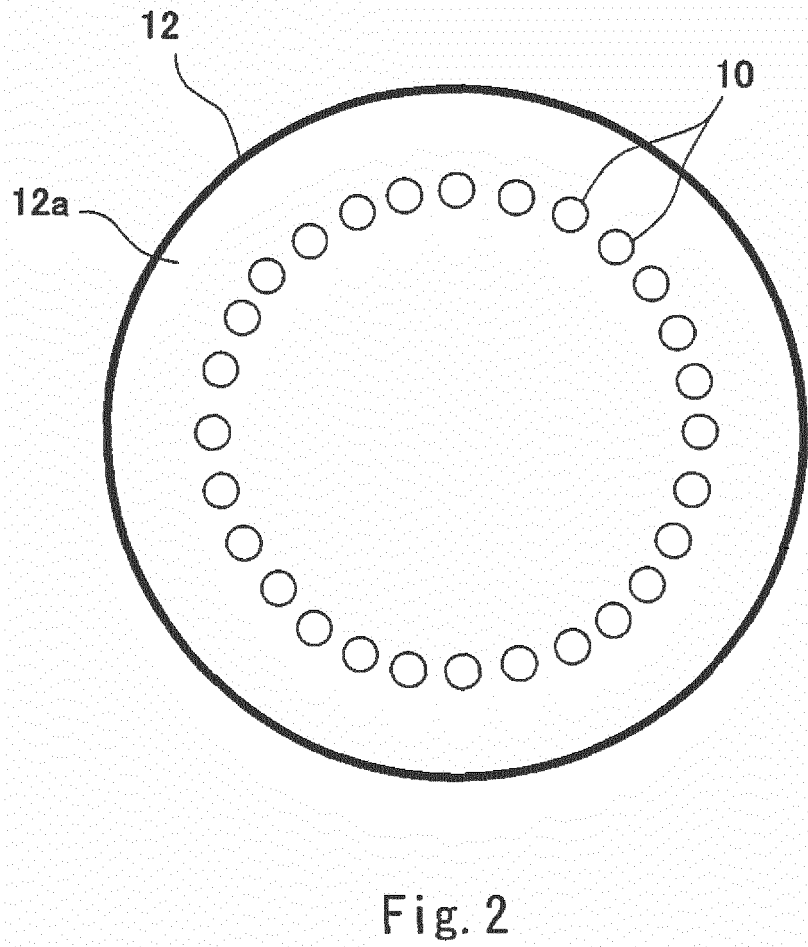


Fig. 1



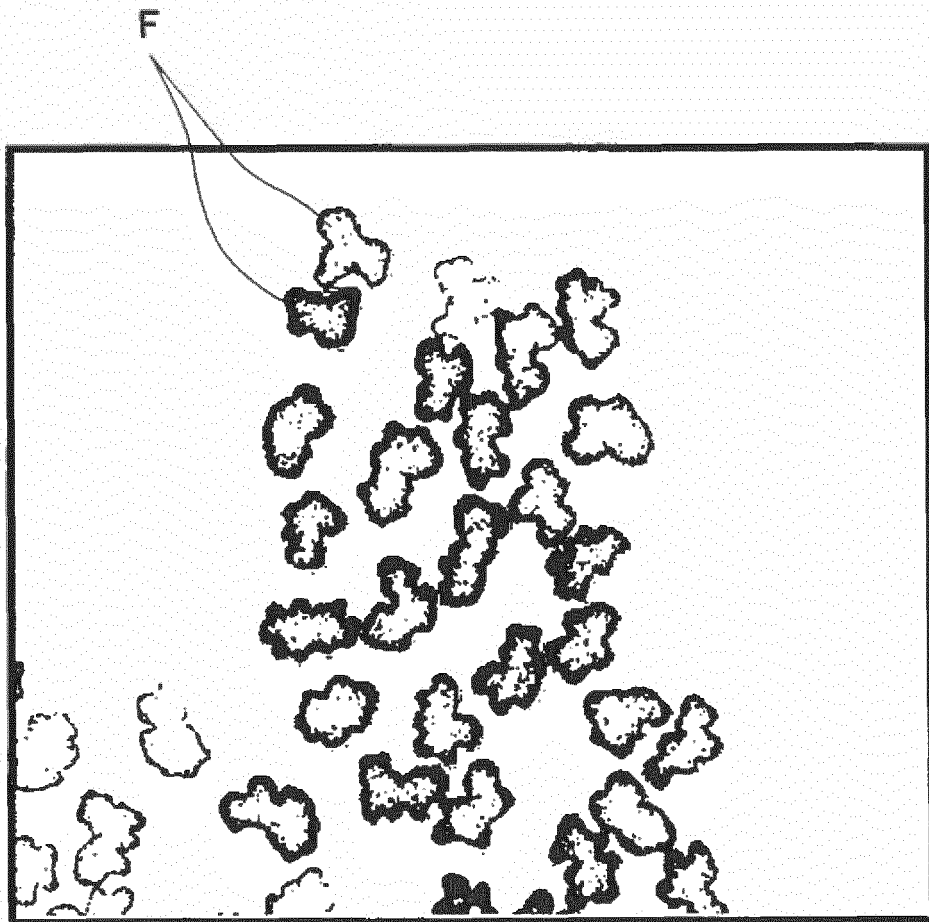


Fig. 3

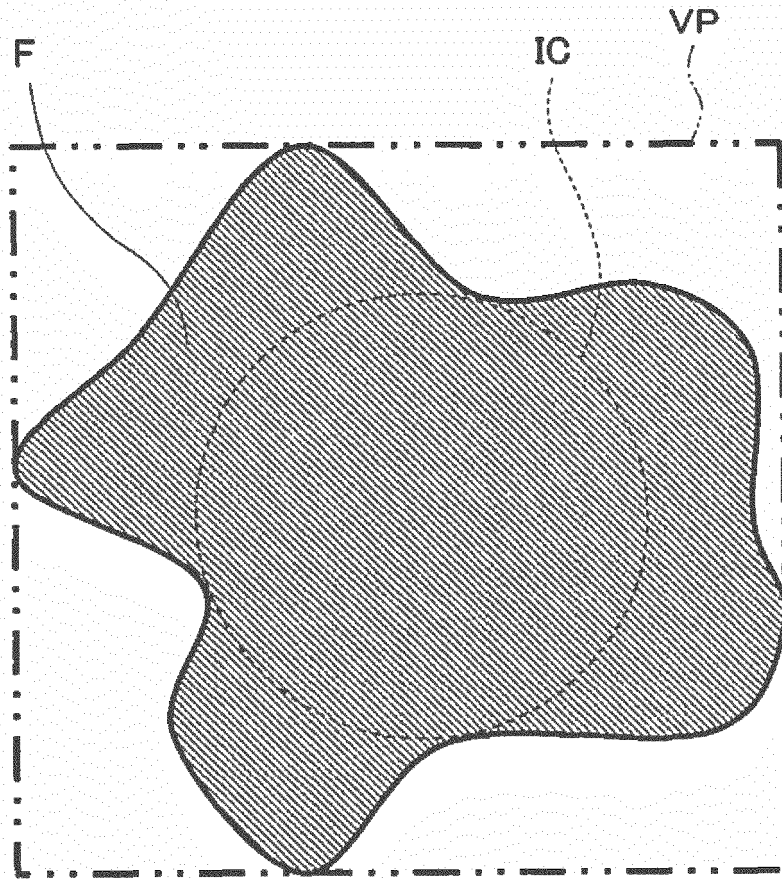


Fig. 4A

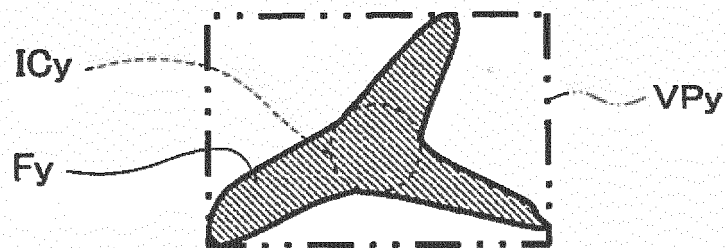


Fig. 4B

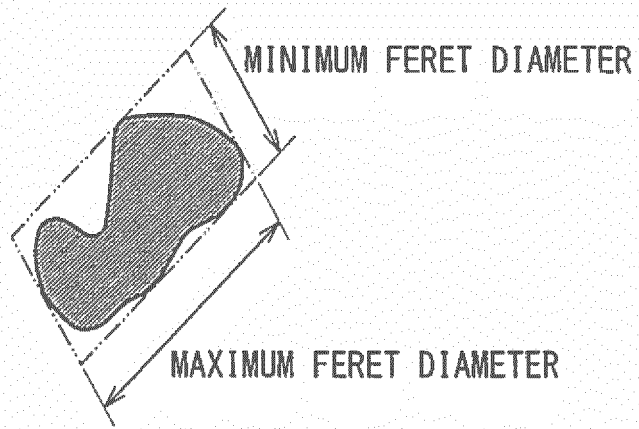


Fig. 5

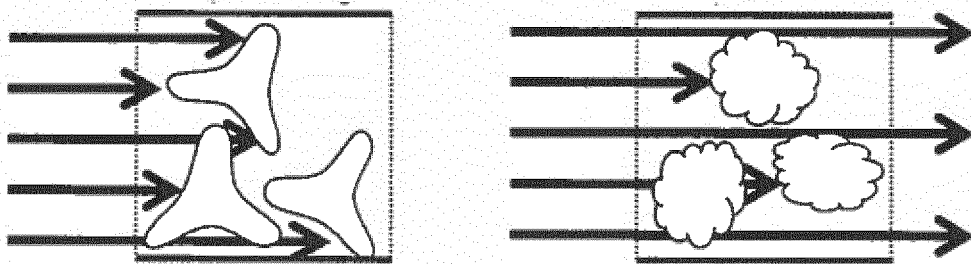


Fig. 6

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2014/001449

5	A. CLASSIFICATION OF SUBJECT MATTER A24D3/10(2006.01) i	
	According to International Patent Classification (IPC) or to both national classification and IPC	
10	B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) A24D3/10	
15	Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2014 Kokai Jitsuyo Shinan Koho 1971-2014 Toroku Jitsuyo Shinan Koho 1994-2014	
	Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)	
20	C. DOCUMENTS CONSIDERED TO BE RELEVANT	
	Category*	Citation of document, with indication, where appropriate, of the relevant passages
25	Y A	JP 5289954 B2 (Celanese Acetate Ltd.), 11 September 2013 (11.09.2013), entire text; all drawings & JP 2009-505649 A & US 2008/0245376 A1 & GB 517551 D & EP 1921933 A & WO 2007/026131 A1 & CN 101252850 A & MX 2008002797 A
30	Y A	JP 3532689 B2 (Celanese Acetate, L.L.C.), 31 May 2004 (31.05.2004), entire text; all drawings & JP 08-260231 A & US 5491024 A & US 5647383 A & EP 0732432 A1 & DE 069600936 C & DE 069600936 D & AT 173305 T & CN 1150952 A
35		
40	<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.	
45	* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
	"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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	"O" document referring to an oral disclosure, use, exhibition or other means	
	"P" document published prior to the international filing date but later than the priority date claimed	
50	Date of the actual completion of the international search 26 May, 2014 (26.05.14)	Date of mailing of the international search report 03 June, 2014 (03.06.14)
	Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
55	Facsimile No.	Telephone No.

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2928340 B2 (Daicel Chemical Industries, Ltd.), 03 August 1999 (03.08.1999), entire text; all drawings & JP 04-65540 A	1-11
A	JP 2008-504456 A (Celanese Acetate, L.L.C.), 14 February 2008 (14.02.2008), paragraphs [0016] to [0019]; fig. 1 & JP 2011-032629 A & US 6924029 B1 & EP 1766111 A & WO 2006/007020 A1 & DE 602005019300 D & KR 10-2007-0039049 A & CN 1981074 A & CN 101422281 A & AT 457376 T & MX PA0614327 A	1-11

REFERENCES CITED IN THE DESCRIPTION

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