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(71) Applicant: **Japan Tobacco, Inc.**
Tokyo 105-8422 (JP)

(72) Inventors:
- **NAKAMURA, Jun**
  Tokyo 130-8603 (JP)
- **KIDO, Yuichiro**
  Tokyo 130-8603 (JP)
- **ICHITSUBO, Hirokazu**
  Tokyo 130-8603 (JP)
- **KAIHATSU, Yutaka**
  Tokyo 130-8603 (JP)
- **NINOMIYA, Yu**
  Tokyo 130-8603 (JP)
- **SUGIYAMA, Akihiro**
  Tokyo 130-8603 (JP)
- **KANTO, Wakako**
  Tokyo 130-8603 (JP)
- **INOUE, Yasunobu**
  Tokyo 130-8603 (JP)

(74) Representative: **Isarpatent**
Patent- und Rechtsanwälte
Friedrichstrasse 31
80801 München (DE)

(54) **SMOKING ARTICLE AND FILTER**

(57) A smoking article according to an embodiment of the present invention includes a tobacco portion, a filter portion having a mouthpiece, a tubular covering portion covering the tobacco portion and the filter portion, and a plurality of openings provided in the covering portion near the mouthpiece.

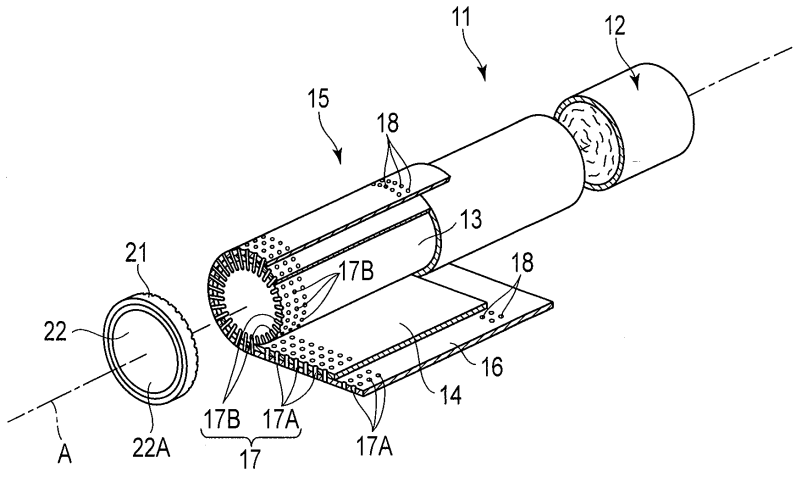

FIG. 2

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Description

Technical Field

[0001] The present invention relates to a smoking article including a filter portion and a filter.

Background Art

[0002] For example, a filter chip for tobacco having a mouthpiece-side end of the filter chip forming a cylindrical shape cut obliquely is disclosed. In the filter chip for tobacco, smoke flows out at right angles to the inclined plane during smoking, which is believed to improve the smoking taste (see, for example, Patent Literature 1).

Citation List

Patent Literature

[0003] Patent Literature 1: Jpn. Pat. Appln. KOKAI Publication No. 59-102386

Summary of Invention

Technical Problem

[0004] A manufacturing process for the conventional filter chip for tobacco described above requires a step for obliquely cutting the mouthpiece-side end of the filter chip at the end of the process. Therefore, the conventional art has a problem that a special processing device is additionally required or the manufacturing efficiency is lowered.

Solution to Problem

[0005] A smoking article according to an embodiment of the present invention includes a tobacco portion, a filter portion having a mouthpiece, a tubular covering portion covering the tobacco portion and the filter portion, and a plurality of openings provided in the covering portion near the mouthpiece.

[0006] A smoking article according to another embodiment of the present invention includes a tobacco portion, a filter portion having a mouthpiece, a tubular covering portion covering the tobacco portion and the filter portion, and an exposed portion provided in the covering portion near the mouthpiece.

[0007] A filter according to an embodiment of the present invention includes a tubular portion attached to one end of a smoking article, a filter portion having a mouthpiece and provided inside the tubular portion, and a plurality of openings provided in the tubular portion near the mouthpiece.

[0008] A smoking article according to an embodiment of the present invention includes a tobacco portion, a filter portion having a mouthpiece, a tubular covering portion covering the tobacco portion and the filter portion, and a plurality of openings provided in the covering portion near the mouthpiece and provided at a predetermined angle with respect to an axis of the filter portion.

[0009] A filter according to an embodiment of the present invention includes a tubular portion attached to one end of a smoking article, a filter portion having a mouthpiece and provided inside the tubular portion, and a plurality of openings provided in the tubular portion near the mouthpiece and provided at a predetermined angle with respect to an axis of the filter portion.

[0010] A smoking article according to an embodiment of the present invention includes a tobacco portion, a filter portion having a mouthpiece, a tubular covering portion covering the tobacco portion and the filter portion, a plurality of openings provided in the covering portion near the mouthpiece, an air intake provided in the covering portion at a position deviating from a neighborhood of the mouthpiece, and a mixing portion provided in the filter portion to mix smoke from the tobacco portion and air from the air intake.

Brief Description of Drawings

[0011]

FIG. 1 is a side view showing a cigarette as an example of a smoking article according to a first embodiment.
FIG. 2 is a perspective view showing the cigarette shown in FIG. 1 by cutting a portion thereof and also exploding a portion thereof.

FIG. 3 is a schematic diagram showing a measuring apparatus that evaluates a smoke of the cigarette shown in FIG. 1.
FIG. 4 is a table showing evaluation results of Comparative Example 101 and Examples 101 to 123 according to a first embodiment.
FIG. 5 is a graph produced based on the table shown in FIG. 4.
FIG. 6 is a schematic diagram showing a diffusion state of smoke of Comparative Example 101 of the table shown in FIG. 4.
FIG. 7 is a schematic diagram showing the diffusion state of smoke of Example 101 of the table shown in FIG. 4.
FIG. 8 is a schematic diagram showing the diffusion state of smoke of Example 117 of the table shown in FIG. 4.
FIG. 9 is a graph in which the X axis takes F values of a representative example of a cigarette with ventilation and the Y axis takes F values of a representative example of a cigarette without ventilation.
FIG. 10 is a sectional view showing a first modification of the cigarette as an example of the smoking article according to the first embodiment.
FIG. 11 is a sectional view showing a second modification of the cigarette as an example of the smoking article according to the first embodiment.
FIG. 12 is a side view showing a cigarette as an example of the smoking article according to a second embodiment.
FIG. 13 is a side view showing a cigarette as an example of the smoking article according to a third embodiment.
FIG. 14 is a side view showing a smoking implement as an example of the smoking article according to a fourth embodiment by cutting a portion thereof.
FIG. 15 is a side view showing a filter by cutting a portion thereof in an embodiment in which the filter is used by being attached to the smoking article.
FIG. 16 is a side view showing a cigarette as an example of the smoking article according to a fifth embodiment by cutting a portion thereof.
FIG. 17 is a perspective view showing the cigarette shown in FIG. 16 by cutting a portion thereof and also exploding a portion thereof.
FIG. 18 is a table showing Comparative Example 201 and Examples 201 to 213 of the cigarette shown in FIG. 16.
FIG. 19 is a schematic diagram showing the diffusion state of smoke of Comparative Example 201 of the table shown in FIG. 18.
FIG. 20 is a graph showing an image analysis result of the smoke of Comparative Example 201 of the table shown in FIG. 18.
FIG. 21 is a schematic diagram showing the diffusion state of smoke of Example 201 of the table shown in FIG. 18.
FIG. 22 is a graph showing an image analysis result of the smoke of Example 201 of the table shown in FIG. 18.
FIG. 23 is a schematic diagram showing the diffusion state of smoke of Example 202 of the table shown in FIG. 18.
FIG. 24 is a graph showing an image analysis result of the smoke of Example 202 of the table shown in FIG. 18.
FIG. 25 is a schematic diagram showing the diffusion state of smoke of Example 203 of the table shown in FIG. 18.
FIG. 26 is a graph showing an image analysis result of the smoke of Example 203 of the table shown in FIG. 18.
FIG. 27 is a schematic diagram showing the diffusion state of smoke of Example 204 of the table shown in FIG. 18.
FIG. 28 is a graph showing an image analysis result of the smoke of Example 204 of the table shown in FIG. 18.
FIG. 29 is a schematic diagram showing the diffusion state of smoke of Example 205 of the table shown in FIG. 18.
FIG. 30 is a graph showing an image analysis result of the smoke of Example 205 of the table shown in FIG. 18.
FIG. 31 is a schematic diagram showing the diffusion state of smoke of Example 206 of the table shown in FIG. 18.
FIG. 32 is a graph showing an image analysis result of the smoke of Example 206 of the table shown in FIG. 18.
FIG. 33 is a schematic diagram showing the diffusion state of smoke of Example 207 of the table shown in FIG. 18.
FIG. 34 is a graph showing an image analysis result of the smoke of Example 207 of the table shown in FIG. 18.
FIG. 35 is a schematic diagram showing the diffusion state of smoke of Example 208 of the table shown in FIG. 18.
FIG. 36 is a schematic diagram showing the diffusion state of smoke of Example 209 of the table shown in FIG. 18.
FIG. 37 is a schematic diagram showing the diffusion state of smoke of Example 210 of the table shown in FIG. 18.
FIG. 38 is a schematic diagram showing the diffusion state of smoke of Example 211 of the table shown in FIG. 18.
FIG. 39 is a schematic diagram showing the diffusion state of smoke of Example 212 of the table shown in FIG. 18.
FIG. 40 is a schematic diagram showing the diffusion state of smoke of Example 213 of the table shown in FIG. 18.
FIG. 41 is a graph showing smoking taste evaluation results of Examples 201 to 207 shown in FIG. 18.
FIG. 42 is a table showing detailed numerical values of the graph shown in FIG. 41.
FIG. 43 is a side view showing the smoking implement as an example of the smoking article according to a sixth embodiment by cutting a portion thereof.
FIG. 44 is a side view showing a filter by cutting a portion thereof in an embodiment in which the filter is used by being attached to the smoking article.
FIG. 45 is a table showing cigarettes as an example of the smoking article of Examples 301 to 309 according to a seventh embodiment, Examples 310 to 314 according to an eighth embodiment, and Comparative Examples 301 to 305.

FIG. 46 is a table showing cigarettes as an example of the smoking article of Examples 315, 317, 319, 321, 338, 339 according to the seventh embodiment, Example 336 according to the eighth embodiment, and Comparative Example 306, 308.
FIG. 47 is a sectional view showing a portion of the cigarette of Example 301 according to the seventh embodiment.
FIG. 48 is a perspective view showing a portion of the cigarette of Example 301 according to the seventh embodiment.
FIG. 49 is a sectional view showing a portion of the cigarette of Example 305 according to the seventh embodiment.
FIG. 50 is a sectional view showing a portion of the cigarette of Example 306 according to the seventh embodiment.
FIG. 51 is a sectional view showing a portion of the cigarette of Example 310 according to the eighth embodiment.
FIG. 52 is a sectional view showing a portion of the cigarette of Example 312 according to the eighth embodiment.
FIG. 53 is a sectional view showing a portion of the cigarette of Example 313 according to the eighth embodiment.
FIG. 54 is a sectional view showing a portion of the cigarette of Example 314 according to the eighth embodiment.
FIG. 55 is a sectional view showing a portion of the cigarette according to Comparative Example 301.
FIG. 56 is a sectional view showing a portion of the cigarette according to Comparative Example 302.
FIG. 57 is a schematic diagram schematically showing a first measuring apparatus.
FIG. 58 is a schematic diagram schematically showing a second measuring apparatus.
FIG. 59 is a diagram showing a ventilation width of the cigarette having four lines of ventilation.
FIG. 60 is a diagram showing a ventilation width of the cigarette having one line of ventilation.
FIG. 61 is a graph showing the relationship between the length of a mixing portion and a ventilation ratio in each Example.
FIG. 62 is a graph showing the relationship between a resistance imparting portion and the ventilation ratio in each Example.
FIG. 63 is a graph showing the relationship between the ventilation ratio and R in each Example.
FIG. 64 is a graph showing the relationship between the length of the mixing portion in the axial direction and R in each Example when there are four lines of ventilation.
FIG. 65 is a graph showing the relationship between the length of the mixing portion in the axial direction and R in each Example when there is one line of ventilation.
FIG. 66 is a graph showing the relationship between L and R in each Example.
FIG. 67 is a graph showing, in an enlarged manner, the position in the neighborhood where L is 0 mm to 2 mm in FIG. 66.
FIG. 68 is a graph showing the relationship between the ventilation ratio and R in each Example.
FIG. 69 is a graph showing the relationship between the ventilation ratio and R in each Example.
FIG. 70 is a graph showing the relationship between L and R in each Example for each ventilation ratio.

Description of Embodiments

(First embodiment of the smoking article)

[0012] A first embodiment of a cigarette as an example of a smoking article will be described below with reference to FIGS. 1 and 2. Smoking articles include cigarettes, cigars, cigarillos, and smoking implements to draw in an aroma and taste of tobacco by electronic device heating or a heat source, and non-heating smoking implements (commercial product: Zero Style Mint) to draw in the aroma and taste of tobacco.

[0013] As shown in FIGS. 1 and 2, a cigarette 11 includes a tobacco portion 12 formed in a cylindrical shape by wrapping cut leaves (tobacco) in cigarette paper, a filter portion 15 in a cylindrical shape containing a filter body 13 and filter wrapper 14 covering surroundings of the filter body 13, tipping paper 16 provided to extend over the tobacco portion 12 and the filter portion 15, and openings 17 provided so as to pass through the filter wrapper 14 and the tipping paper 16. In the present embodiment, the tipping paper 16 is an example of a tubular covering portion covering the tobacco portion 12 and the filter portion 15. The cigarette 11 may also include ventilation 18 (ventilation holes) provided, for example, equidistantly in a ring shape in an intermediate position of the filter portion 15.

[0014] The tipping paper 16 connects the tobacco portion 12 and the filter portion 15. The tipping paper 16 has an inlet port 21 on one end thereof and overlaps with the tobacco portion 12 on the other end on the opposite side of the one end. The ventilation 18 is, for example, a hole provided so as to pass through the tipping paper 16 or a hole reaching the filter portion 15 by passing through the tipping paper 16 and the filter wrapper 14 and plays the role of mainly thinning smoke flowing inside the filter portion 15 by supplying air into the filter portion 15 from outside.

[0015] A plurality of openings 17 are arranged in a ring shape of, for example, four lines. The number of lines of the openings 17 is not limited to four and may be any number ranging from, for example, one to six. In each line, the openings 17 in, for example, a circular shape are arranged equidistantly. The shape of the opening 17 is not limited to the circular shape and may be a different shape such as a polygonal shape. The plurality of openings 17 are provided at a position closer to the side of a mouthpiece 22 (inlet port 21) than a position, for example, 8 mm from the mouthpiece 22 (inlet

port 21) of the filter portion 15 (within the range of less than 8 mm from the mouthpiece 22 (inlet port 21)) in the axial direction A of the cigarette 11 (filter portion 15). The plurality of openings 17 are preferably provided at a position closer to the side of the mouthpiece 22 (inlet port 21) than a position, for example, 4 mm from the mouthpiece 22 (inlet port 21) of the filter portion 15 (within the range of less than 4 mm from the mouthpiece 22 (inlet port 21)) and particularly preferably at a position closer to the side of the mouthpiece 22 (inlet port 21) than a position, for example, 2 mm (within the range of less than 2 mm from the mouthpiece 22 (inlet port 21)) in the axial direction A of the cigarette 11 (filter portion 15). The opening 17 includes a first portion 17A provided so as to pass through the tipping paper 16 and a second portion 17B provided in the filter portion 15 (the filter wrapper 14 and the filter body 13).

[0016] The diameter of the filter portion 15 ranges from, for example, 5 mm to 9 mm and is, for example, 8 mm. The length of the circumference of the filter portion 15 ranges from, for example, 16 mm to 28 mm and is, for example, 25 mm.

[0017] The filter portion 15 is provided abutting on the tobacco portion 12 on an end on the opposite side of the end face 22A in the mouthpiece 22. The filter body 13 has the second portion 17B of the opening 17 provided so as to be connected to the first portion 17A. Each of the second portions 17B is formed so as to extend from the first portion 17A toward the center before stopping at a predetermined depth. The value obtained by adding the depth of the first portion 17A and that of the second portion 17B of each of the openings 17 ranges from, for example, 0.11 mm to 2.61 mm. The first portion 17A and the second portion 17B of the opening 17 are integrally formed and are formed together by, for example, laser beam machining. The depth (defective depth) obtained by adding the depth of the first portion 17A and that of the second portion 17B of the opening 17 is concretely produced under conditions of Comparative Example 101 and Examples 101 to 123 described later. Incidentally, the opening 17 (the first portion 17A and a portion of the second portion 17B) may be provided only in the tipping paper 16 and the filter wrapper 14 without providing the second portion 17B in the filter body 13.

[0018] The method of producing the first portion 17A and the second portion 17B of the opening 17 is not limited to the method using laser beam machining and may be, for example, a mechanical method of press opening using a needle-shaped punch or an electric method using corona discharge.

[0019] The angle of the opening 17 may freely be set. That is, while each of the openings 17 is formed at an angle of 90° with respect to the tangential direction of a cross section of the filter portion 15 in the present embodiment, each of the openings 17 can be formed at any angle. For example, FIG. 10 is a sectional view obtained by cutting the filter portion 15 with a plane perpendicular to the axial direction A and shows a first modification of the present embodiment. As shown in FIG. 10, the opening 17 may be formed at any angle from 1° or more and 179° or less with respect to the tangential direction in a plane perpendicular to the axial direction A (FIG. 10 shows a case in which the angle is 60°. It is assumed here that when the angle with respect to the tangential direction is smaller than 90°, the opening 17 extends in a direction in which smoke flows out, which is a clockwise spiral in FIG. 10. It is also assumed that when the angle with respect to the tangential direction is larger than 90°, the opening 17 extends in a direction in which smoke flows out, which is a counterclockwise spiral in FIG. 10. FIG. 11 is a sectional view obtained by cutting the filter portion 15 by a plane along the axial direction A and shows a second modification of the present embodiment. As shown in FIG. 11, the opening 17 may be formed at any angle from 1° or more and 179° or less with respect to the tangential direction in a plane along the axial direction A (FIG. 11 shows a case in which the angle is 60°. It is assumed here that when the angle with respect to the tangential direction is smaller than 90°, the opening 17 extends in a direction in which the opening 17 moves away from the axis A as the mouthpiece 22 is approached. It is also assumed that when the angle with respect to the tangential direction is larger than 90°, the opening 17 extends in a direction in which the opening 17 moves closer to the axis A as the mouthpiece 22 is approached.). Further, the opening 17 may be formed by combining the first modification and the second modification such that a predetermined angle (the angle of 1° or more and 179° or less, 60° as an example) is formed with respect to the tangential direction in a plane perpendicular to the axial direction A and a predetermined angle (the angle of 1° or more and 179° or less, 60° as an example) is formed with respect to the tangential direction in a plane along the axial direction A.

[0020] The filter body 13 can be formed from various kinds of filler. In the present embodiment, the filter body 13 is formed of a filler of, for example, cellulose semisynthetic fiber such as acetate, but the filler is not limited to such an example. As the filler, for example, vegetable fiber such as cotton, hemp, Manila hemp, palm, and mat rush, animal fiber such as wool and cashmere, cellulose-based fiber such as rayon, cellulose semisynthetic fiber such as diacetate and triacetate, synthetic fiber such as nylon, polyester, acrylic, polyethylene, and polypropylene, or a combination thereof can be used. The component of the filter portion 15 may be, in addition to the above acetate filter, a charcoal filter or a filter containing particulate matter other than charcoal. Examples of particulate matter other than charcoal include acetate granules, powder of cyclodextrin or the like, and microcapsules. The filter portion 15 may be formed of two segments or more.

[0021] The type of the plasticizer used for the filter body 13 of the filter portion 15 does not matter. For example, triethyl citrate, acetyl-triethyl citrate, acetyl-tributyl citrate, dibutyl tartrate, ethylphthalyl-ethylglycolate, methylphthalyl-ethylglycolate, triacetin, triethyl phosphate, triphenyl phosphate, tripropionin, or a combination thereof can be used. In some cases, a plasticizer may not be used.

[0022] The filter body 13 may contain menthol flavor or the like. The method of imparting flavor does not particularly matter and a method of, for example, arranging a string-type material caused to adsorb flavor inside the filter body 13, causing a filler of the filter portion 15 to contain flavor, or arranging a material such as a capsule in which flavor is immobilized inside the filter portion 15 may be used. The type and materials of the filter wrapper 14 used for the filter body 13 of the filter portion 15 do not matter. Filter wrapper having permeability used for common products or filter wrapper having no permeability may be used. Paper produced from vegetable fiber is generally used as the material of filter wrapper, but sheets using chemical fiber of a polymer (such as polypropylene, polyethylene, and nylon) or sheets of a polymer may be used or a metal foil such as aluminum foil may be used.

[0023] A non-lap filter as shown in FIG. 15 of Japanese Patent No. 4262247 may be used for the filter body 13. The non-lap filter has a filter material and a skin forming the filter material in a cylindrical shape and the skin is obtained by thermoforming the filter material. Thus, there is no need for filter wrapper when a non-lap filter is used.

[0024] The material of the tipping paper 16 does not matter. Paper produced from vegetable fiber is generally used for the tipping paper 16, but sheets using chemical fiber of a polymer (such as polypropylene, polyethylene, and nylon) or sheets of a polymer may be used or a metal foil such as aluminum foil may be used.

[0025] Subsequently, the manufacturing process of the cigarette 11 according to the present embodiment will be described. First, the tobacco portions 12 (wound) and the filter portions 15 of a length of two cigarettes are manufactured by a common method. Then, the filter portion 15 of the length of two cigarettes is inserted between the two tobacco portions 12. Further, the tobacco portions 12 and the filter portion 15 are wound up together by the tipping paper 16 having the length of two cigarettes to form a rod-like object connecting the tobacco portions 12 and the filter portion 15. Then, a continuous output beam output from a laser oscillator of a CO_2 laser or the like is distributed in a pulse shape and irradiated from the outer circumferential direction of the rod using a rotating chopper or the like while causing the connected rod-like object to travel at a predetermined speed. The ventilation 18 is formed in the tipping paper 16 by the pulse-shaped laser light. At the same time, the first portion 17A of the opening 17 is formed in the tipping paper 16 and the filter wrapper 14 by the pulse-shaped laser light and also the second portion 17B of a predetermined depth is formed in the filter body 13. Then, the one cigarette 11 is manufactured by cutting the filter portion 15 of the length of two cigarettes and the tipping paper 16 in the center position of the filter portion 15 with a cutter.

[0026] The method of producing the openings 17 is not limited to the above method. For example, the openings 17 may be provided after the ventilation holes 18 are provided using CO_2 laser or conversely, the ventilation holes 18 may be provided after the openings 17 are provided using CO_2 laser. Also, the tipping paper 16 provided with the ventilation holes 18 in advance may be used to produce the openings 17 by CO_2 laser when the cigarette 11 is manufactured. Further, the tipping paper 16 provided with the openings 17 in advance may be used to produce the ventilation holes 18 by CO_2 laser when the cigarette 11 is manufactured (in this case, the openings 17 are opened only in the tipping paper 16). As a further method, the openings 17 may be provided by CO_2 laser after the cigarette 11 is manufactured.

(Measuring apparatus)

[0027] A measuring apparatus 24 that evaluates a smoke (air flow) diffusion effect of the cigarette 11 as described above will be described with reference to FIG. 3. The measuring apparatus 24 includes an air channel separation jig 25, a first membrane flowmeter 26, a second membrane flowmeter 27, a first valve 31 adjacent to the first membrane flowmeter 26, a second valve 32 adjacent to the second membrane flowmeter 27, a pump 33 (suction pump) that sucks the air from inside the air channel separation jig 25, and an exhaust portion 34 through which an exhaust air from the pump 33 is discharged. A buffer to prevent pulsation of the pump 33 is provided at a position upstream of the pump 33. The suction flow rate of the pump 33 is controlled to the flow rate of 1050 ml/min by a mass flow controller.

[0028] The first membrane flowmeter 26 and the second membrane flowmeter 27 can measure the flow rate of smoke (actually the air) discharged into a first portion 35 and a second portion 36, respectively. The first valve 31 and the second valve 32 adjust the flow rates such that the flow rate of air passing through the first portion 35 and the flow rate of air passing through the second portion 36 are each reduced by 50%, more specifically, 525 ml/min when the air is sucked by the pump 33 without the cigarette 11 being attached to the air channel separation jig 25.

[0029] The air channel separation jig 25 includes the first portion 35 (cell) provided in a distant position from the cigarette 11 so that smoke (air) flowing out of the end face 22A of the filter portion 15 is discharged, the second portion 36 (cell) provided closer to the cigarette 11 so that smoke flowing out of the second portion 17B of the filter portion 15 and the openings 17 is discharged, a first seal 37 provided at a position between the first portion 35 and the second portion 36, and a second seal 38 provided so as to abut on the tipping paper 16 of the cigarette 11. Pipes extending from the first portion 35 and the second portion 36 are merged downstream and connected to the pump 33.

[0030] The first portion 35 and the second portion 36 each have a hollow disc shape and the same internal volume. An extended tube 41 in a cylindrical shape attached to the inlet port 21 of the tipping paper 16 of the cigarette 11 is arranged on the inner side of the first portion 35. The extended tube 41 is configured by, for example, tape having a bonding layer on one side and formed by being pasted in a tubular shape onto the inlet port 21 of the tipping paper 16

such that the openings 17 are not blocked. The extended tube 41 guides smoke (air) discharged from the end face 22A of the filter portion 15 into the first portion 35.

[0031] The first and second seals 37, 38 are each formed in a ring shape. The first seal 37 can airtightly separate an internal space of the first portion 35 and that of the second portion 36 in a state in which the extended tube 41 is inserted thereinto. The second seal 38 can airtightly separate the internal space of the second portion 36 and the outside in a state in which the cigarette 11 is inserted thereinto.

(Examples)

[0032] The cigarettes 11 as an example of the smoking article are manufactured under the conditions of Comparative Example 101 and Examples 101 to 123 shown in FIG. 4. In this case, the deficiency rate of the filter portion 15 is decided by the following formula. First, before starting to measure the deficiency rate, the tobacco portion 12 and the filter portion 15 are cut. Then, the filter portion 15 wound by the filter wrapper 14 and the tipping paper 16 is impregnated with an ethanol solution of a concentration of 30 volume percentage to separate only the tipping paper 16 from the filter body 13. The separated tipping paper 16 is extended and put on a preparation for drying. The openings 17 are viewed enlarged by optical microscope to measure the area of the openings 17 using area measuring software. As the total deficiency area near the inlet port 21 of the tipping paper 16, a value obtained by multiplying the area of an opening 17 by the number of all the openings 17 is used. In this case, as the area of the opening 17, an arithmetic mean of areas of 30 openings 17 selected arbitrarily and measured is used. The value obtained by dividing the total deficiency area by the area of the filter portion 15 wound by the tipping paper 16 up to 8 mm from the inlet port 21 is defined as the deficiency rate.

[Mathematical Formula 1]

$$\text{Deficiency rate}\,[\%] = \frac{\text{Total deficiency area}\,[\text{mm}^2]}{\text{Filter circumference}\,[\text{mm}] * 8\ \text{mm}}$$

[0033] The deficiency depth is decided by coloring the filter body 13 with pigments and measuring the depth of the second portion 17B. More specifically, if the opening 17 is cut in round slices in a direction perpendicular to the axial direction A of the filter portion 15 and cross sections thereof are colored uniformly, a deficiency portion of the opening 17 appears in a non-colored state. The depth thereof is measured. In this case, the depth is measured by viewing the second portion 17B enlarged by an optical microscope or a magnifying glass. The value of the deficiency depth is decided by calculating an arithmetic mean of depths of the 10 second portions 17B selected arbitrarily and measured. When the openings 17 are provided only in the tipping paper 16 and the filter wrapper 14 and the second portion 17B is not provided in the filter body 13, the thickness of the tipping paper 16 and the filter wrapper 14 is defined as the deficiency depth. Among deficiency depths shown in the table of FIG. 4, the deficiency depth of 0.11 mm means that the opening 17 does not pass through the tipping paper 16 and the filter wrapper 14 and the opening 17 remains within the range of the thickness of the tipping paper 16 and the filter wrapper 14. Among deficiency depths shown in the table of FIG. 4, the deficiency depth of 0.14 mm or more means that the opening 17 (first portion 17A) passes through the tipping paper 16 and the second portion 17B of a predetermined depth is formed in the filter wrapper 14 and the filter body 13.

[0034] A ratio F of a flow rate Q_2 of smoke (air) passing through the opening 17 of the total flow rate (a flow rate Q_1 passing through the end face 22A of the filter portion 15 + the flow rate Q_2 passing through the opening 17) of smoke (air) passing through the cigarette 11 is measured by the above measuring apparatus. The formula to calculate F is as shown below. The result of calculation is shown in FIG. 4. According to FIG. 4, it is understood that when the deficiency depth is 0.14 mm or more, the ratio F of air passing through the opening 17 increases rapidly regardless of the deficiency rate.

[Mathematical Formula 2]

$$F = \frac{Q_2}{Q_1 + Q_2}$$

[0035] FIG. 5 shows a graph plotting each Example shown in FIG. 4. In FIG. 5, the same mark is attached to Examples of the same deficiency depth. It is evident from the graph that at each deficiency depth, the ratio F of air passing through the opening 17 generally increases with an increasing deficiency rate. The ratio F of air in Examples 101 to 123 is a value equal to 2.8% or more and 68.9% or less.

[0036] In Comparative Example 101 and Examples 101 to 123, the diffusion state of main flow smoke (air) is observed. In FIGS. 6 to 8, the diffusion states of main flow smoke (air) of Comparative Example 101 and representative Examples 101, 117 are shown. Main flow smoke flowing out of the filter portion 15 is passed through a transparent container 42 made of acrylic and the state thereof is captured by a digital video camera to obtain an image every 0.1 s from the start of smoke suction. Each of FIGS. 6 to 8 schematically shows one of such images. As smoking conditions, the smoke suction volume is set to 55 ml/2 s and smoke suction is started when 20 mm of the cigarette 11 from the tip thereof is subjected to automatic combustion.

[0037] Comparative Example 101 shown in FIG. 6 is a state of main flow smoke (air) of the normal cigarette 11 and, as indicated by a broken line, the main flow smoke flows out horizontally from the end face 22A of the filter portion 15. In the cigarette 11 of Example 101, as indicated by a broken line in FIG. 7, most of the main flow smoke flows out horizontally like in Comparative Example 101, but smoke (air flow) flowing out vertically from the outer circumferential portion (opening 17) of the filter portion 15 is confirmed. Further, in the cigarette 11 of Example 117, as indicated by a broken line in FIG. 8, in addition to smoke flowing out horizontally as observed in Comparative Example 101 and Example 101, a large amount of smoke (air) flowing out vertically from the outer circumferential portion (opening 17) of the filter portion 15 is confirmed.

[0038] Further, smoking taste evaluation by a number of persons for Comparative Example 101 and Examples 101 to 123 shows that the cigarettes 11 of Examples 101 to 123 are improved in smoking state when compared with Comparative Example 101.

[0039] Similarly, a fluff test of the filter portion 15 of the cigarettes 11 of Examples 101 to 123 and a cigarette in the shape described in Jpn. Pat. Appln. KOKAI Publication No. 59-102386 is performed. The cigarette 11 of each Example and the cigarette in the shape described in Jpn. Pat. Appln. KOKAI Publication No. 59-102386 are inserted into and removed seven times from the cigarette holder of, for example, an automatic smoking device used for a common smoking test and the neighborhood of the mouthpiece 22 of the filter portion 15 is observed through an optical microscope. For the cigarette in the shape described in Jpn. Pat. Appln. KOKAI Publication No. 59-102386, fluffing of the filter portion 15 is observed in the neighborhood of the inlet port 21. In contrast, no fluffing is observed in the cigarette 11 of each Example.

[0040] In addition, whether the ratio F of air passing through the opening 17 changes depending on whether the ventilation 18 is provided in the filter portion 15 is evaluated. The cigarettes 11 having the same conditions of the deficiency rate and deficiency depth as those of Examples 102, 107, 108, 111, 112, 116, 117, 119, 120 and whose ventilation 18 is blocked are used. The result of measuring the ratio F of air passing through the openings 17 of each sample is shown in FIG. 9. The horizontal axis represents the ratio F of air passing through the openings 17 when the ventilation 18 is not present and the vertical axis represents the ratio F of air passing through the openings 17 when the ventilation 18 is present. It is evident from FIG. 9 that plots are approximately on the straight line of $y = x$ under any conditions. From the foregoing, the fact that the ratio F of air passing through the openings 17 does not change depending on the presence/absence of the ventilation 18 is confirmed. Incidentally, the ventilation 18 is a main means for achieving a cigarette 11 of low tar, and according to the examination result, applicability of the present invention in any tar range is confirmed.

[0041] According to the first embodiment and Examples 101 to 123, the smoking article (cigarette 11) includes the tobacco portion 12, the filter portion 15 having the mouthpiece 22, the tubular covering portion covering the tobacco portion 12 and the filter portion 15, and the plurality of openings 17 provided in the covering portion near the mouthpiece 22.

[0042] According to the above configuration, the openings 17 are provided near the mouthpiece 22 and therefore, smoke can be caused to flow out not only from the end face 22A of the filter portion 15, but also from the openings 17. Accordingly, smoke is more likely to diffuse in the oral cavity during smoking, which can further improve the smoking taste. Also, according to the above configuration, a special filter cutting process is not needed during manufacturing and therefore, the cigarettes 11 having the openings 17 can be manufactured by a common tobacco winding machine, which can simplify the manufacturing process and also prevent a cost increase. Further, the cigarette 11 configured as described above has, like a common cigarette, the filter body 13 partially covered with the tipping paper 16 or the filter wrapper 14 and therefore, an occurrence of quality degradation such as fluffing of filter fiber can be prevented during smoking.

[0043] The smoking article (cigarette 11) reaches the filter portion 15 by passing through the covering portion. According to the above configuration, the outflow of smoke from the openings 17 can further be promoted. Accordingly, the smoking taste can further be improved by increasing the diffusion of smoke during smoking.

[0044] A plurality of the second portions 17B are provided at a position closer to the side of the mouthpiece 22 than a position 8 mm from the mouthpiece 22 in the axial direction A of the filter portion 15. According to the above configuration, the openings 17 can be provided at a place positioned inside the oral cavity during smoking.

[0045] The flow rate of smoke flowing out from the openings 17 relative to the total flow rate of smoke flowing out of the end face 22A of the filter portion 15 and the openings 17 is 2.8% or more and 68.9% or less. According to the above configuration (condition), the smoker can actually feel a sense of smoke spreading in the oral cavity during smoking.

(Second embodiment of the smoking article)

[0046] Subsequently, a second embodiment and a third embodiment of a cigarette 11 as an example of the smoking article will be described with reference to FIGS. 12 and 13. Mainly, portions that are different from the first embodiment will be described and the description of portions common to the first embodiment is omitted.

[0047] In the second embodiment of the cigarette, as shown in FIG. 12, tipping paper 16 is removed in the neighborhood of an inlet port 21 (mouthpiece 22) of the cigarette 11 in a predetermined width in a ring shape to form an exposed portion 51. The exposed portion 51 exposes filter wrapper 14 to the outside. The exposed portion 51 is provided at a position closer to the side of the inlet port 21 (mouthpiece 22) than the position 8 mm from the inlet port 21 (mouthpiece 22) in the axial direction A of the filter portion 15. However, the exposed portion 51 may preferably be at a position closer to the side of the inlet port 21 (mouthpiece 22) than a position 4 mm from the inlet port 21 (mouthpiece 22) or particularly preferably at a position closer to the side of the inlet port 21 (mouthpiece 22) than the position 2 mm from the inlet port 21 (mouthpiece 22). Also according to this embodiment, like the first embodiment and Examples 101 to 123, the diffusion effect of smoke in the oral cavity can be expected to some extent so that the smoking taste can still be improved.

(Third embodiment of the smoking article)

[0048] Mainly, portions that are different from the first embodiment will be described and the description of portions common to the first embodiment is omitted.

[0049] In the third embodiment of the cigarette as an example of the smoking article, as shown in FIG. 13, tipping paper 16 is removed in the neighborhood of an inlet port 21 (mouthpiece 22) of a cigarette 11 in a triangular shape to form a plurality of exposed portions 51. The plurality of exposed portions 51 are provided at the position closer to the side of the inlet port 21 (mouthpiece 22) than the position 8 mm from the inlet port 21 (mouthpiece 22) in the axial direction A of the filter portion 15. However, the plurality of exposed portions 51 may preferably be at the position closer to the side of the inlet port 21 (mouthpiece 22) than the position 4 mm from the inlet port 21 (mouthpiece 22) or particularly preferably at the position closer to the side of the inlet port 21 (mouthpiece 22) than the position 2 mm from the inlet port 21 (mouthpiece 22). The plurality of exposed portions 51 expose filter wrapper 14 to the outside. Also, according to this embodiment, like the first embodiment and Examples 101 to 123, the diffusion effect of smoke in the oral cavity can be expected to some extent so that the smoking taste can still be improved.

[0050] In the third embodiment, the shape of the exposed portions 51 is not limited to the triangular shape. The exposed portions 51 may have, for example, a circular shape such as a round shape and an elliptic shape, a polygonal shape such as a quadrangular shape, a rhombic shape, a parallelogrammic shape, a trapezoidal shape, and a cruciform shape, or a shape combining the above shapes. Alternatively, the exposed portions 51 can have shapes thereof extending up to the inlet port 21 and further, the geometrical shape of the exposed portions 51 may be provided at any angle.

(Fourth embodiment of the smoking article)

[0051] Subsequently, a fourth embodiment of the smoking article will be described with reference to FIG. 14. The smoking article in the fourth embodiment is applied to a non-heating smoking implement 53 that draws in the aroma and taste of tobacco. Here, mainly portions that are different from the first embodiment will be described and the description of portions common to the first embodiment is omitted by attaching common reference signs. In FIG. 14, the upper half of the smoking implement 53 is shown by cutting with a plane passing through the axis A.

[0052] As shown in FIG. 14, the smoking implement 53 includes a tobacco portion 12 formed of cut leaves (tobacco), a first filter portion 15A and a second filter portion 15B in a cylindrical shape abutting on the tobacco portion 12, a tubular covering portion 52 made of resin and covering the tobacco portion 12, the first filter portion 15A, and the second filter portion 15B, and openings 17 provided so as to pass through the covering portion 52. The first filter portion 15A has a mouthpiece 22. The covering portion 52 has an inlet port 21 on one end thereof.

[0053] The openings 17 are provided near the mouthpiece 22 of the covering portion 52 at a position closer to the side of the mouthpiece 22 (inlet port 21) than a position 8 mm from the mouthpiece 22 (inlet port 21) in the axial direction A of the first filter portion 15A. However, the openings 17 may preferably be at a position closer to the side of the mouthpiece 22 (inlet port 21) than a position 4 mm from the mouthpiece 22 (inlet port 21) or particularly preferably at a position closer to the side of the mouthpiece 22 (inlet port 21) than a position 2 mm from the mouthpiece 22 (inlet port 21). A plurality of the openings 17 are arranged in a ring shape of, for example, four lines. The opening 17 contains a first portion 17A provided so as to pass through the covering portion 52 and a second portion 17B provided so as to

stop halfway through the first filter portion 15A.

[0054] Also according to this embodiment, like the first embodiment and Examples 101 to 123, the diffusion effect of smoke (air containing aroma and taste of tobacco emanating from the filter portions) in the oral cavity can be expected so that the smoking taste can still be improved.

(Embodiment of the filter)

[0055] An embodiment of the filter used by being attached to a smoking article will be described with reference to FIG. 15. A filter 81 has, though different from the smoking article itself, a structure of an applied opening 17 similar to that of the above embodiments of the smoking article. Thus, mainly portions of the structure that are different from those of the smoking article according to the first embodiment will be described and common reference signs are attached to portions common to those in the first embodiment. FIG. 15 shows the upper half of the filter 81 by cutting with a plane passing through the axis A.

[0056] The filter 81 is configured to be attachable to and detachable from, for example, the common cigarette 11 as described above. The filter 81 has a tubular portion 82 made of resin and attached to one end of the smoking article (cigarette 11) and a mouthpiece 22 and includes a filter portion 15 in a cylindrical shape provided inside the tubular portion 82 and a plurality of the openings 17 provided in the tubular portion 82 near the mouthpiece 22.

[0057] The openings 17 are provided at a position closer to the side of the mouthpiece 22 (inlet port 21) than a position 8 mm from the mouthpiece 22 (inlet port 21) in the axial direction A of the filter portion 15. However, the openings 17 may preferably be at a position closer to the side of the mouthpiece 22 (inlet port 21) than a position 4 mm from the mouthpiece 22 (inlet port 21) or particularly preferably at a position closer to the side of the mouthpiece 22 (inlet port 21) than a position 2 mm from the mouthpiece 22 (inlet port 21). The plurality of openings 17 are arranged in a ring shape of, for example, four lines. The opening 17 contains a first portion 17A provided so as to pass through the tubular portion 82 and a second portion 17B provided so as to stop halfway through the filter portion 15.

[0058] Also according to this embodiment, like the first embodiment and Examples 101 to 123, the diffusion effect of smoke or the air containing the aroma and taste of tobacco emanating from the filter portion in the oral cavity can be expected so that smoking taste can still be improved.

[0059] The smoking article (cigarette 11) and the filter 81 are not limited to the above embodiments and each Example and can be embodied by modifying elements without deviating from the gist thereof in the stage of working. For example, some elements may be deleted from all elements shown in the embodiments and Examples or elements of different embodiments or Examples may appropriately be combined.

(Fifth embodiment of the smoking article)

[0060] A fifth embodiment of the cigarette as an example of the smoking article will be described below with reference to FIGS. 16 and 17. Mainly, portions that are different from the first embodiment will be described and the description of portions common to the first embodiment is omitted. Incidentally, smoking articles include cigarettes, cigars, hand-rolled cigarettes, cigarillos, smoking implements to draw in the aroma and taste of tobacco by electronic device heating or a heat source, and non-heating smoking implements (commercial product: Zero Style Mint) to draw in the aroma and taste of tobacco. FIG. 16 shows the upper half of a cigarette 11 by cutting with a plane passing through the axis A.

[0061] As shown in FIGS. 16 and 17, the cigarette 11 includes a tobacco portion 12 formed in a cylindrical shape by wrapping cut leaves (tobacco) in winding paper, a filter portion 15 in a cylindrical shape containing a filter body 13 and filter wrapper 14 covering surroundings of the filter body 13, tipping paper 16 provided to extend over the tobacco portion 12 and the filter portion 15, and openings 17 provided so as to pass through the filter wrapper 14 and the tipping paper 16. In the present embodiment, the tipping paper 16 is an example of the tubular covering portion covering the tobacco portion 12 and the filter portion 15. The cigarette 11 may also include ventilation 18 (ventilation holes) provided, for example, equidistantly in a ring shape at an intermediate position of the filter portion 15.

[0062] The tipping paper 16 connects the tobacco portion 12 and the filter portion 15. The tipping paper 16 has an inlet port 21 on one end thereof and overlaps with the tobacco portion 12 on the other end on the opposite side of the one end. The ventilation 18 is, for example, a hole provided so as to pass through the tipping paper 16 or a hole reaching the filter portion 15 by passing through the tipping paper 16 and the filter wrapper 14 and plays the role of mainly thinning smoke flowing inside the filter portion 15 by supplying air into the filter portion 15 from outside.

[0063] A plurality of the openings 17 are arranged in a ring shape (or a radial shape) of, for example, one line, but may also be arranged in a ring shape of a plurality of lines. A plurality of openings 17 in, for example, a circular shape are arranged equidistantly in each line. The plurality of openings 17 are provided near a mouthpiece 22 of the filter portion 15. More specifically, the plurality of openings 17 are provided at a position closer to the side of the mouthpiece 22 (inlet port 21) than a position, for example, 8 mm from the mouthpiece 22 (inlet port 21) of the filter portion 15 (within the range of less than 8 mm from the mouthpiece 22 (inlet port 21)) in the axis A direction of the cigarette 11 (filter portion

15). However, the openings 17 may preferably be at a position closer to the side of the mouthpiece 22 (inlet port 21) than a position 4 mm from the mouthpiece 22 (inlet port 21) or particularly preferably at a position closer to the side of the mouthpiece 22 (inlet port 21) from a position 2 mm from the mouthpiece 22 (inlet port 21). The opening 17 contains a first portion 17A provided so as to pass through the tipping paper 16 and a second portion 17B provided in the filter portion 15 (the filter wrapper 14 and the filter body 13).

[0064] The diameter of the filter portion 15 ranges from, for example, 5 mm to 9 mm and is, for example, 8 mm. The length of the circumference of the filter portion 15 ranges from, for example, 16 mm to 28 mm and is, for example, 25 mm.

[0065] The filter portion 15 is provided abutting on the tobacco portion 12 on an end on the opposite side of an end face 22A of the mouthpiece 22. The filter body 13 has the second portion 17B of the opening 17 provided so as to be connected to the first portion 17A. Each of the second portions 17B is formed so as to extend from the first portion 17A toward the center before stopping at a predetermined depth. The first portion 17A and the second portion 17B of the opening 17 are integrally formed and are formed together by, for example, laser beam machining. The depth (defective depth) obtained by adding the depth of the first portion 17A and that of the second portion 17B of the opening 17 is concretely produced under conditions of Comparative Example 201 and Examples 201 to 213 described later. Incidentally, the opening 17 (the first portion 17A and a portion of the second portion 17B) may be provided only in the tipping paper 16 and the filter wrapper 14 without providing the second portion 17B in the filter body 13.

[0066] The opening 17 is provided so as to form an angle θ with respect to the axis A passing through the center of the filter portion 15. The angle at which the opening 17 is provided is set as in each Example described later. For example, the angle θ formed between the opening 17 and the axis A of the filter portion 15 can be set to, for example, 1° or more and 179° or less, but the angle of the opening 17 is not limited to the above example. The angle θ formed between the opening 17 and the axis A of the filter portion 15 may be set to 1° or more and less than 90°. In this case, the opening 17 can also be said to be provided obliquely with respect to the axis A of the filter portion 15. It is assumed here that when the angle θ is smaller than 90°, the opening 17 extends in a direction in which the opening 17 moves away from the axis A as the mouthpiece 22 is approached. It is also assumed that when the angle θ is larger than 90°, the opening 17 extends in a direction in which the opening 17 moves closer to the axis A as the mouthpiece 22 is approached.

[0067] The method of producing the first portion 17A and the second portion 17B of the opening 17 is not limited to the method by laser beam machining and may be, for example, a mechanical method of press opening by a needle-shaped punch or an electric method by corona discharge. The opening 17 in the present embodiment has a circular shape, but the shape of the opening 17 does not matter. The opening 17 may have, for example, a circular shape such as a round shape and an elliptic shape, a polygonal shape such as a triangular shape, a quadrangular shape, a rhombic shape, a parallelogrammic shape, a trapezoidal shape, and a cruciform shape, a shape combining the above shapes, or such a shape extending up to the mouthpiece 22. Further, the shape of the opening 17 may have any orientation or a plurality of the openings 17 may be combined and arranged by changing the angle (orientation) of the neighboring openings 17.

[0068] Subsequently, the manufacturing process of the cigarette 11 according to the present embodiment will be described. First, the tobacco portions 12 (wound) and the filter portions 15 of a length of two cigarettes are manufactured by a common method. Then, the filter portion 15 of the length of two cigarettes is inserted between the two tobacco portions 12. Further, the tobacco portions 12 and the filter portion 15 are wound up together by the tipping paper 16 having the length of two cigarettes to form a rod-like object connecting the tobacco portions 12 and the filter portion 15. Then, a continuous output beam output from a laser oscillator of CO_2 laser or the like is distributed in a pulse shape and irradiated from the outer circumferential direction of the rod using a rotating chopper or the like while causing the connected rod-like object to travel at a predetermined speed. The ventilation 18 is formed in the tipping paper 16 by the pulse-shaped laser light. At the same time, the first portion 17A of the opening 17 is formed in the tipping paper 16 and the filter wrapper 14 by the pulse-shaped laser light and also the second portion 17B of a predetermined depth is formed in the filter body 13. Then, the one cigarette 11 is manufactured by cutting the filter portion 15 and the tipping paper 16 in the center position of the filter portion 15 having the length of two cigarettes with a cutter.

[0069] The method of producing the openings 17 is not limited to the above method. For example, the openings 17 may be provided after the ventilation holes 18 are provided using CO_2 laser or conversely, the ventilation holes 18 may be provided after the openings 17 are provided using CO_2 laser. Also, the tipping paper 16 provided with the ventilation holes 18 in advance may be used to produce the openings 17 by CO_2 laser when the cigarette 11 is manufactured. Further, the tipping paper 16 provided with the openings 17 in advance may be used to produce the ventilation holes 18 by CO_2 laser when the cigarette 11 is manufactured (in this case, the openings 17 are opened only in the tipping paper 16). As still another method, the openings 17 may be provided by CO_2 laser after the common cigarette 11 is manufactured. In all cases, a laser beam irradiated to form the openings 17 is irradiated so as to form the angle θ with respect to the axis A.

(Observation of smoke and image analysis of smoke)

[0070] The cigarettes 11 as an example of the smoking article are manufactured under the conditions of Comparative Example 201 and Examples 201 to 213 shown in FIG. 18. The opening 17 forming the angle θ with respect to the axis A is produced in the outer circumferential portion of the filter portion 15 by irradiating the outer circumferential portion of the mouthpiece 22 of the cigarette 11 with a laser beam at the angle θ with respect to the axis A (Examples 201 to 207). Also, the cigarettes 11 having different depths with a constant opening angle (for example, 45°) are produced by changing the intensity of the irradiated laser beam (Examples 208 to 213). The opening area, opening depth, and opening angle of the produced cigarettes 11 are shown in the table of FIG. 18. In the table of FIG. 18, the opening angle indicates the setting value of the irradiation angle set for the laser beam machine. As the condition common to each Example, 37 openings 17 are provided for each of the cigarettes 11 at the position of about 1.5 mm from the mouthpiece in one line.

[0071] The opening depth and opening angle of the created opening 17 are measured as described below. First, a razor is inserted through the mouthpiece 22 of the filter portion 15 to separate the filter portion 15 into two portions (like chopping wood) and a deficient portion thereof is enlarged by an optical microscope or a magnifying glass to measure the depth of the opening 17. An arithmetic mean of depths of 10 openings 17 selected arbitrarily and measured is adopted as the opening depth. By arbitrarily setting the irradiation angle of a laser beam, an opening can be created in the filter portion 15 at such angle. It also turns out that when the irradiation angle of a laser beam is changed, there is a tendency that the opening area becomes smaller and the opening depth becomes deeper as 90° is approached. This is because the irradiation area of the filter portion 15 is increased and the opening area is increased by irradiating a laser beam obliquely and the opening depth is correspondingly decreased. However, the opening area and the depth can independently be changed by adjusting the irradiation area and intensity of a laser beam.

[0072] The opening area of the opening 17 is measured as described below. After the openings 17 are produced in the outer circumferential portion of the filter portion 15 of tobacco, the wound portion (tobacco portion 12) and the filter portion 15 are cut. The filter portion 15 wound by the filter wrapper 14 and the tipping paper 16 is impregnated with an ethanol solution of the concentration of 30 volume percentage to separate only the tipping paper 16 from the filter body 13. The separated tipping paper 16 is extended and put on a preparation for drying. The openings 17 are measured by viewing enlarged with an optical microscope to measure the area of the openings 17 using area measuring software. As the area (opening area) of the opening 17, an arithmetic mean of areas of 30 openings 17 selected arbitrarily and measured is used.

[0073] In Comparative Example 201 and Examples 201 to 213, the diffusion state of main flow smoke (air) is observed. In FIGS. 19 to 30, the diffusion states of main flow smoke (air) of Comparative Example 201 and Examples 201 to 213 are shown. Smoke flowing out of the filter portion 15 is passed through a transparent container 42 made of acrylic and the state thereof is captured by a digital video camera to cut out an image every 0.1 s from the start of smoke suction. Each of FIGS. 19, 21, 23, 25, 27, 29, 31, 33, and 35 to 40 schematically shows one of such images. As smoking conditions, the smoke suction volume is set to 55 ml/2 s and smoke suction is started when 20 mm of the cigarette 11 from the tip thereof is subjected to automatic combustion. FIGS. 20, 22, 24, 26, 28, 30, 32, 34 show results of analyzing images of Examples 201 to 207.

[0074] The image analysis method in each Example will be described. Commercial image analysis software is used for image analysis. In the image analysis according to the present embodiment, for example, an image of 0.4 s after the start of smoke suction is processed in monochrome and next, an image (control image) that does not allow smoke to flow out is processed in monochrome. Then, the control image as the background is subtracted from the image of 0.4 s after the start of smoke suction to extract only a monochrome image of smoke after 0.4 s. For example, at the position spaced 1 mm from the mouthpiece 22 (mouthpiece end face), the lightness at each position in a direction perpendicular to the axis A of the filter portion 15 is measured. The lightness is a value obtained by converting white to black into numerical values; for example, white is 255, black is 0, with intermediate values assigned to gray depending on the darkness. The numerical value increases in places where smoke is dense and is 0 in places where there is no smoke. A graph is produced by assigning the position in a direction perpendicular to the axis A of the filter portion 15 to the horizontal axis and lightness to the vertical axis.

[0075] The position in a direction perpendicular to the axis A of the filter portion 15 is normalized by setting 1 to the upper end of the filter portion 15 of the corresponding image and -1 to the lower end of the filter portion 15, and the lightness is normalized by setting the highest numerical value of lightness to 1 for each corresponding image. The above method is an example of the image analysis method and a different image analysis method can be adopted.

[0076] Comparative Example 201 shown in FIG. 19 is a state of main flow smoke 71 (air) of the normal cigarette 11 and, as indicated by a broken line, the smoke (main flow smoke 71) flows out horizontally from the end face 22A of the filter portion 15. In this case, from the image analysis result in FIG. 20, the main flow smoke 71 is between the upper end and the lower end of the filter portion 15, that is, within the range larger than -1 of the horizontal axis and smaller than +1 in Comparative Example 201. Therefore, it is understood that smoke is not diffused in Comparative Example 201.

[0077] In the cigarette 11 of Example 201, as indicated by a broken line in FIG. 21, most of the smoke (main flow

smoke 71) flows out horizontally as in Comparative Example 201, but smoke (diffusion smoke 72) flowing out obliquely with respect to the axis A from the outer circumferential portion (opening 17) of the filter portion 15 is confirmed. From the image analysis result of Example 201 shown in FIG. 22, a small amount of smoke is confirmed in portions of -1 or less and +1 or more of the horizontal axis.

[0078] FIG. 23 shows a schematic diagram of an image showing the diffusion level of smoke of Example 202. In Example 202, as indicated by a broken line in FIG. 23, in addition to the horizontal outflow of smoke (main flow smoke 71) observed in Comparative Example 201 and Example 201, a large amount of the diffusion smoke 72 (air) flowing out from the openings 17 obliquely with respect to the axis A and downstream in the flowing direction of the main flow smoke 71 is confirmed. As is evident from FIG. 23, the diffusion smoke 72 obliquely flowing out from the openings 17 first diffuses before the outflow of the main flow smoke 71. This phenomenon is considered to be caused by the fact that the channel resistance of the portion where the opening 17 is present is smaller than that of the portion where the main flow smoke 71 passes (near the mouthpiece 22 of the filter portion 15).

[0079] In the image analysis result of Example 202 shown in FIG. 24, a certain amount of smoke is detected in an area larger than +1 of the horizontal axis and an area smaller than -1. According to the analysis result in FIG. 24, it is clear that diffusion of smoke in the range of about twice the size of the diameter of the cigarette 11 occurs.

[0080] FIG. 25 shows a schematic diagram of an image showing the diffusion level of smoke of Example 203. In FIG. 25, a large amount of the diffusion smoke 72 flowing out from the openings 17 obliquely with respect to the axis A and downstream in the flowing direction of the main flow smoke 71 is observed along with smoke (main flow smoke 71) in the horizontal direction. The amount of the diffusion smoke 72 flowing out from the openings 17 increases when compared with Example 202. The angle formed between the diffusion smoke 72 flowing out from the openings 17 and the axis A is larger than in Example 202. Further, also in Example 203, like in Example 202, the diffusion smoke 72 first diffuses before the outflow of the main flow smoke 71.

[0081] In the image analysis result of Example 203 shown in FIG. 26, a large amount of smoke is detected in an area larger than +1 of the horizontal axis and an area smaller than -1. According to the analysis result in FIG. 26, diffusion of smoke in the range of about twice to four times the size of the diameter of the cigarette 11 is detected.

[0082] FIG. 27 shows a schematic diagram of an image showing the diffusion level of smoke of Example 204. In FIG. 27, a large amount of the diffusion smoke 72 flowing out from the openings 17 obliquely with respect to the axis A and downstream in the flowing direction of the main flow smoke 71 is observed along with smoke (main flow smoke 71) in the horizontal direction. The angle formed between the diffusion smoke 72 flowing out from the openings 17 and the axis A becomes larger than in Example 203. Further, also in Example 204, like in Examples 202, 203, the diffusion smoke 72 first diffuses before the outflow of the main flow smoke 71.

[0083] In the image analysis result of Example 204 shown in FIG. 28, diffused smoke is detected in an area larger than +1 of the horizontal axis and an area smaller than -1. According to the analysis result in FIG. 28, diffusion of smoke in the range of about three times the size of the diameter of the cigarette 11 is detected.

[0084] FIG. 29 shows a schematic diagram of an image showing the diffusion level of smoke of Example 205. In FIG. 29, a large amount of the diffusion smoke 72 flowing out from the openings 17 obliquely with respect to the axis A and downstream in the flowing direction of the main flow smoke 71 is observed along with smoke (main flow smoke 71) in the horizontal direction. The angle formed between the diffusion smoke 72 flowing out from the openings 17 and the axis A becomes still larger than in Example 204. Further, also in Example 205, like in Examples 202 to 204, the diffusion smoke 72 first diffuses before the outflow of the main flow smoke 71.

[0085] In the image analysis result of Example 205 shown in FIG. 30, diffused smoke is detected in an area larger than +1 of the horizontal axis and an area smaller than -1. According to the analysis result in FIG. 30, diffusion of a large amount of smoke in the range of about 2.5 times to 3.5 times the size of the diameter of the cigarette 11 is detected.

[0086] FIG. 31 shows a schematic diagram of an image showing the diffusion level of smoke of Example 206. In FIG. 31, a large amount of the diffusion smoke 72 flowing out from the openings 17 in a direction substantially perpendicular to the axis A is observed along with smoke (main flow smoke 71) in the horizontal direction. Also in Example 206, like in Examples 202 to 205, the diffusion smoke 72 flowing out from the openings 17 first diffuses before the outflow of the main flow smoke 71.

[0087] In the image analysis result of Example 206 shown in FIG. 32, diffused smoke is detected in an area larger than +1 of the horizontal axis and an area smaller than -1. According to the analysis result in FIG. 32, diffusion of a large amount of smoke in the range of about 2 times to 4 times the size of the diameter of the cigarette 11 is detected.

[0088] FIG. 33 shows a schematic diagram of an image showing the diffusion level of smoke of Example 207. In FIG. 33, a large amount of the diffusion smoke 72 flowing out from the openings 17 obliquely with respect to the axis A and upstream (direction from the mouthpiece 22 toward the tobacco portion 12) in the flowing direction of the main flow smoke 71 is observed along with smoke (main flow smoke 71) in the horizontal direction. Also in Example 207, like in Examples 202 to 206, the diffusion smoke 72 flowing out from the openings 17 obliquely first diffuses before the outflow of the main flow smoke 71.

[0089] In the image analysis result of Example 207 shown in FIG. 34, diffused smoke is detected in an area larger

than +1 of the horizontal axis and an area smaller than -1. According to the analysis result in FIG. 34, diffusion of a large amount of smoke in the range of about 2 times to 3 times the size of the diameter of the cigarette 11 is detected. According to the observation of smoke and the image analysis of smoke in Examples 201 to 207, as described above, diffusion of smoke in the oral cavity is generally good when the angle θ formed between the opening 17 and the axis A of the filter portion 15 is 20° or more and 110° or less.

[0090] In Examples 208 to 213, the angle θ formed between the opening 17 and the axis A of the filter portion 15 is set to 45° and the depth (opening depth) of the opening 17 is different from Example to Example.

[0091] FIG. 35 shows a schematic diagram of an image showing the diffusion level of smoke of Example 208. In Example 208, the openings 17 are provided only in the tipping paper 16 and the depth of the opening is 0.04 mm. In Example 208, as indicated by a broken line in FIG. 35, the smoke (main flow smoke 71) flows out horizontally from the end face 22A of the filter portion 15. In addition, the diffusion smoke 72 flowing out slightly from the opening 17 is confirmed.

[0092] FIG. 36 shows a schematic diagram of an image showing the diffusion level of smoke of Example 209. In Example 209, the openings 17 are provided in the tipping paper 16 and the filter wrapper 14 and the depth of the opening 17 is 0.11 mm. In Example 209, as indicated by a broken line in FIG. 36, while most of the smoke (main flow smoke 71) flows out horizontally, the diffusion smoke 72 (air flow) flowing out from the openings 17 obliquely with respect to the axis A and downstream in the flowing direction of the main flow smoke 71 is confirmed. However, the diffusion smoke 72 flowing out from the openings 17 diffuses at an angle smaller than the desired angle (45°).

[0093] FIG. 37 shows a schematic diagram of an image showing the diffusion level of smoke of Example 210. In Example 210, the depth of the opening 17 is 0.82 mm. In Example 210, as indicated by a broken line in FIG. 37, while most of the smoke (main flow smoke 71) flows out horizontally, a large amount of the diffusion smoke 72 (air flow) flowing out from the openings 17 obliquely with respect to the axis A and downstream in the flowing direction of the main flow smoke 71 is confirmed.

[0094] FIG. 38 shows a schematic diagram of an image showing the diffusion level of smoke of Example 211. In Example 211, the depth of the opening 17 is 1.11 mm. In Example 211, as indicated by a broken line in FIG. 38, in addition to the main flow smoke 71 flowing out horizontally, a large amount of the diffusion smoke 72 (air flow) flowing out from the openings 17 obliquely with respect to the axis A and downstream in the flowing direction of the main flow smoke 71 is confirmed. The diffusion smoke 72 flowing out from the openings 17 diffuses by forming the approximately desired angle (45°) with respect to the axis A.

[0095] FIG. 39 shows a schematic diagram of an image showing the diffusion level of smoke of Example 212. In Example 212, the depth of the opening 17 is 1.71 mm. In Example 212, as indicated by a broken line in FIG. 39, in addition to the main flow smoke 71 flowing out horizontally, a large amount of the diffusion smoke 72 (air flow) flowing out from the openings 17 obliquely with respect to the axis A and downstream in the flowing direction of the main flow smoke 71 is confirmed. The diffusion smoke 72 diffuses by forming the approximately desired angle (45°) with respect to the axis A.

[0096] FIG. 40 shows a schematic diagram of an image showing the diffusion level of smoke of Example 213. In Example 213, the depth of the opening 17 is 1.76 mm. In Example 213, as indicated by a broken line in FIG. 40, diffusion of smoke approximately the same as in Example 212 is confirmed. Also in Example 213, the diffusion smoke 72 flowing out from the openings 17 diffuses by forming the approximately desired angle (45°) with respect to the axis A. From the above observation results of smoke, the smoke can sufficiently be diffused when the depth of the opening 17 is 0.82 mm or more and preferably, it is better to diffuse the smoke at an angle equal to the desired angle (45°) or more with respect to the axis A by setting the depth of the opening 17 to 1.11 mm or more. The upper limit of the depth of the opening 17 is such a depth at which the bottom of the opening 17 reaches the center of the filter portion 15.

(Evaluation of smoking taste)

[0097] Using the cigarette 11 without the openings 17 as a control article, a relative comparison to evaluate sensory strength of the cigarette 11 provided with the openings 17 near the mouthpiece 22 is made. The cigarette 11 used for the evaluation is the cigarette 11 in Examples 201 to 207 shown in FIG. 18 and the tobacco portion 12 and the filter portion 15 thereof are given a "mint-like flavor" in advance. For example, after the two cigarettes 11 are smoked, the strength of "mint-like flavor" in the evaluation sheet is evaluated on a scale of 7: very weak, considerably weak, a little weak, unchanged, a little strong, considerably strong, and very strong when compared with the control article. Such wording is written in the evaluation sheet and in addition, a scale is shown next to such wording. Each subject evaluates the strength of "mint-like flavor" by checking any position on the scale. The number of subjects is 19.

[0098] First, as the first process, check results of the subjects are converted into numbers. More specifically, the strength is converted into numbers by measuring the distance from the end of the scale. As the second process, these numbers are normalized (standardized) for each subject. As the third process, the analysis of variance of the numbers normalized for each subject is performed. Accordingly, the evaluation result shown in FIG. 41 is obtained. In the evaluation result of FIG. 41, a positive number means that the "mint-like flavor" is sensed more strongly and a negative number

means that the "mint-like flavor" is sensed more weakly.

[0099] From the smoking taste evaluation result, it is understood that the angle formed between the axis A and the opening 17 is suitably 30° or more and 90° or less and preferably 45° or more and 70° or less.

[0100] According to the fifth embodiment and Examples 201 to 213, the smoking article (cigarette 11) includes the tobacco portion 12, the filter portion 15 having the mouthpiece 22, the tubular covering portion covering the tobacco portion 12 and the filter portion 15, and the plurality of openings 17 provided in the covering portion near the mouthpiece 22 at a predetermined angle with respect to the axis A of the filter portion 15.

[0101] According to the above configuration, the openings 17 are provided near the mouthpiece 22 and therefore, smoke can be caused to flow out not only from the end face 22A of the filter portion 15, but also from the openings 17. Accordingly, smoke is more likely to spread in the oral cavity during smoking, which can further improve the smoking taste. Also, according to the above configuration, a special filter cutting process is not needed during manufacturing and therefore, the cigarettes 11 having the openings 17 can be manufactured by a common tobacco winding machine, which can simplify the manufacturing process and also prevent a cost increase. Further, the cigarette 11 configured as described above has, like a common cigarette, the filter body 13 partially covered with the tipping paper 16 or the filter wrapper 14 and therefore, an occurrence of quality degradation such as fluffing of filter fiber can be prevented during smoking.

[0102] The angle formed between the opening 17 and the axis A is 20° or more and 110° or less. According to the configuration, smoke can sufficiently be diffused in the oral cavity. Accordingly, the smoking taste can be improved. The fact that smoke can sufficiently be diffused in the oral cavity by providing the opening 17 in the range of the angle can be supported by the observations of smoke and image analysis results of Examples 201 to 207.

[0103] Further, the angle formed between the opening 17 and the axis A is preferably 30° or more and 90° or less. Particularly preferably, the angle is 45° or more and 70° or less. According to the configuration, smoke can further suitably be diffused in the oral cavity. The fact that smoke can sufficiently be diffused in the oral cavity in such range can be supported by the observations of smoke and image analysis results of Examples 201 to 207 and smoking taste evaluation results of Examples 201 to 207.

[0104] The opening 17 passes through the covering portion to reach the filter portion 15. According to the configuration, the outflow of smoke from the opening 17 can further be promoted. Accordingly, the smoking taste can further be improved by increasing the diffusion of smoke during smoking.

[0105] The depth of the opening 17 is 0.82 mm or more. According to this configuration, smoke can further be diffused in the oral cavity. The fact that smoke can sufficiently be diffused in the oral cavity in such range can be supported by the observations of smoke in Examples 208 to 213.

(Sixth embodiment of the smoking article)

[0106] Subsequently, a sixth embodiment of the smoking article will be described with reference to FIG. 43. The smoking article in the sixth embodiment is applied to a non-heating smoking implement 53 that draws in an aroma and taste of tobacco. Here, mainly portions that are different from the fifth embodiment will be described and the description of portions common to the fifth embodiment is omitted by attaching common reference signs. In FIG. 43, the upper half of the smoking implement 53 is shown by cutting with a plane passing through the axis A.

[0107] As shown in FIG. 43, the smoking implement 53 includes a tobacco portion 12 formed of cut leaves (tobacco), a first filter portion 15A and a second filter portion 15B in a cylindrical shape abutting on the tobacco portion 12, a tubular covering portion 52 made of resin and covering the tobacco portion 12, the first filter portion 15A, and the second filter portion 15B, and openings 17 provided so as to pass through the covering portion 52. The first filter portion 15A has a mouthpiece 22. The covering portion 52 has an inlet port 21 on one end thereof.

[0108] The openings 17 are provided near the mouthpiece 22 of the covering portion 52 at a position closer to the side of the mouthpiece 22 (inlet port 21) than a position 8 mm from the mouthpiece 22 (inlet port 21) in the axial direction A of the first filter portion 15A. A plurality of the openings 17 is arranged in a ring shape (or a radial shape) of, for example, one line, but may also be arranged in a ring shape of a plurality of lines. The opening 17 contains a first portion 17A provided so as to pass through the covering portion 52 and a second portion 17B provided so as to stop halfway through the first filter portion 15A. The opening 17 is provided such that the angle θ is formed with respect to the axis A passing through the center of the filter portion 15. The angle at which the opening 17 is provided is the same as in the fifth embodiment.

[0109] As is evident from FIG. 43, the basic structure of the smoking implement 53 according to the sixth embodiment is the same as that of the cigarette 11 according to the fifth embodiment shown in FIG. 16. Thus, if the observation of smoke and the image analysis of the smoking implement 53 according to the sixth embodiment are performed in Examples of the same conditions as Examples 201 to 213 in the fifth embodiment and the smoking taste evaluation thereof is performed in Examples of the same conditions as Examples 201 to 207, results similar to those in the fifth embodiment are obtained. Incidentally, smoke (main flow smoke, air flow) of the smoking implement 53 according to the present embodiment is colorless and thus, colored smoke is used for the observation of smoke and the image analysis.

[0110] Also according to this embodiment, like the fifth embodiment and Examples 201 to 223, the diffusion effect of smoke (air containing an aroma and taste of tobacco emanating from the filter portion) in the oral cavity can be expected so that the smoking taste can still be improved.

(Embodiment of the filter)

[0111] An embodiment of the filter used by being attached to a smoking article will be described with reference to FIG. 44. A filter 81 has, though different from the smoking article itself, a structure of an applied opening 17 similar to that of the above embodiments of the smoking article. Thus, mainly portions of the structure that are different from those of the smoking article according to the fifth embodiment will be described and common reference signs are attached to portions common to those in the fifth embodiment. FIG. 44 shows the upper half of the filter 81 by cutting with a plane passing through the axis A.

[0112] The filter 81 is configured to be attachable to and detachable from a smoking article, for example, the common cigarette 11 (cigarette not provided with the openings 17) as described above. The filter 81 has a tubular portion 82 made of resin and attached to one end of the smoking article (cigarette 11) and a mouthpiece 22 and includes a filter portion 15 in a cylindrical shape provided inside the tubular portion 82 and a plurality of the openings 17 provided in the tubular portion 82 near the mouthpiece 22.

[0113] The plurality of openings 17 are provided near the mouthpiece 22 of the filter portion 15. More specifically, the openings 17 are provided at a position closer to the side of the mouthpiece 22 (inlet port 21) than the position 8 mm from the mouthpiece 22 (inlet port 21) in the axial direction A of the filter portion 15. However, the plurality of openings 17 may preferably be at a position closer to the side of the mouthpiece 22 (inlet port 21) than a position 4 mm from the mouthpiece 22 (inlet port 21) or particularly preferably at a position closer to the side of the mouthpiece 22 (inlet port 21) than a position 2 mm from the mouthpiece 22 (inlet port 21). The plurality of openings 17 are arranged in a ring shape (or a radial shape) of, for example, one line, but may also be arranged in a ring shape of a plurality of lines. The opening 17 contains a first portion 17A provided so as to pass through the tubular portion 82 and a second portion 17B provided so as to stop halfway through the filter portion 15. The opening 17 is provided such that the angle θ is formed with respect to the axis A passing through the center of the filter portion 15. The angle at which the opening 17 is provided is the same as in the fifth embodiment.

[0114] As is evident from FIG. 44, the basic structure of the filter 81 according to the embodiment is the same as that around the filter of the cigarette 11 (structure including the filter portion 15, tipping paper 16 and the like) according to the fifth embodiment shown in FIG. 16. Thus, if the observation of smoke and the image analysis of the filter 81 according to the embodiment are performed in Examples of the same conditions as Examples 201 to 213 in the fifth embodiment and the smoking taste evaluation thereof is performed in Examples of the same conditions as Examples 201 to 207, results similar to those in the fifth embodiment are obtained. In the observation, analysis, and evaluation, the general cigarette 11 is attached to the filter 81. Smoking conditions are the same as those in the fifth embodiment.

[0115] That is, also according to the present embodiment, like the fifth embodiment and Examples 201 to 213, the diffusion effect of smoke or the air containing an aroma and taste of tobacco emanating from the filter portion 15 in the oral cavity can be expected so that the smoking taste can still be improved.

[0116] The smoking articles (the cigarette 11 and the smoking implement 53) and the filter 81 are not limited to the above embodiments and each Example and can be embodied by modifying elements without deviating from the gist thereof in the stage of working. For example, some elements may be deleted from all elements shown in the embodiments and Examples or elements of different embodiments or Examples may appropriately be combined.

[0117] Embodiments of the cigarette as an example of the smoking article will be described. Incidentally, smoking articles include cigarettes, cigars, hand-rolled cigarettes, cigarillos, smoking implements to draw in an aroma and taste of tobacco by electronic device heating or a heat source, and non-heating smoking implements (commercial product: Zero Style Mint) to draw in the aroma and taste of tobacco.

(Seventh embodiment of the smoking article)

[0118] A seventh embodiment of the smoking article will be described below with reference to FIGS. 45 to 50. In FIGS. 47, 49, and 50, the upper half of the cigarette 11 is cut with a plane passing through the axis A and the side of a filter portion 15 is shown enlarged. Portions that are different from the first embodiment will mainly be described and the description of portions common to the first embodiment is omitted.

[0119] As shown in FIGS. 47 and 48, the cigarette 11 includes a tobacco portion 12 formed in a cylindrical shape by wrapping cut leaves (tobacco) in winding paper, the filter portion 15 in a cylindrical shape containing a filter body 13 and filter wrapper 14 covering surroundings of the filter body 13, tipping paper 16 provided to extend over the tobacco portion 12 and the filter portion 15, openings 17 provided so as to pass through the filter wrapper 14 and the tipping paper 16, an air intake 19 provided in the tipping paper 16 at a position deviating from the neighborhood of a mouthpiece 22, and

a mixing portion 20 provided inside the filter portion 15. The "position deviating from the neighborhood of the mouthpiece 22" where the air intake 19 is provided can be said to be either a position corresponding to the neighborhood of an intermediate portion in the axis A direction of the filter portion 15 or a position corresponding to the tobacco portion 12 side of the filter portion 15, or both.

[0120] The tipping paper 16 connects the tobacco portion 12 and the filter portion 15. The tipping paper 16 has an inlet port 21 on one end thereof and overlaps with the tobacco portion 12 on the other end on the opposite side of the one end. In the present embodiment, the tipping paper 16 is an example of the tubular covering portion covering the tobacco portion 12 and the filter portion 15.

[0121] The filter portion 15 is provided abutting on the tobacco portion 12 on an end on the opposite side of the end face 22A in the mouthpiece 22. The diameter of the filter portion 15 ranges from, for example, 5 mm to 9 mm and is, for example, 8 mm. The length of the circumference of the filter portion 15 ranges from, for example, 16 mm to 28 mm and is, for example, 25 mm.

[0122] The air intake 19 includes a plurality of ventilations 18 (ventilation holes, holes) passing through the tipping paper 16. The air intake 19 has the plurality of ventilations 18 arranged in, for example, one line or a plurality of lines (shape of a ring or a plurality of rings) and, for example, equidistantly and the plurality of ventilations 18 are contained in each line (each ring).

[0123] The plurality of ventilations 18 (ventilation holes, holes) are provided within the range of a predetermined length (width) in the axis A direction of the tipping paper 16. The predetermined length differs according to the number of lines of the ventilations 18 in each Example. If, as shown in FIG. 59, the number of lines (number of rings) of the ventilations 18 is four, the predetermined length (width) is, for example, about 2.3 mm. If, as shown in FIG. 60, the number of lines (number of rings) of the ventilation 18 is one, the predetermined length (width) is larger than the diameter of the hole of the ventilation 18 and, for example, is about 0.5 mm (variations of position of the ventilation 18 within the predetermined length when the number of lines of the ventilation 18 is one are caused due to factors on the production side).

[0124] The ventilation 18 is, for example, a hole provided so as to pass through the tipping paper 16 or a hole reaching the filter portion 15 by passing through the tipping paper 16 and the filter wrapper 14. The ventilation 18 plays the role of mainly thinning smoke (main flow smoke) flowing inside the filter portion 15 by supplying air into the filter portion 15 from outside. The ventilation 18 can assume various shapes such as a round shape and a quadrangular shape.

[0125] In the present embodiment, the mixing portion 20 is formed as a cavity formed inside the filter portion 15. That is, the filter body 13 (plug) is not present in this portion and only the tipping paper 16 and the filter wrapper 14 are present. The mixing portion 20 can mix smoke from the tobacco portion 12 and the air flowing through the ventilation 18.

[0126] A plurality of the openings 17 are arranged in a ring shape (or a radial shape) of, for example, one line, but may also be arranged in a ring shape of a plurality of rings. In each line, the plurality of openings 17 in, for example, a circular shape are arranged, for example, equidistantly. The plurality of openings 17 are provided near the mouthpiece 22 of the filter portion 15. More specifically, the plurality of openings 17 are provided at a position closer to the side of the mouthpiece 22 (inlet port 21) than a position 8 mm from the mouthpiece 22 (inlet port 21) of the filter portion 15 (within the range of less than 8 mm from the mouthpiece 22 (inlet port 21)) in the axis A direction of the cigarette 11 (filter portion 15). However, the plurality of openings 17 may preferably be at a position closer to the side of the mouthpiece 22 (inlet port 21) than a position 4 mm from the mouthpiece 22 (inlet port 21) or particularly preferably at a position closer to the side of the mouthpiece 22 (inlet port 21) than a position 2 mm from the mouthpiece 22 (inlet port 21).

[0127] In the present embodiment, as an example of the above, the 37 openings 17 as the plurality of openings 17 are provided in a ring shape of one line. The opening 17 contains a first portion 17A provided so as to pass through the tipping paper 16 and a second portion 17B provided in the filter portion 15 (the filter wrapper 14 and the filter body 13).

[0128] The method of producing the opening 17 is not limited to laser beam machining and may be, for example, a mechanical method of press opening by a needle-shaped punch or an electric method by corona discharge. The opening 17 in the present embodiment has a circular shape, but the shape of the opening 17 does not matter. The opening 17 may have, for example, a circular shape such as a round shape and an elliptic shape, a polygonal shape such as a triangular shape, a quadrangular shape, a rhombic shape, a parallelogrammic shape, a trapezoidal shape, and a cruciform shape, a shape combining the above shapes, or such a shape extending up to the mouthpiece 22. Further, the shape of the opening 17 may have any orientation or a plurality of the openings 17 may be combined and arranged by changing the angle (orientation) of the neighboring openings 17.

[0129] Subsequently, the manufacturing process of the cigarette 11 according to the present embodiment will be described. First, the tobacco portions 12 (wound) and the filter portions 15 of a length of two cigarettes are manufactured by a common method. Then, the filter portion 15 of the length of two cigarettes is inserted between the two tobacco portions 12. Further, the tobacco portions 12 and the filter portion 15 are wound up together by the tipping paper 16 having the length of two cigarettes to form a rod-like object connecting the tobacco portions 12 and the filter portion 15. Then, a continuous output beam output from a laser oscillator of CO_2 laser or the like is distributed in a pulse shape and irradiated from the outer circumferential direction of the rod using a rotating chopper or the like while causing the connected rod-like object to travel at a predetermined speed. The ventilation 18 is formed in the tipping paper 16 by the pulse-

shaped laser light. At the same time, the first portion 17A of the opening 17 is formed in the tipping paper 16 and the filter wrapper 14 by the pulse-shaped laser light and also the second portion 17B of a predetermined depth is formed in the filter body 13. Then, the one cigarette 11 is manufactured by cutting the filter portion 15 and the tipping paper 16 in the center position of the filter portion 15 having the length of two cigarettes with a cutter.

[0130] The method of producing the openings 17 is not limited to the above method. For example, the openings 17 may be provided after the ventilation 18 is provided using a CO_2 laser or conversely, the ventilation 18 may be provided after the openings 17 are provided using a CO_2 laser. Also, the tipping paper 16 provided with the ventilation 18 in advance may be used to produce the openings 17 by CO_2 laser when the cigarette 11 is manufactured. Further, the tipping paper 16 provided with the openings 17 in advance may be used to produce the ventilation 18 by CO_2 laser when the cigarette 11 is manufactured (in this case, the openings 17 are created only in the tipping paper 16). As another method, the openings 17 may be provided by CO_2 laser after the common cigarette 11 is manufactured. Further, the tipping paper 16 in which a plurality of lines of the ventilation 18 are created in advance by punching or the like may be used (see FIG. 49).

[0131] The depth of the opening 17 is measured as described below. A razor is inserted from immediately above the opening 17 in the mouthpiece 22 of the filter portion 15 by visual checking to cut the filter in the deepest portion of the opening 17. If the tow of the cut section is colored with a fluorescent marker, the surrounding of the opened portion is colored. Therefore, a portion that is not colored is the opening 17. The opening 17 is enlarged by an optical microscope or a magnifying glass to measure the depth thereof. An arithmetic mean of depths of 10 openings 17 selected arbitrarily and measured is adopted as the depth of the opening 17. The depth of the opening 17 is in the range of 1.8 mm and 2.1 mm.

[0132] The opening area of the opening 17 is measured as described below. After the openings 17 are produced, the tobacco portion 12 and the filter portion 15 are cut. The filter portion 15 wound by the filter wrapper 14 and the tipping paper 16 is impregnated with an ethanol solution of the concentration of 30 volume percentage to separate only the tipping paper 16 from the filter portion 15. The separated tipping paper 16 is extended and put on a preparation for drying. An opening is enlarged by an optical microscope to measure the area of the opening using area measuring software of the device. As the area of an opening 17, an arithmetic mean of areas of 10 openings 17 selected arbitrarily and measured is used. The area of the opening 17 is in the range of 0.08 to 0.11 mm^2.

(Examples 301 to 309, 315, 317, 319, 321, 338, 339 of the smoking article)

[0133] FIGS. 47 and 48 show the cigarette 11 in Example 301. The cigarette 11 in Example 301 is created under conditions of the table shown in FIG. 45. The number of lines of the ventilation 18 is four and the mixing portion 20 is provided immediately below the ventilation 18. That is, in Example 301, the mixing portion 20 is provided at a position overlapping with the air intake 19 (ventilation 18) in the axis A direction.

[0134] Because Examples 302 to 304 have generally the same structure as that of the cigarette 11 in Example 301, individual illustrations are omitted. The cigarettes 11 in Examples 302 to 304 are created under conditions of the table shown in FIG. 45. The number of lines of the ventilation 18 is four and the mixing portion 20 is provided immediately below the ventilation 18. The length of the mixing portion 20 in the axis A direction is in the order of Example 301 < Example 302 < Example 303 < Example 304. In Examples 302 to 304, the mixing portion 20 is provided at a position overlapping with the air intake 19 (ventilation 18) in the axis A direction.

[0135] FIG. 49 shows the cigarette 11 in Example 305. The cigarette 11 in Example 305 is created under conditions of the table shown in FIG. 45. The number of lines of the ventilation 18 is four. The mixing portion 20 is provided subsequently to the ventilation 18 (air intake 19), that is, on the downstream side (mouthpiece 22 side) of the ventilation 18. The position of the mixing portion 20 can be said to be a position between the ventilation 18 and the mouthpiece 22.

[0136] Because Examples 319, 321 have generally the same structure as that of the cigarette 11 in Example 305, individual illustrations are omitted. The cigarettes 11 in Examples 319, 321 are created under conditions of the table shown in FIG. 46. The number of lines of the ventilation 18 is one or four and the mixing portion 20 is provided subsequently to the ventilation 18 (air intake 19), that is, on the downstream side (mouthpiece 22 side) of the ventilation 18. The length of the mixing portion 20 in the axis A direction is in the order of Example 319 < Example 305 < Example 321. Under the condition of providing the mixing portion 20 downstream of the ventilation 18, the length of the mixing portion 20 in the axis A direction can appropriately be set in the range of 2 mm or more and 20 mm or less.

[0137] FIG. 50 shows the cigarette 11 in Example 306. The cigarette 11 in Example 306 is created under conditions of the table shown in FIG. 45. The number of lines of the ventilation 18 is one and the mixing portion 20 is provided immediately below the ventilation 18. That is, in Example 306, the mixing portion 20 is provided at a position overlapping with the air intake 19 (ventilation 18) in the axis A direction.

[0138] Because Examples 307 to 309 have generally the same structure as that of the cigarette 11 in Example 306, individual illustrations are omitted. The cigarettes 11 in Examples 307 to 309 are created under conditions of the table shown in FIG. 45. The number of lines of the ventilation 18 is one and the mixing portion 20 is provided immediately below the ventilation 18. The length of the mixing portion 20 in the axis A direction is in the order of Example 306 <

Example 307 < Example 308 < Example 309. In Examples 307 to 309, the mixing portion 20 is provided at a position overlapping with the air intake 19 (ventilation 18) in the axis A direction.

[0139] Because Examples 315, 338, 317, 339 have generally the same structure as that of the cigarette 11 in Examples 307 to 309, individual illustrations are omitted. The cigarettes 11 in Examples 315, 338, 317, 339 are created under conditions of the table shown in FIG. 46. The number of lines of the ventilation 18 is one or two and the mixing portion 20 is provided immediately below the ventilation 18. The ventilation ratio of Examples 315, 317 is, for example, 50% or less and the ventilation ratio of Examples 338, 339 is, for example, 20% or less. In Examples 315, 338, 317, 339, the mixing portion 20 is provided at a position overlapping with the air intake 19 (ventilation 18) in the axis A direction.

(Eighth embodiment of the smoking article)

[0140] Subsequently, an eighth embodiment of the smoking article will be described with reference to FIGS. 51 to 54. Portions that are different from the seventh embodiment will mainly be described and the description of portions common to the seventh embodiment is omitted by attaching common reference signs.

[0141] As shown in FIG. 51, the cigarette 11 as an example of the smoking article includes a tobacco portion 12 formed in a cylindrical shape by wrapping cut leaves (tobacco) in winding paper, a filter portion 15 in a cylindrical shape containing a filter body 13 and filter wrapper 14 covering surroundings of the filter body 13, tipping paper 16 provided to extend over the tobacco portion 12 and the filter portion 15, openings 17 provided so as to pass through the filter wrapper 14 and the tipping paper 16, an air intake 19 provided in the tipping paper 16 at a position deviating from the neighborhood of a mouthpiece 22, and a resistance imparting portion 61 provided, for example, near the center of the filter portion 15 to give ventilation resistance. In the present embodiment, the center of the filter portion 15 is, for example, the center in the direction (so-called radial direction) crossing the axis A direction. In the present embodiment, the tipping paper 16 is an example of the tubular covering portion covering the tobacco portion 12 and the filter portion 15.

[0142] The tipping paper 16 connects the tobacco portion 12 and the filter portion 15. The tipping paper 16 has an inlet port 21 on one end thereof and overlaps with the tobacco portion 12 on the other end on the opposite side of the one end.

[0143] The air intake 19 includes a plurality of ventilations 18 (ventilation holes, holes) passing through the tipping paper 16. The air intake 19 has the plurality of ventilations 18 arranged in, for example, one line or a plurality of lines (shape of a ring or a plurality of rings) and, for example, equidistantly and the plurality of ventilations 18 are contained in each line (each ring).

[0144] The filter portion 15 is provided abutting on the tobacco portion 12 on an end on the opposite side of an end face 22A in the mouthpiece 22. The diameter of the filter portion 15 is, for example, 8 mm. In the present embodiment, a portion positioned around (on the outer side of) the resistance imparting portion 61 of the filter portion 15 is a mixing portion 20 to mix smoke from the tobacco portion 12 and the air from the air intake 19 (ventilation 18). The configuration of the mixing portion 20 is, like the configuration of other portions of the filter portion 15, normally a filter.

[0145] The plurality of ventilations 18 (ventilation holes, holes) are provided within the range of a predetermined length (width) in the axis direction of the tipping paper 16. The predetermined length differs according to the number of lines of the ventilation 18 in each Example. In the present embodiment, the number of lines (number of rings) of the ventilation 18 is one and, as shown in FIG. 60, the predetermined length is, for example, 0.5 mm.

[0146] As shown in FIG. 51, the ventilation 18 is, for example, a hole provided so as to pass through the tipping paper 16 or a hole reaching the filter portion 15 by passing through the tipping paper 16 and the filter wrapper 14.

[0147] A plurality of the openings 17 are arranged in a ring shape (or a radial shape) of, for example, one line, but may also be arranged in a ring shape of a plurality of rings. In each line, the plurality of openings 17 in, for example, a circular shape are arranged, for example, equidistantly. The plurality of openings 17 are provided near the mouthpiece 22 of the filter portion 15. More specifically, the plurality of openings 17 are provided at a position closer to the side of the mouthpiece 22 (inlet port 21) than a position 8 mm from the mouthpiece 22 (inlet port 21) of the filter portion 15 (within the range of less than 8 mm from the mouthpiece 22 (inlet port 21)) in the axis A direction of the cigarette 11 (filter portion 15). However, the plurality of openings 17 may preferably be at a position closer to the side of the mouthpiece 22 (inlet port 21) than a position 4 mm from the mouthpiece 22 (inlet port 21) or particularly preferably at a position closer to the side of the mouthpiece 22 (inlet port 21) than a position 2 mm from the mouthpiece 22 (inlet port 21). In the present embodiment, as an example of the above, the 37 openings 17 as the plurality of openings 17 are provided in a ring shape of one line.

[0148] The resistance imparting portion 61 is configured as, for example, a string made of cotton and passed into the filter portion 15. However, the resistance imparting portion 61 is not limited to a string made of cotton and may be, for example, a filler of acetate (cellulose semisynthetic fiber) or the like densified or compressed to make the channel resistance higher than that of the normal filter portion 15 (see Example 336). That is, the material as the resistance imparting portion 61 does not matter. While the diameter of the filter portion 15 is 8 mm, the diameter of the resistance imparting portion 61 is set, as will be described later in Examples 310 to 314, 336, in the range of 1 mm and 5 mm.

Because the resistance imparting portion 61 makes it difficult for smoke and air to pass through, smoke from the tobacco portion 12 and air from the air intake 19 flow mainly through the mixing portion 20 located around the resistance imparting portion 61.

(Examples 310 to 314, 336 of the smoking article)

[0149] FIG. 51 shows the cigarette 11 in Example 310. The cigarette 11 in Example 310 is created under conditions of the table shown in FIG. 45. The number of lines of the ventilation 18 is one. A string as the resistance imparting portion 61 is provided in the center of the filter portion 15. The diameter of the string is 1 mm. The string as the resistance imparting portion 61 is provided to extend from the position overlapping with the air intake 19 (ventilation 18) in the axis A direction up to the mouthpiece 22. The mixing portion 20 is provided around (on the outer side of) the resistance imparting portion 61. The ventilation resistance of the resistance imparting portion 61 is a few times to a few tens of times higher than that of the mixing portion 20. FTF in FIG. 45 indicates an FTF filter and a filter whose string is arranged in a core portion.

[0150] Because Example 311 has generally the same structure as that of the cigarette 11 in Example 310, an illustration thereof is omitted. The cigarette 11 in Example 311 is created under conditions of the table shown in FIG. 45. The number of lines of the ventilation 18 is one. The diameter of the string is 3.1 mm. The string as the resistance imparting portion 61 is provided in the center of the filter portion 15. The diameter of the string is 1 mm. The string as the resistance imparting portion 61 extends from the position overlapping with the air intake 19 (ventilation 18) in the axis A direction up to the mouthpiece 22. The mixing portion 20 is provided around (on the outer side of) the resistance imparting portion 61. The ventilation resistance of the resistance imparting portion 61 is a few times to a few tens of times higher than that of the mixing portion 20.

[0151] FIG. 52 shows a cigarette in Example 312. The cigarette 11 in Example 312 is created under conditions of the table shown in FIG. 45. The number of lines of the ventilation 18 is one. The diameter of the string is 5 mm. The string as the resistance imparting portion 61 is provided in the center of the filter portion 15. The diameter of the string is 1 mm. The string as the resistance imparting portion 61 extends from the position overlapping with the air intake 19 (ventilation 18) in the axis A direction up to the mouthpiece 22. The mixing portion 20 is provided around (on the outer side of) the resistance imparting portion 61. The ventilation resistance of the resistance imparting portion 61 is a few times to a few tens of times higher than that of the mixing portion 20. The bottom of the opening 17 reaches the string as the resistance imparting portion 61.

[0152] Because Example 336 has generally the same structure as that of the cigarette 11 in Example 312, an individual illustration thereof is omitted. The cigarette 11 in Example 336 is created under conditions of the table shown in FIG. 46. The number of lines of the ventilation 18 is one. The core portion (resistance portion) as the resistance imparting portion 61 is configured by a filler (acetate or the like) denser than the portion (mixing portion 20) around the filter portion 15. The number of fibers of the filler in the resistance imparting portion 61 is larger than that of fibers of the filler in the mixing portion 20 and the thickness of fiber of the filler in the resistance imparting portion 61 is thicker than the fiber of the filler in the mixing portion 20. Therefore, the ventilation resistance of the resistance imparting portion 61 is a few times to a few tens of times higher than that of the mixing portion 20. The diameter of the resistance imparting portion 61 is 4 mm. The resistance imparting portion 61 extends from the position overlapping with the air intake 19 (ventilation 18) in the axis A direction up to the mouthpiece 22.

[0153] FIG. 53 shows a cigarette in Example 313. The cigarette 11 in Example 313 is created under conditions of the table shown in FIG. 45. The number of lines of the ventilation 18 is one. The diameter of the string is 3.1 mm. The string as the resistance imparting portion 61 extends from the position overlapping with the air intake 19 (ventilation 18) in the axis A direction up to a position upstream of the mouthpiece 22 (position substantially in the center between the ventilation 18 and the mouthpiece 22). The mixing portion 20 is provided around (on the outer side of) the resistance imparting portion 61.

[0154] FIG. 54 shows the cigarette 11 in Example 314. The cigarette 11 in Example 314 is created under conditions of the table shown in FIG. 45. The number of lines of the ventilation 18 is one. The diameter of the string is 3.1 mm. The string as the resistance imparting portion 61 extends from a position upstream of the mouthpiece 22 (position substantially in the center between the ventilation 18 and the mouthpiece 22) up to the mouthpiece 22. The mixing portion 20 is provided around (on the outer side of) the resistance imparting portion 61.

(Comparative Examples 301 to 305, 306, 308 of the smoking article)

[0155] The inventors prepared the cigarettes 11 in Comparative Examples under conditions of the tables in FIGS. 45 and 46 independently of Examples 301 to 309 in the eighth embodiment and Examples 310 to 314 in the ninth embodiment.

[0156] FIG. 55 shows the cigarette 11 in Comparative Example 301. The number of lines of the ventilation 18 is four.

[0157] FIG. 56 shows the cigarette 11 in Comparative Example 302. The number of lines of the ventilation 18 is one.

[0158] Because Comparative Examples 303 to 305, 306, 308 have configurations similar to the configuration of Comparative Examples 301, 302, illustrations thereof are omitted. The number of lines of the ventilation 18 in the cigarette 11 in Comparative Example 303 is two. The number of lines of the ventilation 18 in the cigarette 11 in Comparative Example 304 is one. In the cigarette 11 in Comparative Example 305, the ventilation 18 is not provided.

(Measuring apparatus of the air ratio: first measuring apparatus)

[0159] A first measuring apparatus 24 to measure the ratio of the air passing through the opening 17 and the air passing through the mouthpiece 22 of the filter portion 15 will be described with reference to FIG. 57. The first measuring apparatus 24 includes an air channel separation jig 25, a first membrane flowmeter 26, a second membrane flowmeter 27, a first valve 31 adjacent to the first membrane flowmeter 26, a second valve 32 adjacent to the second membrane flowmeter 27, a pump 33 (suction pump) that sucks air from inside the air channel separation jig 25, and an exhaust portion 34 into which an exhaust from the pump 33 is discharged. A buffer to prevent pulsation of the pump 33 is provided at a position upstream of the pump 33. The flow rate of suction of the pump 33 is controlled to the flow rate of 1050 ml/min by a mass flow controller.

[0160] The air channel separation jig 25 has a first portion 35 (cell) provided in a distant position from the cigarette 11 so that smoke (air) flowing out of the end face 22A of the filter portion 15 is discharged, a second portion 36 (cell) provided closer to the cigarette 11 so that smoke flowing out of a second portion 17B of the filter portion 15 and the openings 17 is discharged, a first seal 37 provided at a position between the first portion 35 and the second portion 36, and a second seal 38 provided so as to abut on the tipping paper 16 of the cigarette 11. Tubes extending from the first portion 35 and the second portion 36 are merged downstream before being connected to the pump 33.

[0161] The first measuring apparatus 24 is initially adjusted such that the first membrane flowmeter 26 and the second membrane flowmeter 27 each have the value of 525 ml/min while no cigarette for measurement is inserted. The cigarettes 11 in Examples 301 to 314 and Comparative Examples 301 to 305 are inserted to measure the flow rate passing through the end face 22A of the filter portion 15 and the flow rate passing through the openings 17 using the first membrane flowmeter 26 and the second membrane flowmeter 27. The cigarettes 11 in Examples 301 to 314 and Comparative Examples 301 to 305 are provided with an extended tube 41 created by attaching tape having an adhesive layer, for example, on one side to the inlet port 21 in a tubular shape. The extended tube 41 guides air passing through the end face 22A of the filter portion 15 to the first portion 35.

[0162] A ratio F_{air} of the flow rate of air passing through the openings 17 defined by the following formula (1) is calculated from each measured value. Q_{air1} is the flow rate of air passing through the end face 22A of the filter mouthpiece 22 and Q_{air2} is the flow rate of air passing through the opening 17. An arithmetic mean of the 10 cigarettes 11 is used as the measured value. Measurement results of Fair are shown in the tables of FIGS. 45 and 46.

[Mathematical Formula 3]

$$F_{air} = \frac{Q_{air2}}{Q_{air1} + Q_{air2}} \qquad (1)$$

(Measuring apparatus of the crude tar amount: second measuring apparatus)

[0163] A second measuring apparatus 62 to measure the ratio of the crude tar amount flowing out from the openings 17 will be described with reference to FIG. 58. The second measuring apparatus 62 includes a smoke channel separation jig 63 and a linear smoking device 64. The smoke channel separation jig 63 has a first cell 65 provided at a distant position from the cigarette 11, a second cell 66 provided closer to the cigarette 11 so that smoke flowing out from the openings 17 is discharged, a third seal 67 provided at a position between the first cell 65 and the second cell 66, and a fourth seal 68 provided so as to abut on the tipping paper 16 of the cigarette 11.

[0164] Each cell is connected to a different smoke suction port on the linear smoking device. The total flow rate of suction for the two cells is set to 35.0 mL/2.0 s and the suction volume of the smoke suction port connected to the second cell 66 is set so as to be equal to the ratio Fair of the flow rate of air passing through the openings 17.

[0165] The cigarette 11 of each Example and each Comparative Example is inserted and crude tar flowing out of the end face 22A of the filter portion 15 and crude tar flowing out from the openings 17 are collected by a Cambridge pat connected to each cell and measured by an electronic balance. Incidentally, the extended tube 41 similar to the above one is provided in the cigarette 11.

[0166] The amount of the collected crude tar is calculated by subtracting the total weight of the Cambridge pat before the smoking test and the Cambridge holder holding the pat from the total weight of the Cambridge pat after the smoking test and the Cambridge holder. In addition, a ratio F_{smoke} of the amount of crude tar flowing out from the openings 17

defined by the formula (2) is calculated from each measured value. Q_{smoke1} is the weight of crude tar flowing out of the end face 22A of the mouthpiece 22 of the filter portion 15 and Q_{smoke2} is the weight of crude tar flowing out from the openings 17. R defined by the formula (3) is used as an index of the density of smoke flowing out from the openings 17. Measurement results of F_{smoke} and R are shown in the tables of FIGS. 45 and 46. When R is a number near 0.5 to 1, smoke of normal density is generally considered to be flowing out from the openings 17.

[Mathematical Formula 4]

$$F_{smoke} = \frac{Q_{smoke2}}{Q_{smoke1} + Q_{smoke2}} \quad (2)$$

[Mathematical Formula 5]

$$R = \frac{F_{smoke}}{F_{air}} \quad (3)$$

(Discussion of test results)

[0167] First, regarding Comparative Examples 301 to 305, the relationship between the ventilation ratio (Vf%) and R will be discussed will reference to FIG. 63. In Comparative Example 305, the ventilation ratio (ratio of the flow rate of air flowing in from the air intake 19 (ventilation 18) to the total flow rate obtained by adding the flow rate of smoke from the tobacco portion 12 through the mouthpiece 22 and the flow rate of air flowing in from the air intake 19) is 0%, F_{smoke} is 62.6%, and R is 1.08. In Comparative Example 304, the ventilation ratio is 26.2%, F_{smoke} is 36.8%, and R is 0.701. In Comparative Example 304, it is evident that the outflow of crude tar from the openings 17 is suppressed and smoke is slightly thinned. Further, in Comparative Example 303, the ventilation ratio is 52.3%, F_{smoke} is 22.8%, and R is 0.39. In Comparative Example 303, it is evident that when compared with a case in which there is no ventilation 18, the density R of smoke flowing out from the openings 17 is 1/2 or less. In Comparative Examples 301, 302 in which the ventilation ratio is increased, the value of R further decreases (see FIG. 63).

[0168] Next, whether the ventilation ratio decreases in examples (seventh embodiment and Examples 301 to 305) in which the mixing portion 20 as a cavity is provided in the filter portion 15 is discussed. The discussion result is shown in FIG. 61. As is evident from FIG. 61, the ventilation ratio is not effected even if the mixing portion 20 is provided like in Examples 301 to 305. The ventilation ratio is 50% or more in each of Examples 301 to 305.

[0169] Similarly, whether the ventilation ratio decreases in examples (eighth embodiment and Examples 310 to 314) in which the resistance imparting portion 61 (string) is provided in the filter portion 15 is discussed. The discussion result is shown in FIG. 62. As is evident from FIG. 62, the ventilation ratio is not affected even if the resistance imparting portion 61 is provided like in Examples 310 to 314. The ventilation ratio is 50% or more in each of Examples 310 to 314.

[0170] Further, the relationship between the length of the mixing portion 20 in the axis A direction and R is examined when the ventilation has four lines in examples in which the mixing portion 20 as a cavity is provided in the filter portion 15 (Examples 301 to 305). The examination result is shown in FIG. 64. From the above result, it is evident that the density R of smoke flowing out from the openings 17 increases with an increasing length of the mixing portion 20. It is understood that the density R of smoke increases rapidly when the length of the mixing portion 20 increases from 3.0 mm to 4.0 mm and then levels off when the length is 4.0 mm or more.

[0171] On the other hand, when the mixing portion 20 is positioned between the ventilation 18 and the mouthpiece 22 like in Example 305, the density R of smoke is 0.381 even if the length of the mixing portion 20 in the axis A direction is 8.0 mm. Thus, when compared with a case in which the mixing portion 20 overlaps with the ventilation 18 (Examples 301 to 304), it is evident that the density R of smoke flowing out from the openings 17 is lower.

[0172] Similarly, the relationship between the length of the mixing portion 20 in the axis A direction and R is examined when the mixing portion 20 as a cavity is provided in the filter portion 15 and the ventilation has one line (Examples 306 to 309). The examination result is shown in FIG. 65. From the above result, it is evident that the density R of smoke flowing out from the openings 17 increases with an increasing length of the mixing portion 20. It is understood that the density R of smoke increases rapidly when the length of the mixing portion 20 increases from 2.0 mm to 3.0 mm and then levels off when the length is 3.0 mm or more.

[0173] Further, a general examination independent of the number of lines of the ventilation 18 is conducted by totaling

both results when the ventilation 18 has four lines and the ventilation 18 has one line. Here, the relationship between the value of L defined below and R is examined.

L = (length of the mixing portion 20 (cavity)) − (width of the ventilation 18 (Vf width))

[0174] The length of the mixing portion 20 is the length in the axis A direction. The width of the ventilation 18 is the predetermined length in which the plurality of ventilations 18 are provided in the axis A direction.

[0175] Examination results are shown in FIGS. 66, 67, and 70. FIG. 67 is an enlarged view of the position where L in FIG. 66 ranges from about 0 mm to 2 mm. According to FIGS. 66 and 67, the density R of smoke increases rapidly when L is between 0 mm and 1 mm. Then, the density R of smoke almost levels off when L is 1.5 mm or more. This indicates that (1) the air and smoke are not sufficiently mixed immediately after the air flows in from the ventilation 18 and a mixing interval is needed in addition to the width of the ventilation 18 and (2) the length of about 1 mm (R is preferably 0.5 or more and particularly preferably 0.8 or more, see FIG. 67) is needed as the mixing interval, which does not depend on the number of lines of the ventilation 18.

[0176] FIG. 70 shows the relationship between L and the density R of smoke for each ventilation ratio. The approximate curve of a broken line corresponds to 80% of the ventilation ratio (Vf); the approximate curve of an alternate long and short dash line corresponds to chiefly 50% of the ventilation ratio (Vf); and the approximate curve of an alternate long and two short dashes line corresponds to chiefly 20% of the ventilation ratio (Vf). According to FIG. 70, it is evident that there is no dependency on the ventilation ratio and the density R of smoke increases rapidly when L is between 0 mm and 1 mm. Then, R almost levels off when L is 1.5 mm or more.

[0177] Lastly, Examples in which the resistance imparting portion 61 is provided in the filter portion 15 is examined. First, the relationship between the position where the resistance imparting portion 61 (string) is provided and R is discussed. The discussion result is shown in FIG. 68. Example 311 is a case in which the resistance imparting portion 61 extends from the position overlapping with the ventilation 18 to the mouthpiece 22 has the highest value of R (R = 0.397), then follows the value of R of Example 314 in which the resistance imparting portion 61 extends from a position upstream of the mouthpiece 22 (position substantially in the center between the ventilation 18 and the mouthpiece 22) to the mouthpiece 22 (R = 0.321), and further follows the value of R of Example 313 in which the resistance imparting portion 61 extends from the position overlapping with the ventilation 18 to a position upstream of the mouthpiece 22 (position substantially in the center between the ventilation 18 and the mouthpiece 22) (R = 0.270).

[0178] Examples 311, 313, 314 have values of R higher than when the resistance imparting portion 61 is not provided (that is, values on an approximate straight line created from values of Comparative Examples 301 to 305 shown in FIG. 68) and it is understood that the R value is improved by the installation of the resistance imparting portion 61.

[0179] Subsequently, the relationship between the diameter of the resistance imparting portion 61 and the R is discussed. The discussion result is shown in FIG. 69. In Examples 310, 311, 312 described below, the string as the resistance imparting portion 61 extends from the position overlapping with the air intake 19 (ventilation 18) in the axis A direction to the mouthpiece 22. In Example 310 in which the diameter of the resistance imparting portion 61 (string) is 1.0 mm, R is 0.145 and the value of R is positioned near the approximate straight line created from values of Comparative Examples 301 to 305. On the other hand, in Example 311 in which the diameter of the resistance imparting portion 61 (string) is increased to 3.1 mm, the density R of smoke is 0.397, which shows that the R value increases due to the resistance imparting portion 61. If the diameter of the resistance imparting portion 61 (string) is further increased to 5.0 mm (Example 312), R is 0.862, which shows a rapid increase in R. When the diameter of the resistance imparting portion 61 (string) is 4.0 mm (Example 336), R is 0.757, which is a sufficient improvement of the R value.

[0180] In Example 312, the bottom of the opening 17 is provided in the string as the resistance imparting portion 61. A rapid increase of R in Example 312 is also considered to be affected by suppression of the smoke and air in the axis A direction with the penetration of the opening 17 through the mixing portion 20.

[0181] From the above discussion results, the diameter of the resistance imparting portion 61 is preferably 4 mm or more. In other words, the ratio of the diameter of the resistance imparting portion 61 to the diameter (8 mm) of the filter portion 15 is preferably 50% or more. Further, in other words, the bottom of the opening 17 preferably reaches the resistance imparting portion 61.

[0182] From the above examination results, the smoking article preferably adopts the following configuration.

[0183] The smoking article includes the tobacco portion 12, the filter portion 15 having the mouthpiece 22, a tubular covering portion covering the tobacco portion 12 and the filter portion 15, a plurality of the openings 17 provided in the covering portion near the mouthpiece 22, the air intake 19 provided in the covering portion at a position deviating from the neighborhood of the mouthpiece 22, and the mixing portion 20 provided in the filter portion 15 that mixes smoke

from the tobacco portion 12 and the air from the air intake 19.

[0184] According to the above configuration, the air flowing in from the air intake 19 and smoke from the tobacco portion 12 can be mixed well by providing the mixing portion 20. Accordingly, for example, the density of smoke flowing out from the openings 17 created for the purpose of efficiently diffusing smoke in the oral cavity can be prevented from being extremely thinned out. Accordingly, the desired smoke diffusion effect can be gained in the oral cavity.

[0185] The mixing portion 20 is a cavity provided in the filter portion 15. According to the above configuration, the configuration of the mixing portion 20 can be realized easily at low cost. In addition, the mixing portion 20 can continuously be manufactured by a common tobacco winding machine, which is industrially advantageous. Therefore, a decrease of the density of smoke flowing out from the openings 17 can effectively be prevented without significantly changing existing tobacco manufacturing equipment.

[0186] The mixing portion 20 is provided at a position overlapping with the air intake 19 in the axis A direction. According to the above configuration, smoke from the tobacco portion 12 and the air flowing in from the air intake 19 can efficiently be mixed. Accordingly, the density of smoke flowing out from the openings 17 can be prevented from decreasing.

[0187] The air intake 19 includes a plurality of holes passing through the covering portion; the plurality of holes are provided within the range of the predetermined length in the axis A direction of the covering portion, and the value obtained by subtracting the predetermined length from the length of the mixing portion 20 in the axis A direction is 1.0 mm or more. From the above discussion results, it is understood that after smoke and the air encounter, a certain distance is needed before the smoke and air are mixed up. According to the above configuration, a distance in which smoke from the tobacco portion 12 and the air from the air intake 19 are sufficiently mixed can be secured in the mixing portion 20 (R is generally 0.8 or so). Accordingly, a decrease of the density of smoke flowing out from the openings 17 can effectively be prevented. Incidentally, the value obtained by subtracting the predetermined length from the length of the mixing portion 20 in the axis A direction is a value substantially smaller than the total length of the filter portion 15.

[0188] The value obtained by subtracting the predetermined length from the length of the mixing portion 20 in the axis A direction is 1.5 mm or more. According to the above configuration, a distance in which smoke from the tobacco portion 12 and the air from the air intake 19 are sufficiently mixed can be secured in the mixing portion 20 (R is generally 0.9 or more). Accordingly, a decrease of the density of smoke flowing out from the openings 17 can effectively be prevented.

[0189] The mixing portion 20 is provided closer to the mouthpiece 22 than the air intake 19. According to the above configuration, the degree of freedom of the installation position of the mixing portion 20 can be improved. The length of the mixing portion 20 in the axis A direction of the filter portion 15 is 2 mm or more and 20 mm or less. According to the above configuration, when compared with smoking articles in which the mixing portion 20 is not provided (for example, Comparative Example 306), the R value is slightly improved. Therefore, it is effective to provide the mixing portion 20 closer to the mouthpiece 22 than the air intake 19 within the above range to improve the R value.

[0190] The smoking article includes the resistance imparting portion 61 that imparts ventilation resistance near the center of the filter portion 15 and the mixing portion 20 is positioned on the outer side from the resistance imparting portion 61 of the filter portion 15. According to the above configuration, smoke from the tobacco portion 12 can be prevented from concentrating in the center of the filter portion 15 by the resistance imparting portion 61. Accordingly, smoke from the tobacco portion 12 and the air from holes of the air intake 19 can efficiently be mixed in the mixing portion 20 present around the resistance imparting portion 61.

[0191] The resistance imparting portion 61 extends from the position overlapping with the air intake 19 in the axis A direction to the mouthpiece 22. According to the above configuration, smoke from the tobacco portion 12 does not concentrate in the center of the filter portion 15 in any portion ranging from the position overlapping with the air intake 19 in the axis A direction to the mouthpiece 22 and the concentration of the smoke flowing out from the openings 17 can be prevented from decreasing.

[0192] The diameter of the resistance imparting portion 61 is 50% or more of the diameter of the filter portion 15. According to the above configuration, smoke from the tobacco portion 12 and the air from holes of the air intake 19 can efficiently be mixed in the mixing portion 20 (R is generally 0.75 or more). Accordingly, the concentration of the smoke flowing out from the openings 17 can be prevented from decreasing.

[0193] The ratio of flow rate of air flowing in from the air intake 19 to the total flow rate obtained by adding the flow rate of smoke from the tobacco portion 12 through the mouthpiece 22 and the flow rate of air flowing in from the air intake 19 is 50% or more. According to the above configuration, the concentration of smoke flowing out from the openings 17 can be prevented from being thinned out in so-called Vf (high ventilation) products. The ventilation 18 is a main means for achieving a cigarette 11 of low tar and is adopted in many low-tar products.

[0194] The smoking article is not limited to the above embodiments and each Example and can be embodied by altering elements without deviating from the gist thereof in the stage of working. In the seventh embodiment, for example, a particulate substance such as charcoal and various capsules (for example, capsules containing menthol or mint spices) may be arranged inside the mixing portion 20 configured as a cavity. In addition, some elements may be deleted from all elements shown in the embodiments and Examples or elements extending over different embodiments or Examples may appropriately be combined.

Reference Signs List

[0195]

11	Cigarette
12	Tobacco portion
13	Filter body
14	Filter wrapper
15	Filter portion
16	Tipping paper
17	Opening
18	Ventilation
19	Air intake
20	Mixing portion
22	Mouthpiece
22A	End face
51	Exposed portion
52	Covering portion
53	Smoking implement
61	Resistance imparting portion
81	Filter
82	Tubular portion

Claims

1. A smoking article comprising:

a tobacco portion;
a filter portion having a mouthpiece;
a tubular covering portion covering the tobacco portion and the filter portion; and
a plurality of openings provided in the covering portion near the mouthpiece.

2. The smoking article according to claim 1, wherein the opening passes through the covering portion to reach the filter portion.

3. The smoking article according to claim 2, wherein the plurality of openings are provided at a position closer to a side of the mouthpiece than a position 8 mm from the mouthpiece in an axial direction of the filter portion.

4. The smoking article according to claim 3, wherein the plurality of openings are provided at a predetermined angle with respect to an axis of the filter portion.

5. The smoking article according to claim 4, wherein an angle formed by the opening and the axis is 20° or more and 110° or less.

6. The smoking article according to claim 5, wherein the angle formed by the opening and the axis is 30° or more and 90° or less.

7. The smoking article according to claim 6, wherein the angle formed by the opening and the axis is 45° or more and 70° or less.

8. The smoking article according to any one of claims 5 to 7, wherein a depth of the opening is 0.82 mm or more.

9. The smoking article according to claim 3, further comprising:

an air intake provided in the tobacco portion at the position deviating from a neighborhood of the mouthpiece; and
a mixing portion provided in the filter portion to mix smoke from the tobacco portion and air from the air intake.

10. The smoking article according to claim 9, wherein the mixing portion is a cavity provided in the filter portion.

11. The smoking article according to claim 10,
wherein the mixing portion is provided in the position overlapping with the air intake in an axis direction of the filter portion.

12. The smoking article according to claim 11,
wherein the air intake contains a plurality of holes passing through the covering portion and the plurality of holes are provided within a range of a predetermined length in the axis direction of the covering portion and
a value obtained by subtracting the predetermined length from a length of the mixing portion in the axis direction is 1.0 mm or more.

13. The smoking article according to claim 12,
wherein the value obtained by subtracting the predetermined length from the length of the mixing portion in the axis direction is 1.5 mm or more.

14. The smoking article according to claim 10,
wherein the mixing portion is provided on a mouthpiece side from the air intake.

15. The smoking article according to claim 14,
wherein a length of the mixing portion in an axis direction of the filter portion is 2 mm or more and 20 mm or less.

16. The smoking article according to claim 9, further comprising: a resistance imparting portion that imparts ventilation resistance near a center of the filter portion, wherein
the mixing portion is positioned on an outer side of the resistance imparting portion of the filter portion.

17. The smoking article according to claim 16,
wherein the resistance imparting portion extends from the position overlapping with the air intake in the axis direction to the mouthpiece.

18. The smoking article according to claim 16,
wherein a diameter of the resistance imparting portion is 50% or more of the diameter of the filter portion.

19. The smoking article according to claim 16,
wherein a bottom of the opening reaches into the resistance imparting portion.

20. The smoking article according to claim 3, wherein a ratio of a flow rate of an air flow flowing out from the opening to a total flow rate of the air flow flowing out from an end face of the filter portion and the opening is 2.8% or more and 68.9% or less.

21. The smoking article according to claim 1, wherein the covering portion is tipping paper.

22. The smoking article according to claim 1, wherein the covering portion is formed from a resin material.

23. A smoking article comprising:

a tobacco portion;
a filter portion having a mouthpiece;
a tubular covering portion covering the tobacco portion and the filter portion; and
an exposed portion provided in the covering portion near the mouthpiece.

24. A filter comprising:

a tubular portion attached to one end of a smoking article;
a filter portion having a mouthpiece and provided inside the tubular portion; and
a plurality of openings provided in the tubular portion near the mouthpiece.

25. The filter according to claim 24, wherein the plurality of openings are provided at a predetermined angle with respect

to an axis of the filter portion.

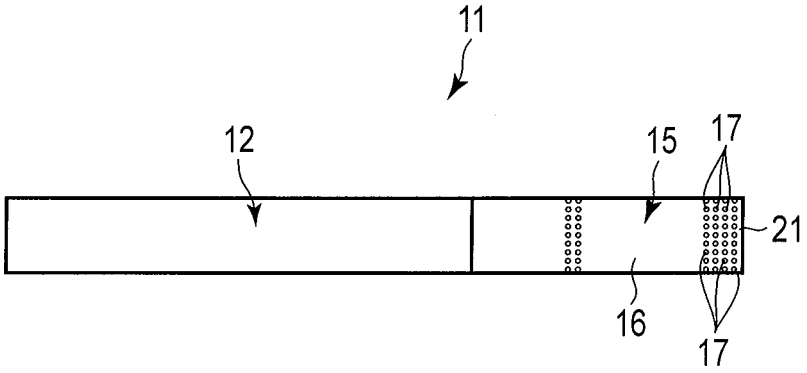
11
12
15
17
21
16
17

FIG. 1

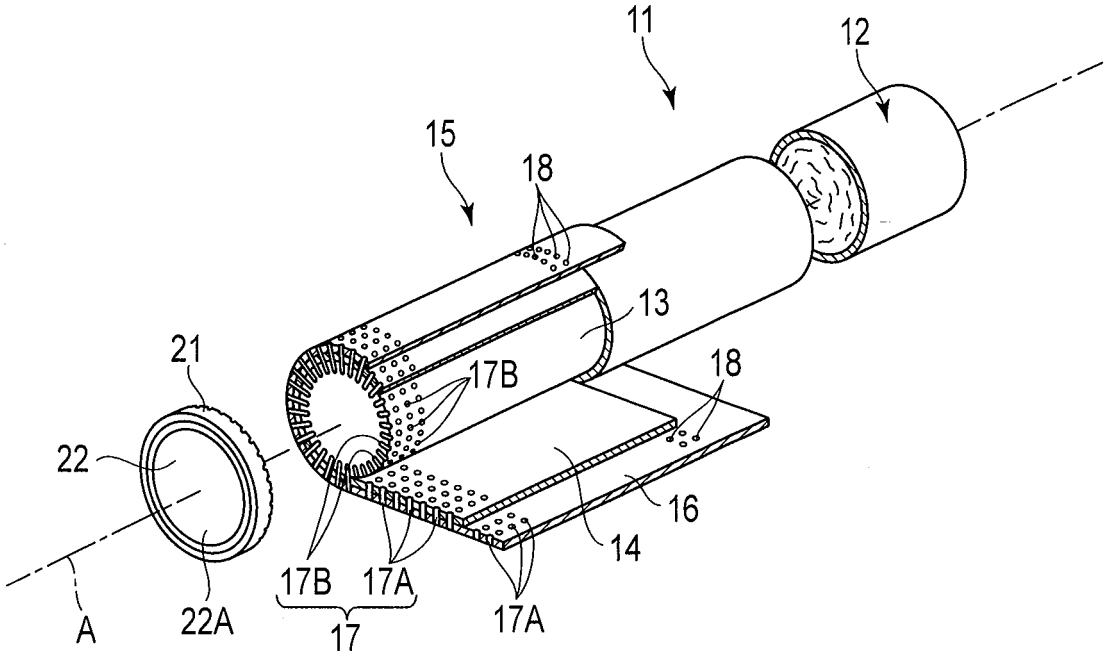
11
12
15
18
13
21
17B
18
22
16
14
17B
17A
17A
A
22A
17

FIG. 2

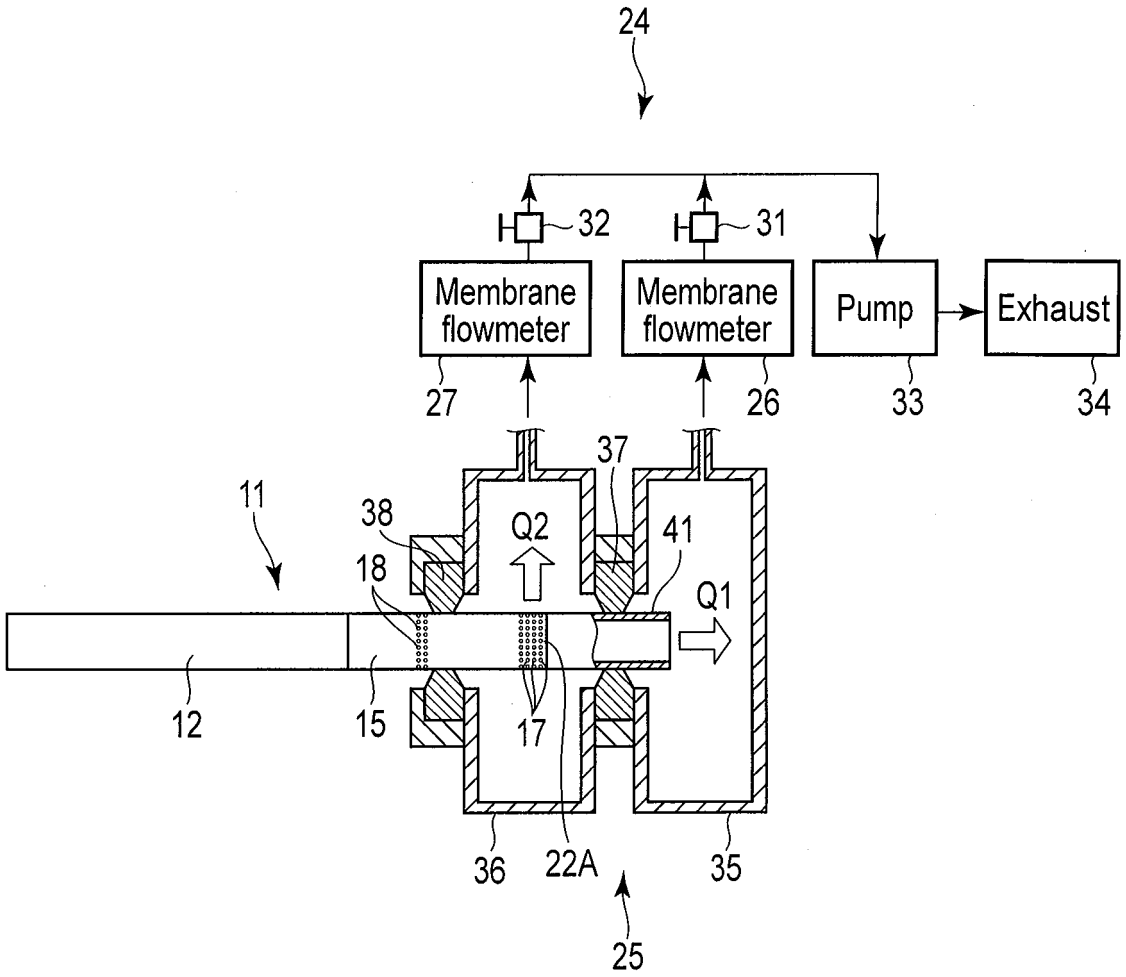
24
32
31
Membrane flowmeter
Membrane flowmeter
Pump
Exhaust
27
26
33
34
37
11
38
Q2
41
18
Q1
12
15
17
36
22A
35
25

FIG. 3

Sample specs of each example

Sample	Deficiency rate [%]	Deficiency depth [mm]	F [%]
Comparative example 101	0	0	0
Example 101	2.3	0.11	2.8
Example 102	7.6	0.11	9.5
Example 103	0.3	2.61	18.2
Example 104	0.5	0.60	18.5
Example 105	2.9	0.14	24.8
Example 106	11	0.60	26.9
Example 107	1.6	0.60	36.0
Example 108	1.0	2.61	36.7
Example 109	2.6	0.60	38.3
Example 110	2.1	0.60	44.7
Example 111	3.2	0.60	48.4
Example 112	9.6	0.14	48.8
Example 113	5.2	0.60	53.2
Example 114	4.3	0.60	53.7
Example 115	3.8	1.33	56.0
Example 116	6.4	0.60	60.6
Example 117	10.5	0.60	62.4
Example 118	2.6	2.61	64.7
Example 119	11.9	0.60	65.2
Example 120	12.6	1.03	66.3
Example 121	5.1	2.61	68.6
Example 122	12.5	2.61	68.6
Example 123	7.7	2.61	68.9

FIG. 4

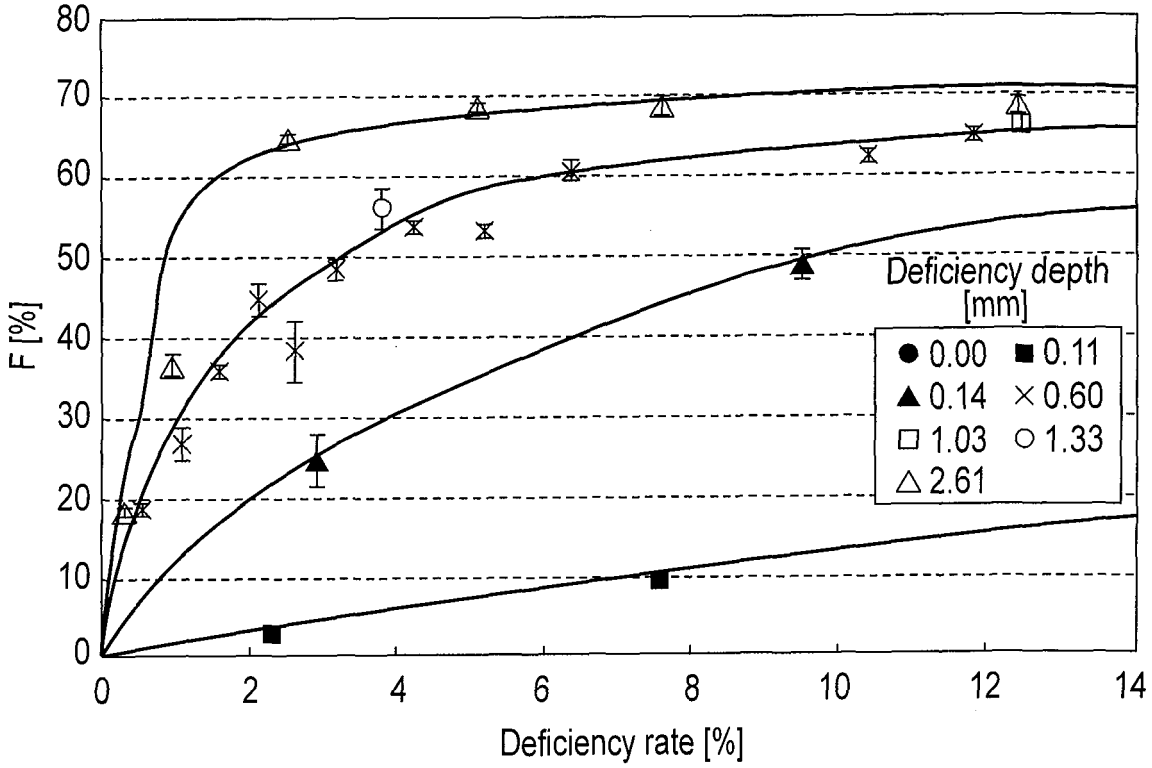
80
70
60
50
40
30
20
10
0
F [%]
0
2
4
6
8
10
12
14
Deficiency rate [%]
Deficiency depth [mm]
0.00
0.11
0.14
0.60
1.03
1.33
2.61

FIG. 5

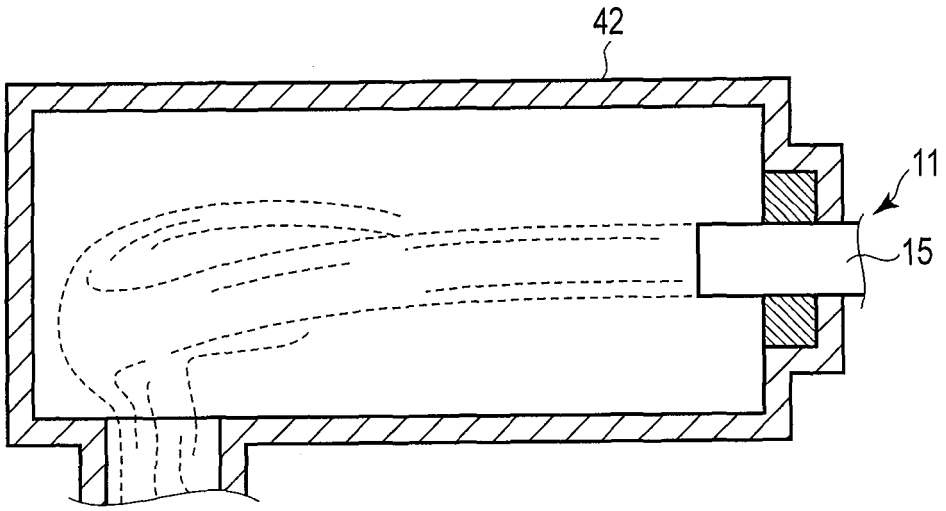
42
11
15

FIG. 6

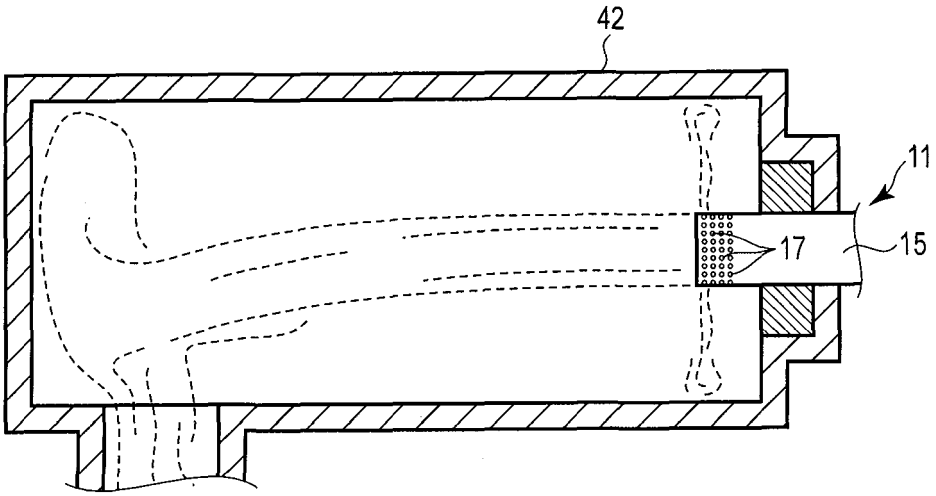

FIG. 7

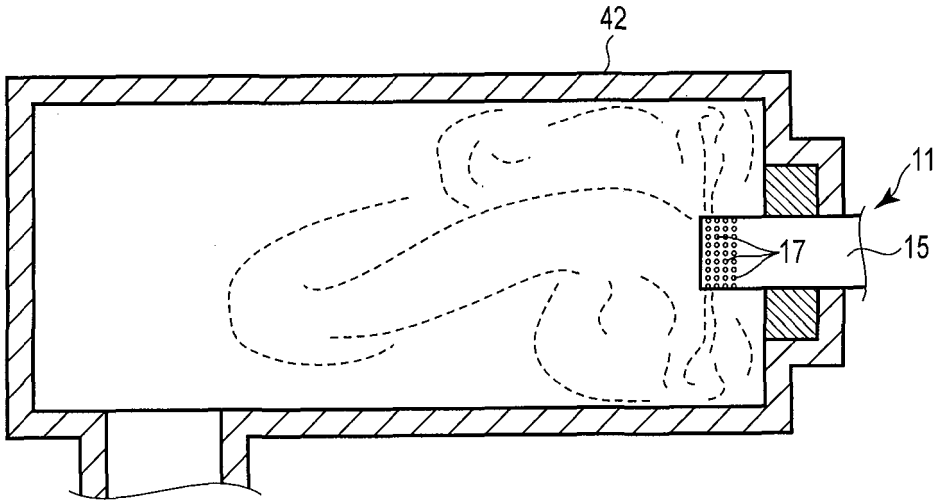

FIG. 8

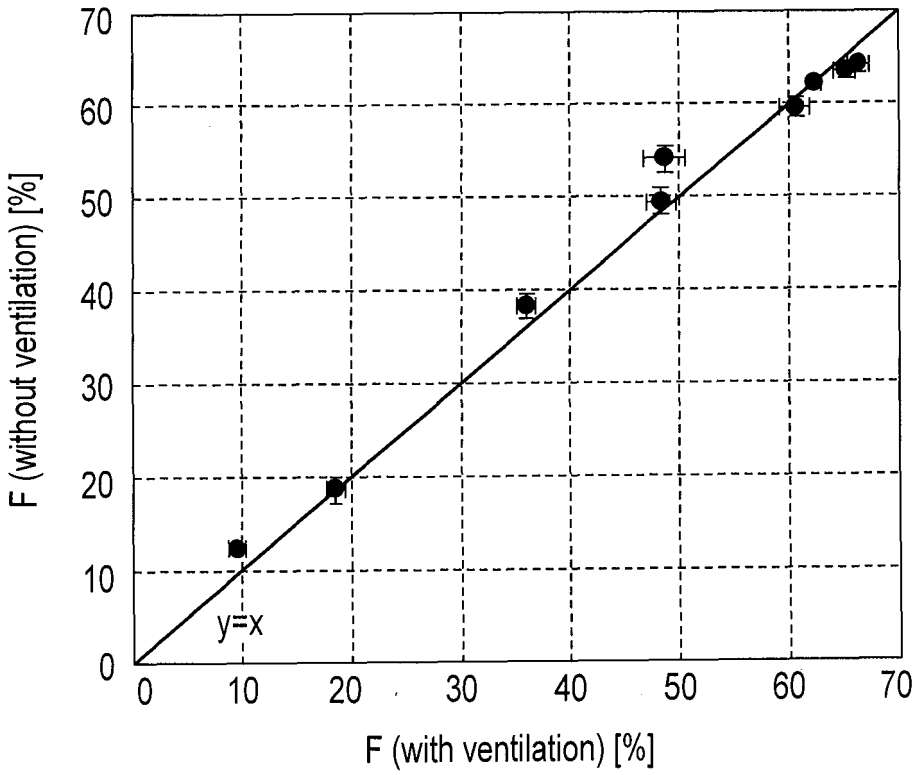
70
60
50
40
30
20
10
0
F (without ventilation) [%]
y=x
0
10
20
30
40
50
60
70
F (with ventilation) [%]

FIG. 9

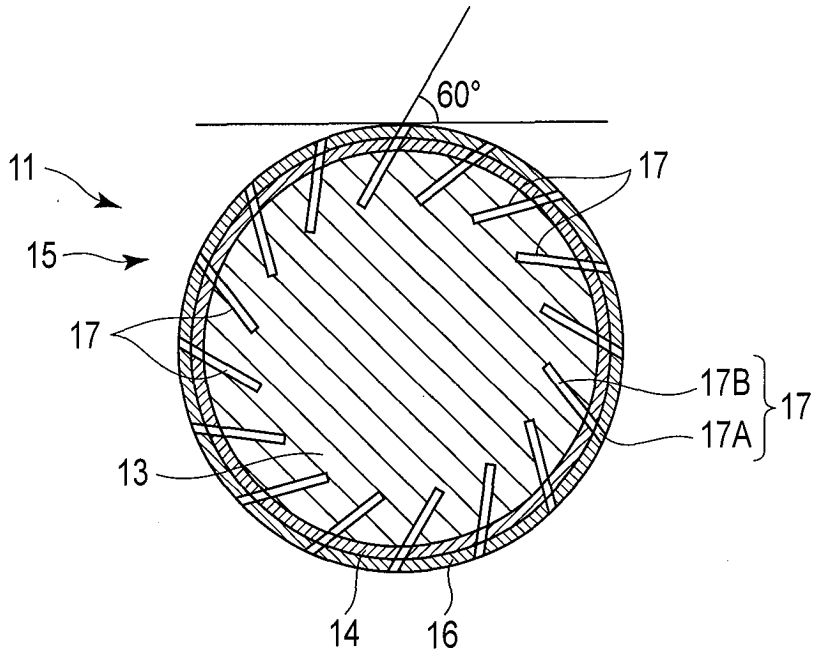
60°
11
15
17
17
17B
17A
17
13
14
16

FIG. 10

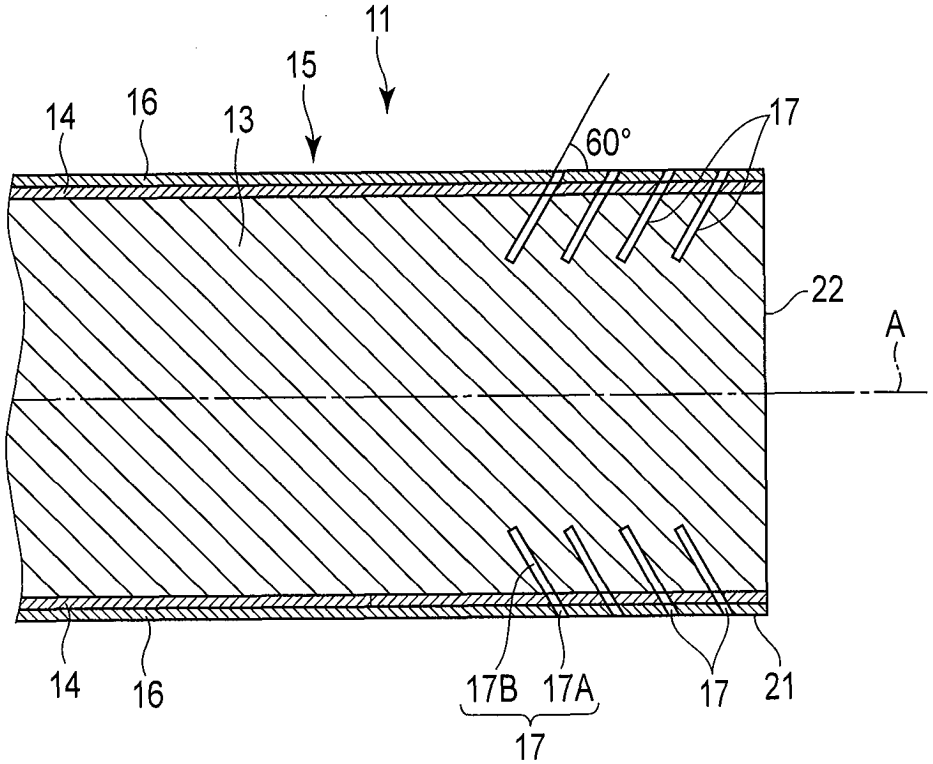
11
15
14
16
13
60°
17
22
A
14
16
17B
17A
17
17
21

FIG. 11

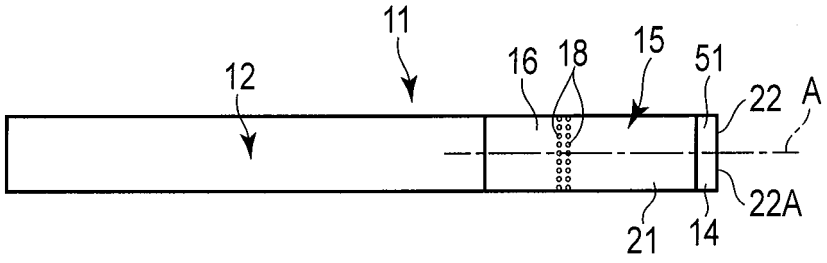

FIG. 12

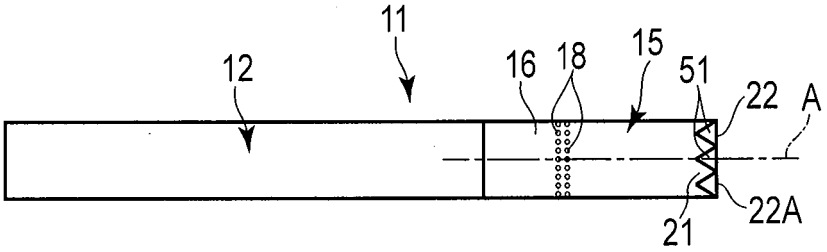

FIG. 13

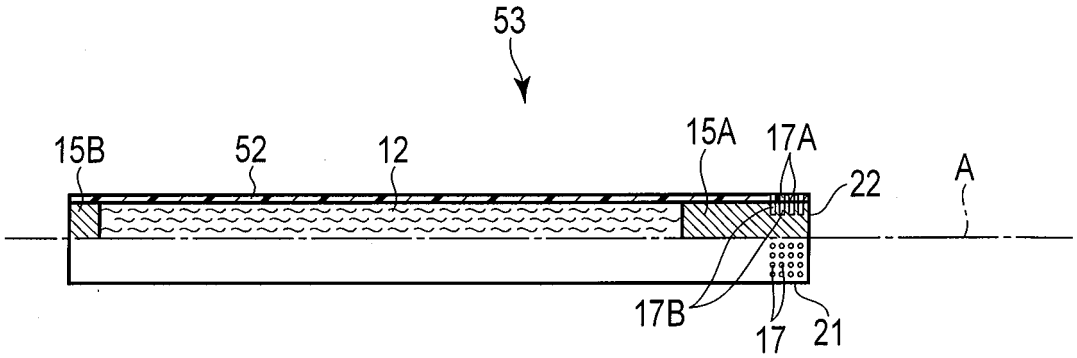

FIG. 14

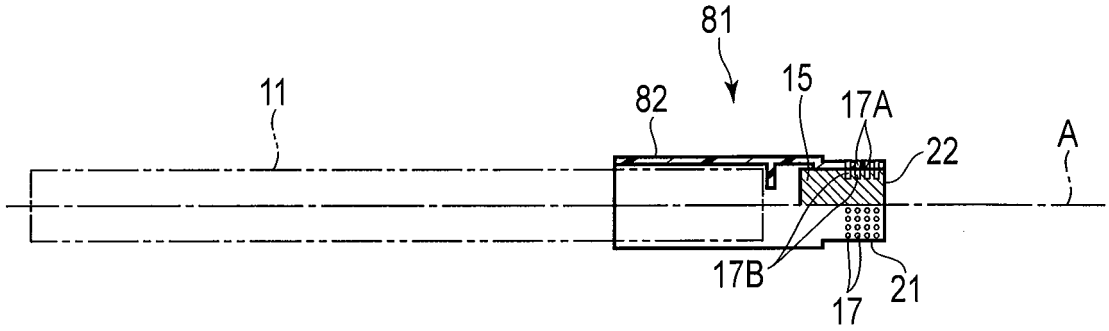

FIG. 15

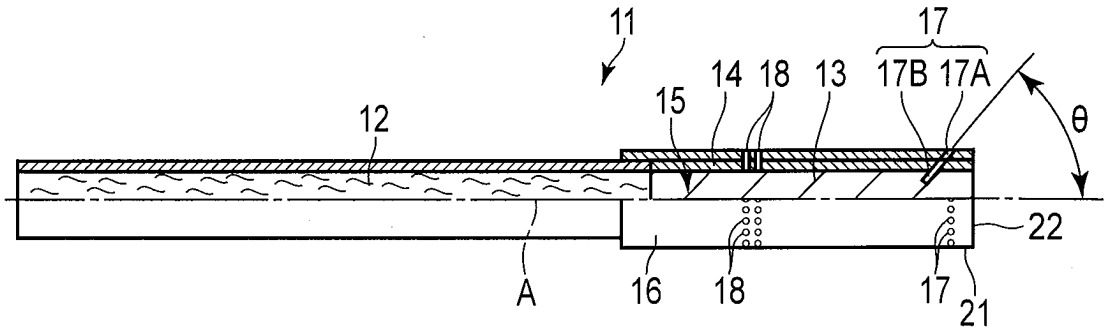
11
17
14
18
13
17B
17A
15
θ
12
22
A
16
18
17
21

FIG. 16

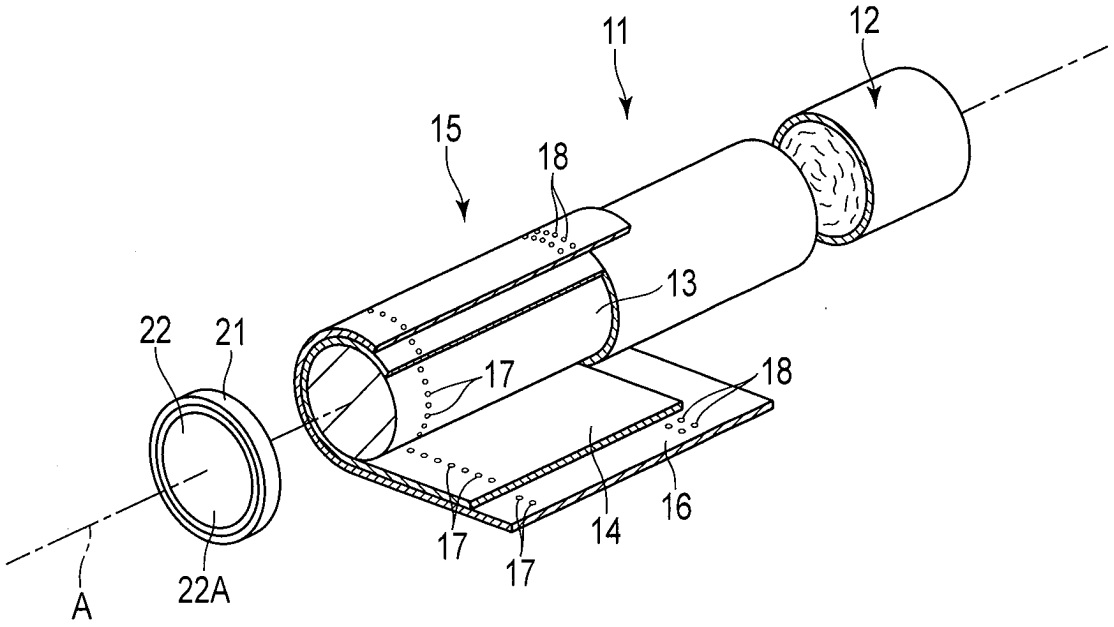
11
12
15
18
13
22
21
17
18
16
14
17
17
A
22A

FIG. 17

	Opening angle [°]	Opening area [mm2/hole]	Opening depth [mm]
Comparative Example 201	-	-	-
Example 201	20	0.09	1.88
Example 202	30	0.07	2.11
Example 203	45	0.06	2.59
Example 204	60	0.06	2.61
Example 205	70	0.06	2.76
Example 206	90	0.09	2.39
Example 207	110	0.08	2.68
Example 208	45	0.01	0.04 (Opened only in tipping paper)
Example 209	45	0.04	0.11 (Opened in tipping paper and filter wrapper)
Example 210	45	0.04	0.82
Example 211	45	0.05	1.11
Example 212	45	0.05	1.71
Example 213	45	0.05	1.76

FIG. 18

EP 2 789 248 A1

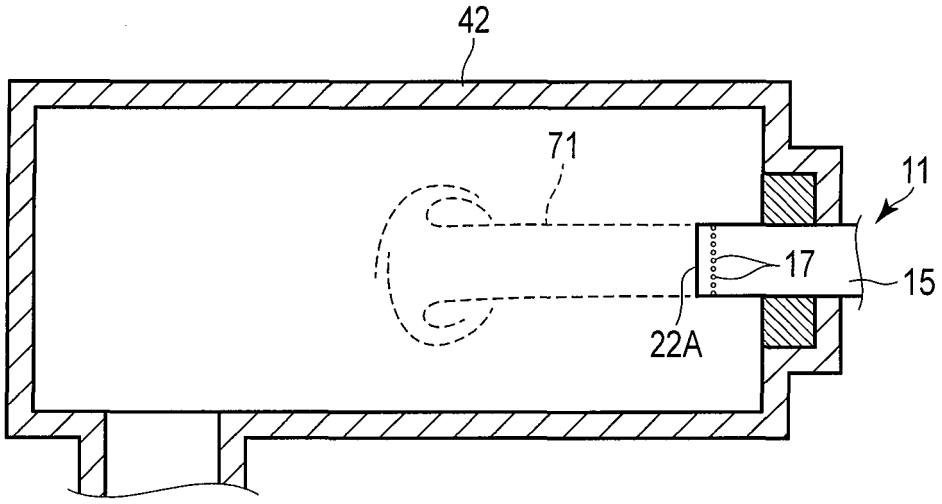
42
71
11
17
15
22A

FIG. 19

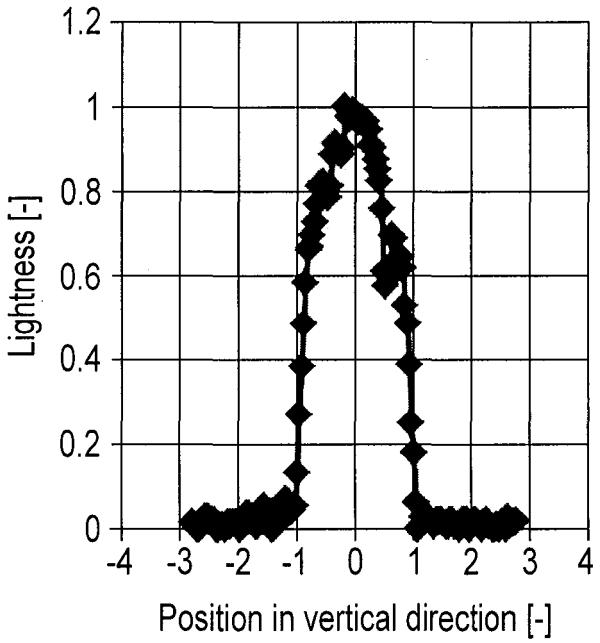
1.2
1
0.8
0.6
0.4
0.2
0
Lightness [-]
-4
-3
-2
-1
0
1
2
3
4
Position in vertical direction [-]

FIG. 20

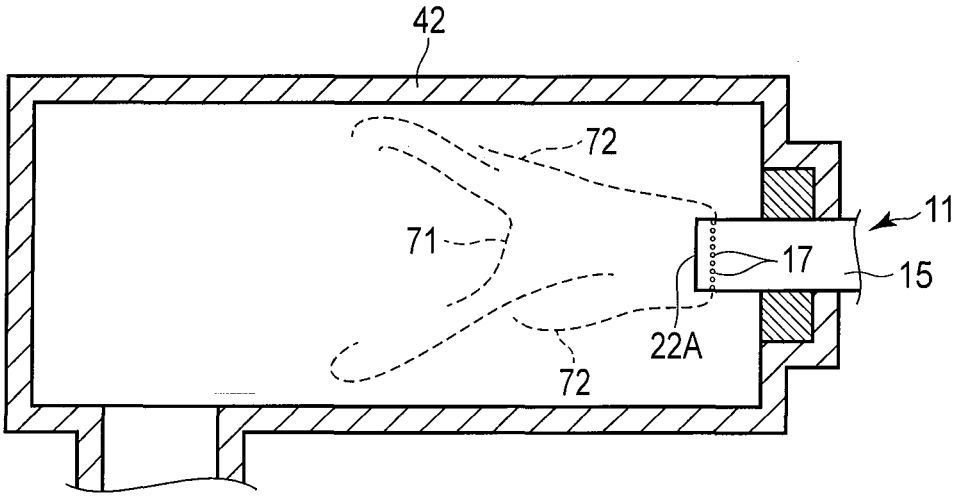
42
72
71
11
17
15
22A
72

FIG. 21

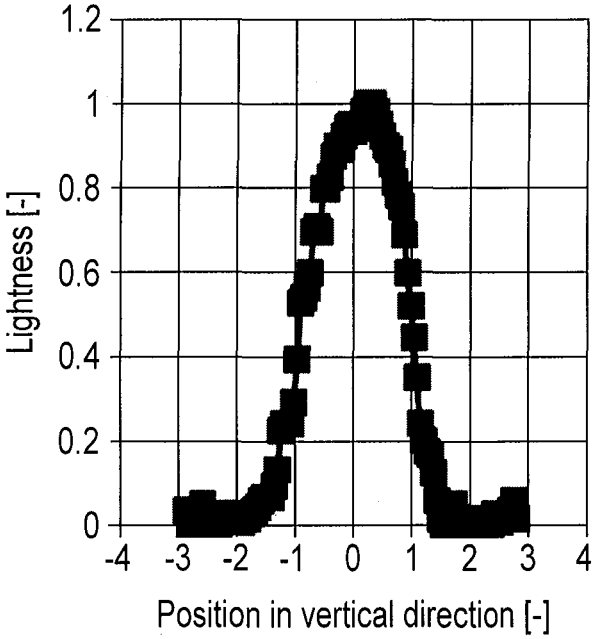
1.2
1
0.8
0.6
0.4
0.2
0
Lightness [-]
-4
-3
-2
-1
0
1
2
3
4
Position in vertical direction [-]

FIG. 22

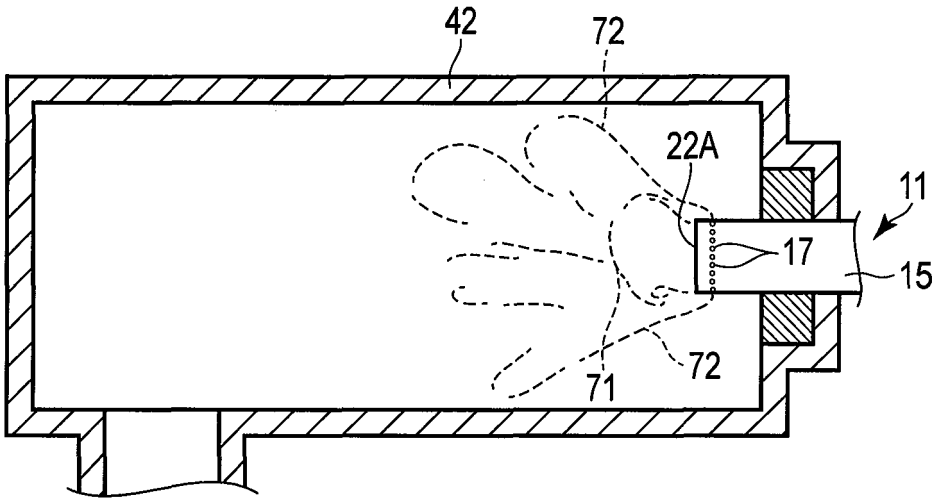
42
72
22A
11
17
15
72
71

FIG. 23

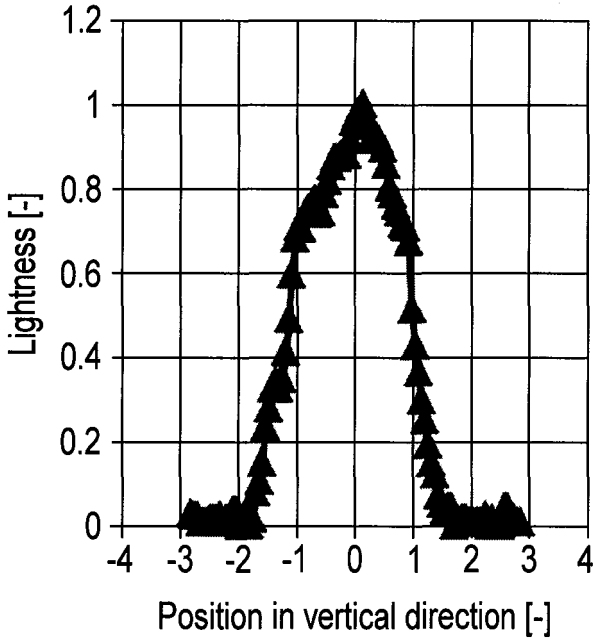
1.2
1
0.8
0.6
0.4
0.2
0
Lightness [-]
-4
-3
-2
-1
0
1
2
3
4
Position in vertical direction [-]

FIG. 24

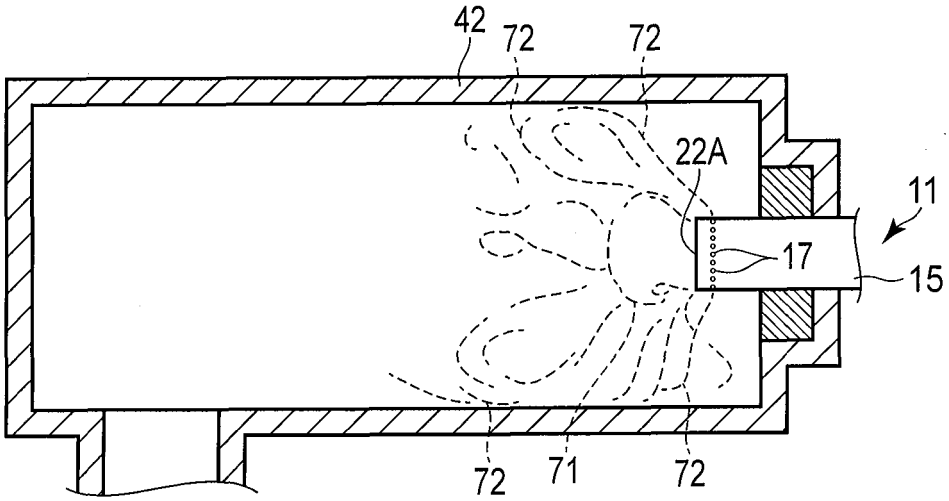
42
72
72
22A
11
17
15
72
71
72

FIG. 25

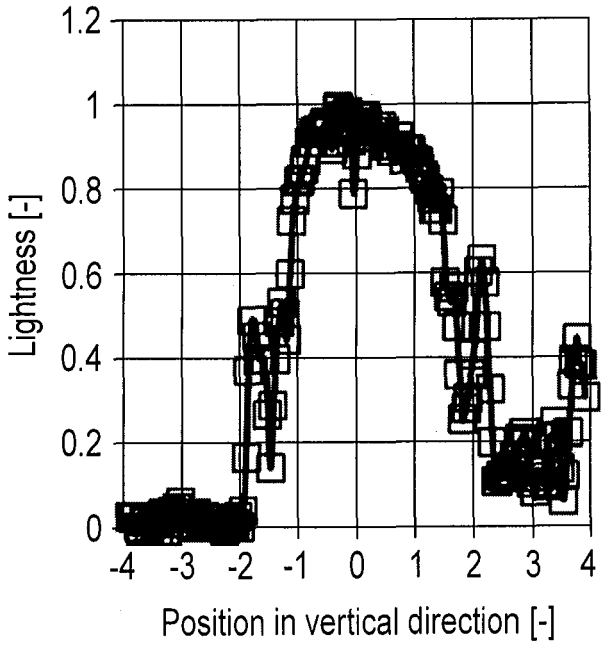
1.2
1
0.8
0.6
0.4
0.2
0
Lightness [-]
-4
-3
-2
-1
0
1
2
3
4
Position in vertical direction [-]

FIG. 26

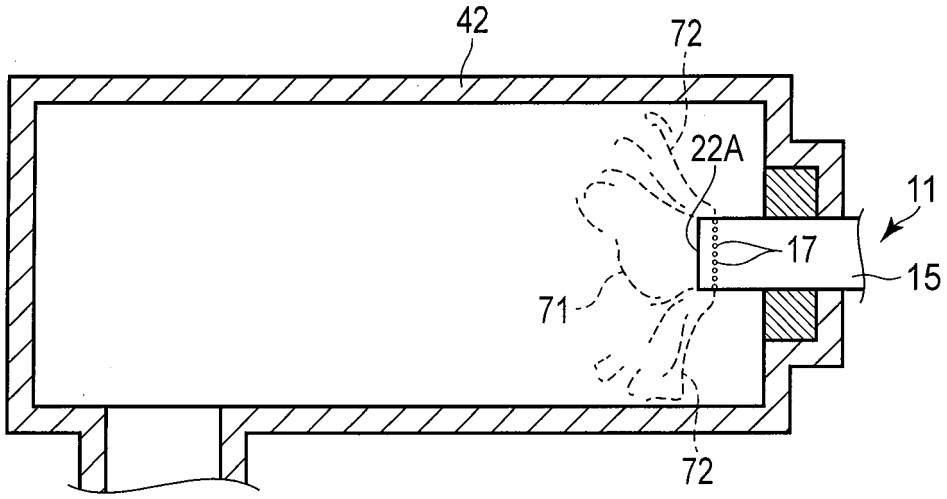
42
72
22A
11
17
15
71
72

FIG. 27

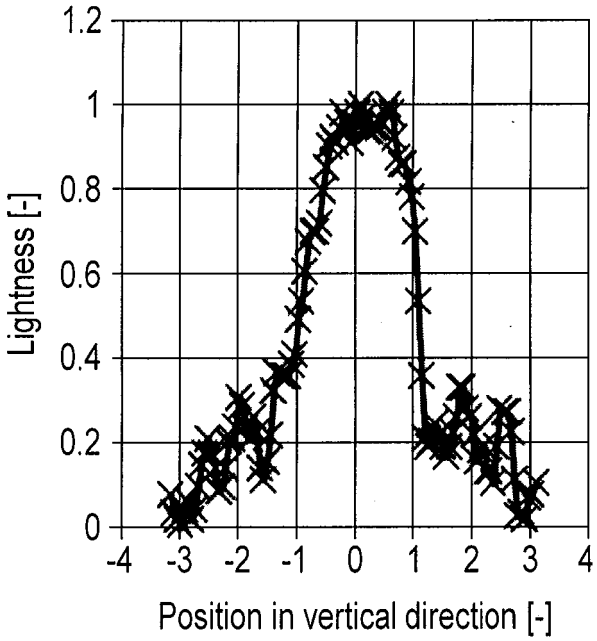
1.2
1
0.8
0.6
0.4
0.2
0
Lightness [-]
-4
-3
-2
-1
0
1
2
3
4
Position in vertical direction [-]

FIG. 28

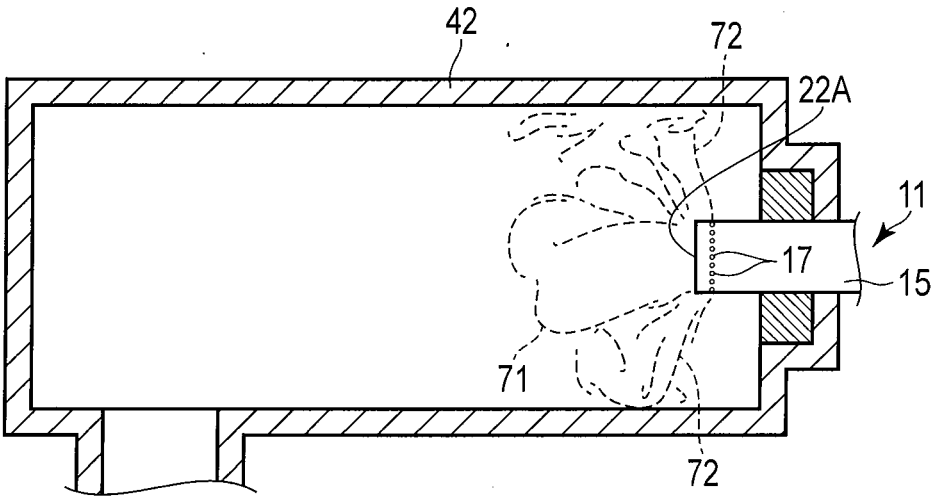
42
72
22A
11
17
15
71
72

FIG. 29

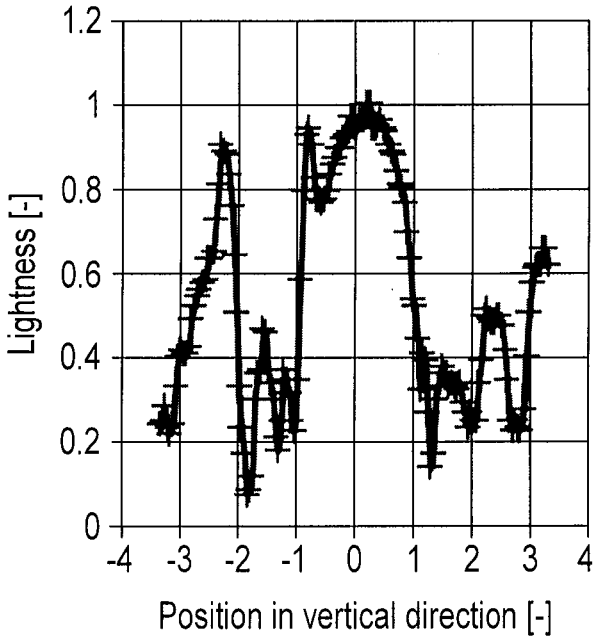
1.2
1
0.8
0.6
0.4
0.2
0
Lightness [-]
-4
-3
-2
-1
0
1
2
3
4
Position in vertical direction [-]

FIG. 30

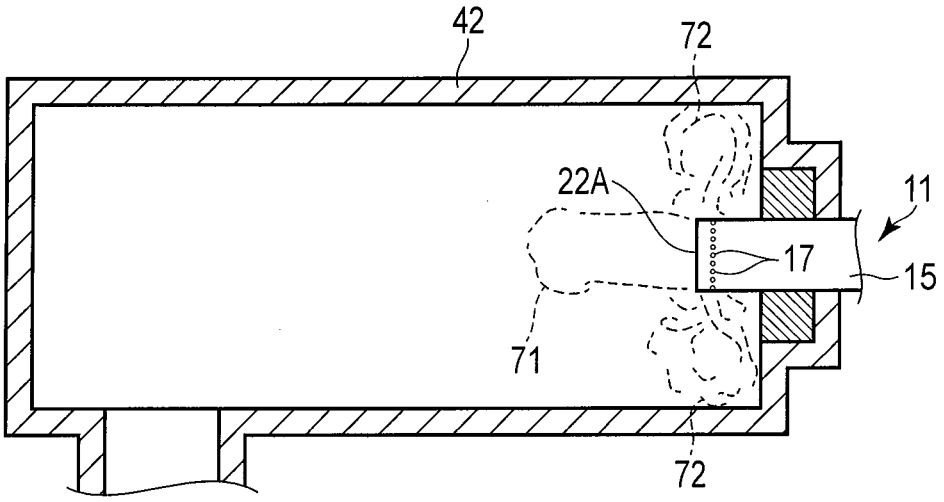
42
72
22A
11
17
15
71
72

FIG. 31

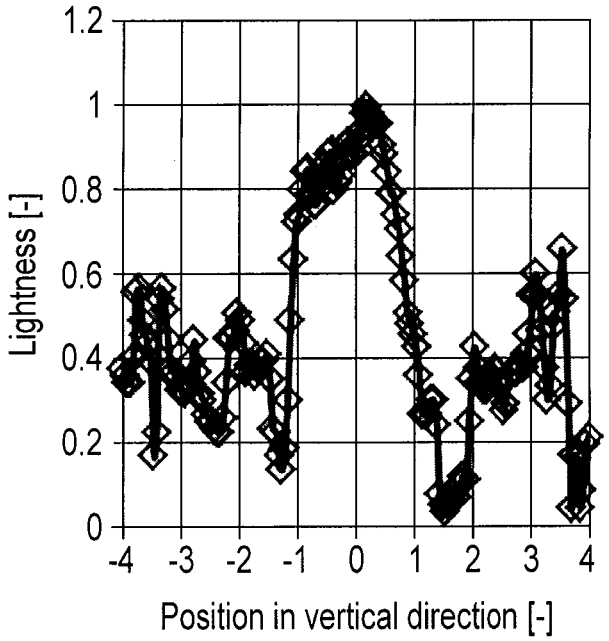
1.2
1
0.8
0.6
0.4
0.2
0
Lightness [-]
-4
-3
-2
-1
0
1
2
3
4
Position in vertical direction [-]

FIG. 32

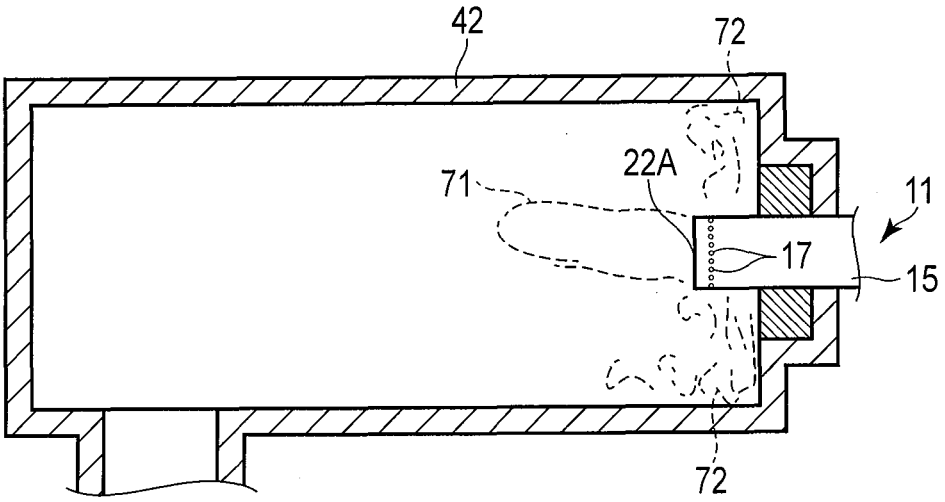
42
72
22A
71
11
17
15
72

FIG. 33

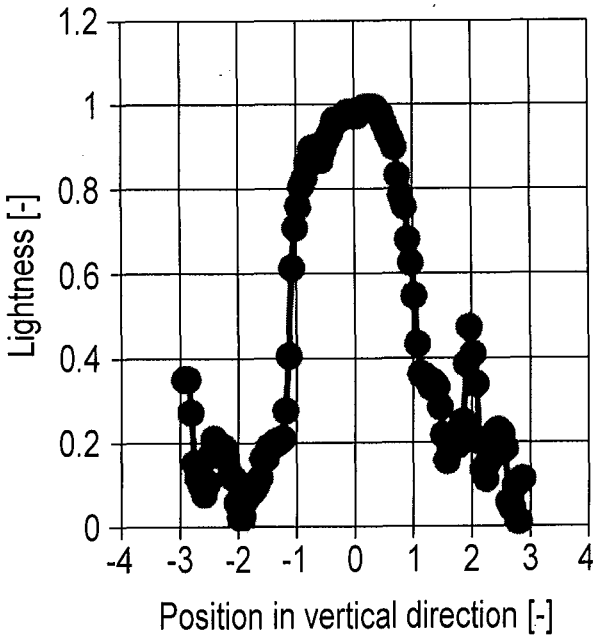
1.2
1
0.8
0.6
0.4
0.2
0
Lightness [-]
-4
-3
-2
-1
0
1
2
3
4
Position in vertical direction [-]

FIG. 34

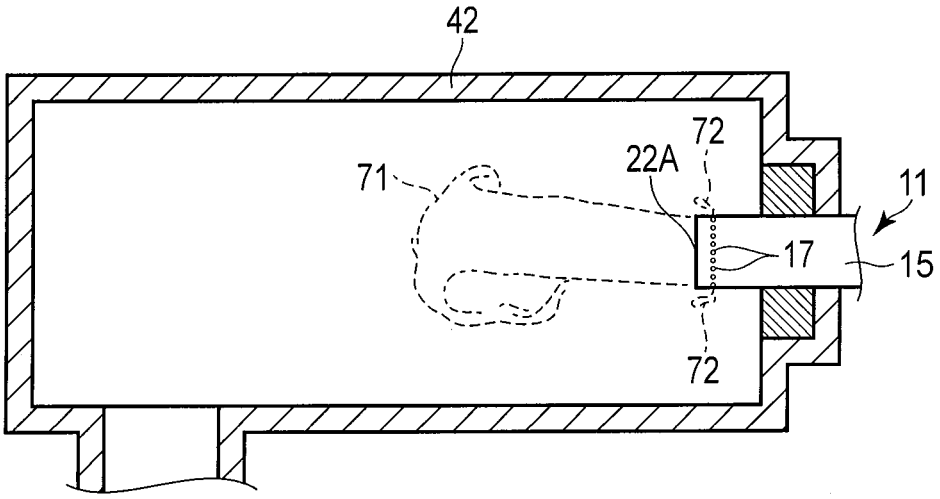

FIG. 35

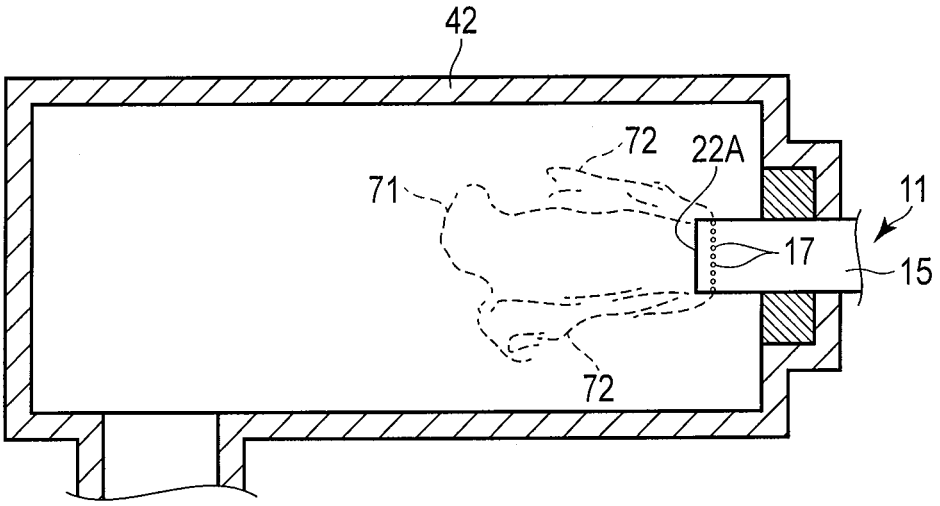

FIG. 36

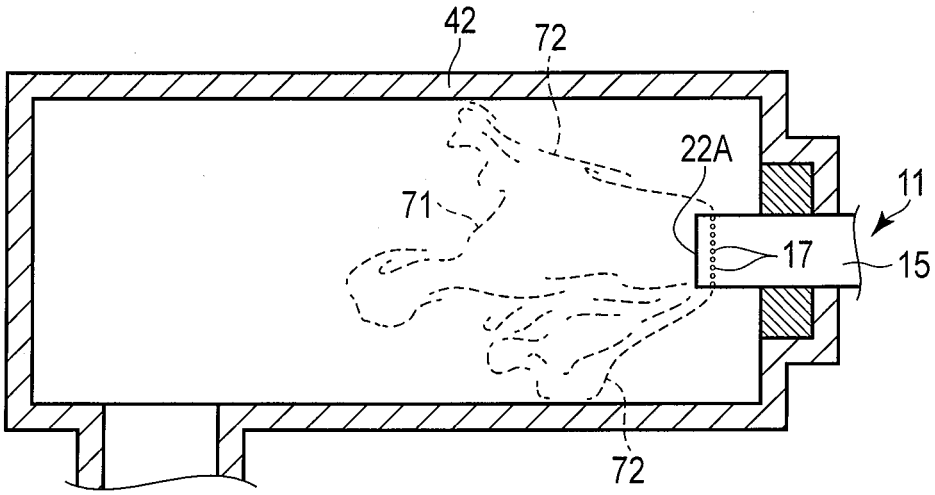

FIG. 37

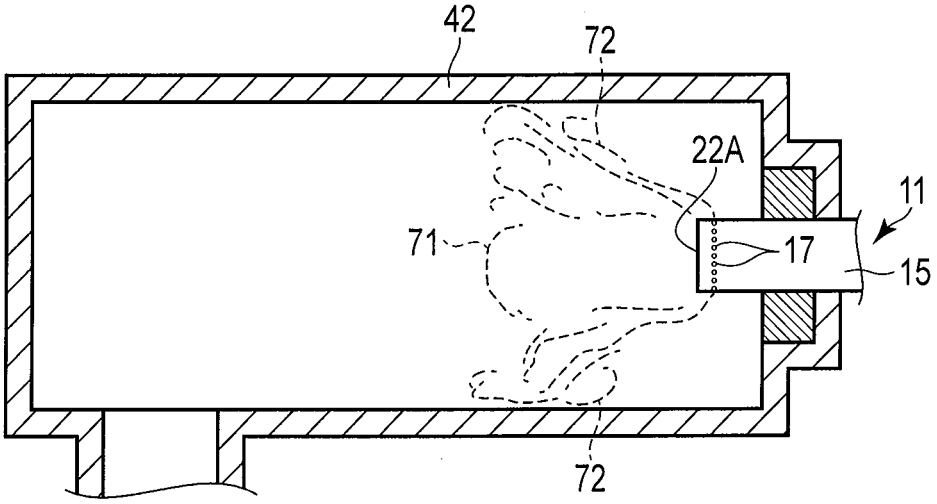

FIG. 38

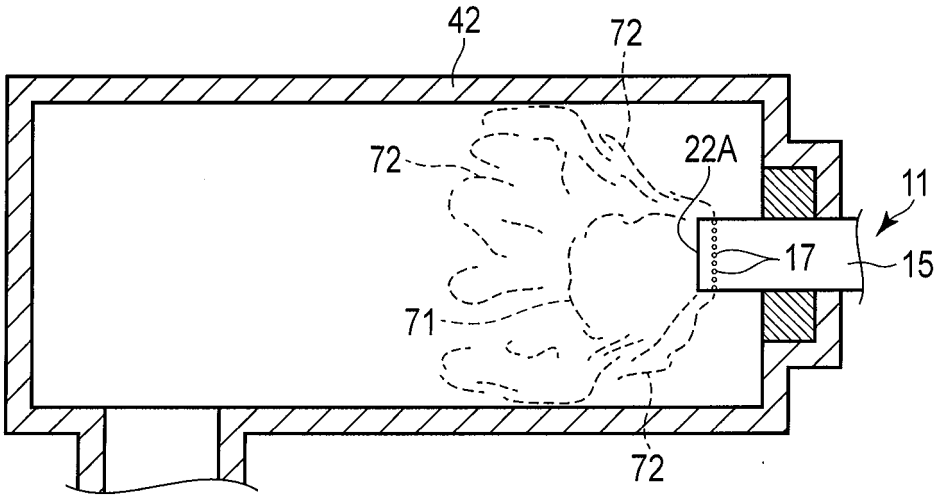

FIG. 39

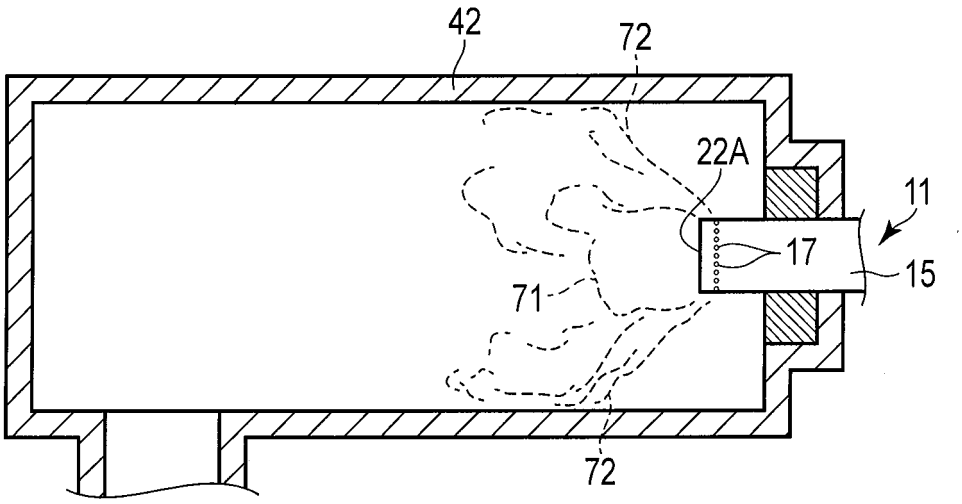

FIG. 40

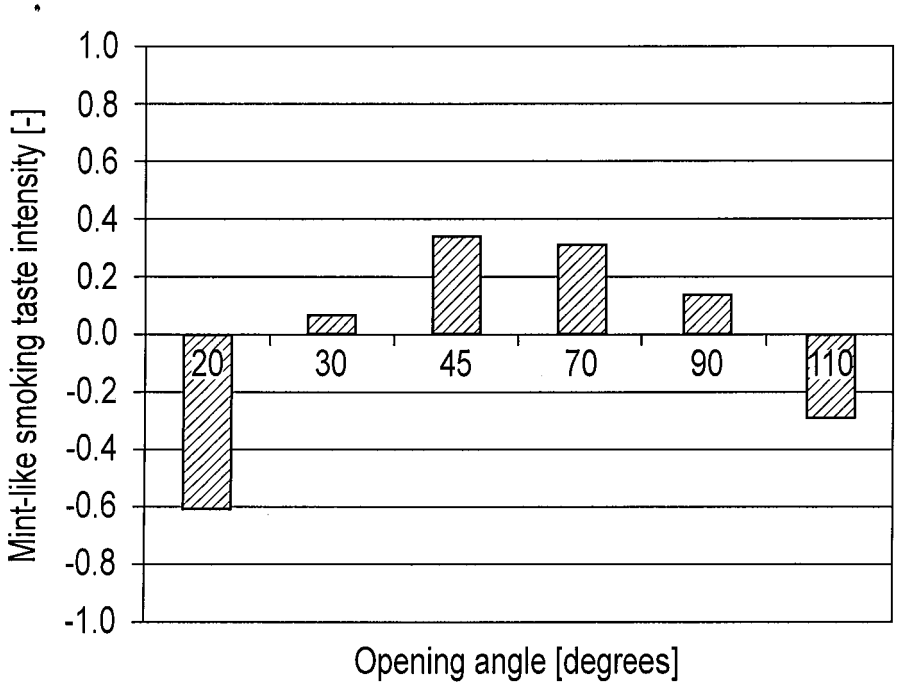

FIG. 41

Opening angle [degrees]	Mint-like smoking taste intensity [-]
20	-0.607
30	0.076
45	0.349
70	0.316
90	0.142
110	-0.292

FIG. 42

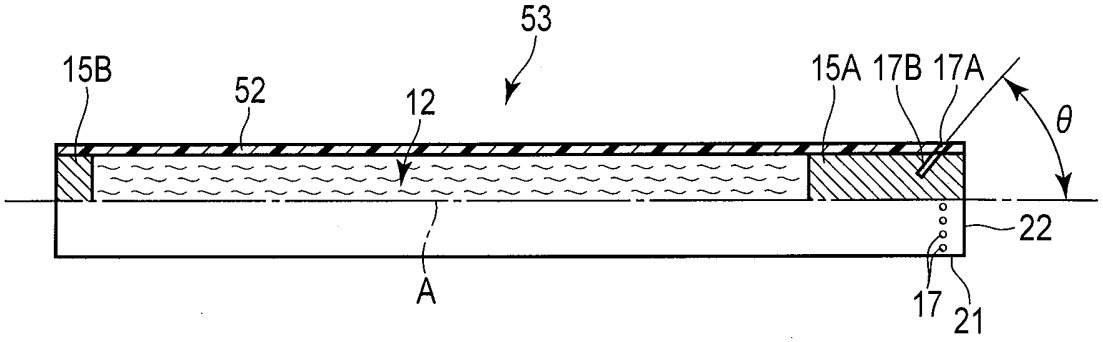

FIG. 43

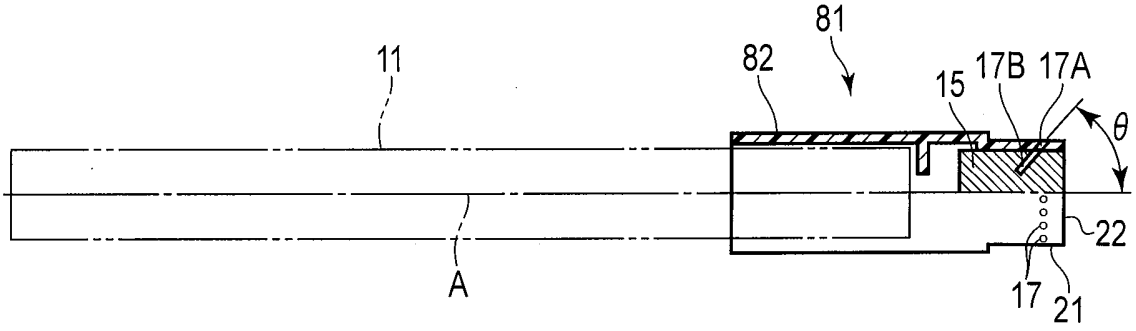

FIG. 44

LOT	Filter type				Filter length [mm]				Vf position [mm]				L [mm]	Vf [%]	Air outflow rate F_air [-]	Smoke outflow rate F_smoke [-]	R[-]
	First segment	Second segment	Third segment	Remarks	First segment	Second segment	Third segment	Total filter length	Cuts to Vf	Vf width	Vf to mouth-piece	Number of lines of Vf					
Comparative example 301	Acetate	-	-	None	30	-	-	30	15.2	2.3	12.5	4	-2.3	81.5	58.5%	4.5%	0.077
Comparative example 302	Acetate	-	-	None	27	-	-	27	14.5	0.5	12	1	-0.5	82.8	58.0%	6.9%	0.119
Comparative example 303	Acetate	-	-	None	27	-	-	27	12.1	1.7	13.2	2	-1.7	52.3	58.1%	22.8%	0.393
Comparative example 304	Acetate	-	-	None	27	-	-	27	12.9	0.2	13.9	1	-0.2	26.2	52.5%	36.8%	0.701
Comparative example 305	Acetate	-	-	None	27	-	-	27	-	-	-	0	-	0.0	57.8%	62.6%	1.084
Example 301	Acetate	Cavity	Acetate	Cavity; immediately below Vf	18	3	12	33	18.2	2.3	12.5	4	0.7	82.5	44.4%	17.2%	0.388
Example 302	Acetate	Cavity	Acetate	Cavity; immediately below Vf	19	4	11	34	19.2	2.3	12.5	4	1.7	81.5	56.8%	53.7%	0.946
Example 303	Acetate	Cavity	Acetate	Cavity; immediately below Vf	20	5	10	35	20.2	2.3	12.5	4	2.7	83.2	49.8%	46.8%	0.941
Example 304	Acetate	Cavity	Acetate	Cavity; immediately below Vf	23	12	7	42	27.2	2.3	12.5	4	9.7	83.5	59.2%	55.1%	0.931
Example 305	Acetate	Cavity	Acetate	Cavity; subsequent to Vf	25.5	8	4.5	38	23.2	2.3	12.5	4	5.7	83.5	54.9%	20.9%	0.381
Example 306	Acetate	Cavity	Acetate	Cavity; immediately below Vf	15	1	12	28	15.5	0.5	12	1	0.5	79.8	53.2%	40.0%	0.752
Example 307	Acetate	Cavity	Acetate	Cavity; immediately below Vf	15	2	12	29	16.5	0.5	12	1	1.5	80.3	58.7%	57.6%	0.982
Example 308	Acetate	Cavity	Acetate	Cavity; immediately below Vf	15	3	12	30	17.5	0.5	12	1	2.5	80.1	59.2%	59.5%	1.006
Example 309	Acetate	Cavity	Acetate	Cavity; immediately below Vf	20	12	7	39	26.5	0.5	12	1	11.5	81.8	59.8%	61.2%	1.023
Example 310	Acetate	FTF	-	String diameter 1.0mm	13	14	-	27	14.5	0.5	12	1	-0.5	73.9	68.6%	10.0%	0.145
Example 311	Acetate	FTF	-	String diameter 3.1mm	13	14	-	27	14.5	0.5	12	1	-0.5	72.8	69.9%	27.7%	0.397
Example 312	Acetate	FTF	-	String diameter 5.0mm	13	14	-	27	14.5	0.5	12	1	-0.5	76.0	77.2%	66.6%	0.862
Example 313	Acetate	FTF	Acetate	String diameter 3.1mm	13	7	7	27	14.5	0.5	12	1	-0.5	71.9	63.0%	17.0%	0.270
Example 314	Acetate	FTF	-	String diameter 3.1mm	20	7	-	27	14.5	0.5	12	1	-0.5	75.3	70.3%	22.6%	0.321

FIG. 45

LOT	Filter type				Filter length [mm]					Vf position [mm]				L [mm]	Vf [%]	Air outflow rate F_air [-]	Smoke outflow rate F_smoke [-]	R [-]
	First segment	Second segment	Third segment	Remarks	Flag length	First segment	Second segment	Third segment	Total filter length	Cuts to Vf	Vf width	Vf to mouth-piece	Number of lines of Vf					
Example 315	Acetate	Cavity	Acetate	Cavity; immediately below Vf	27	14.5	2.7	12.5	29.7	10.1	1.7	15.2	2	1.0	49.0	47.7%	26.6%	0.557
Example 338	Acetate	Cavity	Acetate	Cavity; immediately below Vf	27	13.5	1.2	13.5	28.2	12.9	0.1	14.0	1	1.1	19.6	52.1%	44.1%	0.845
Example 317	Acetate	Cavity	Acetate	Cavity; immediately below Vf	27	15.5	3.7	11.5	30.7	10.1	1.7	15.2	2	2.0	48.2	49.4%	45.1%	0.914
Example 339	Acetate	Cavity	Acetate	Cavity; immediately below Vf	27	14.5	2.2	12.5	29.2	12.9	0.1	14.0	1	2.1	18.3	52.8%	51.4%	0.972
Comparative example 308	Acetate	-	-	None	27	27.0	-	-	27.0	12.9	0.1	14.0	1	2.0	17.7	53.5%	43.5%	0.812
Example 319	Acetate	Cavity	Acetate	Cavity; subsequent to Vf	30	19.5	2	10.5	32	17.2	2.3	12.5	4	-0.3	80.2	53.0%	15.1%	0.284
Example 321	Acetate	Cavity	Acetate	Cavity; subsequent to Vf	30	25	20	5	42	5	0.25	25	1	19.8	85.8	53.0%	17.2%	0.325
Comparative example 306	Acetate	-	-	None	30	30	-	-	30	5	0.24	25	1	-0.2	83.7	53.7%	6.8%	0.128
Example 336	Acetate	Resistance portion	-	ϕ4mm	27	13	14	-	27	14.5	0.5	12	1	-	79.2	48.4%	36.6%	0.757

FIG. 46

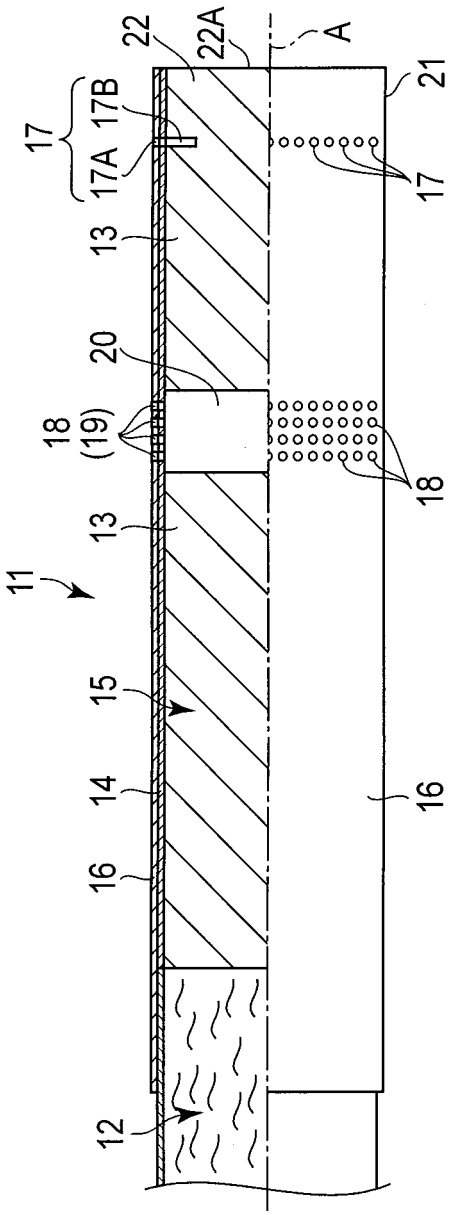

FIG. 47

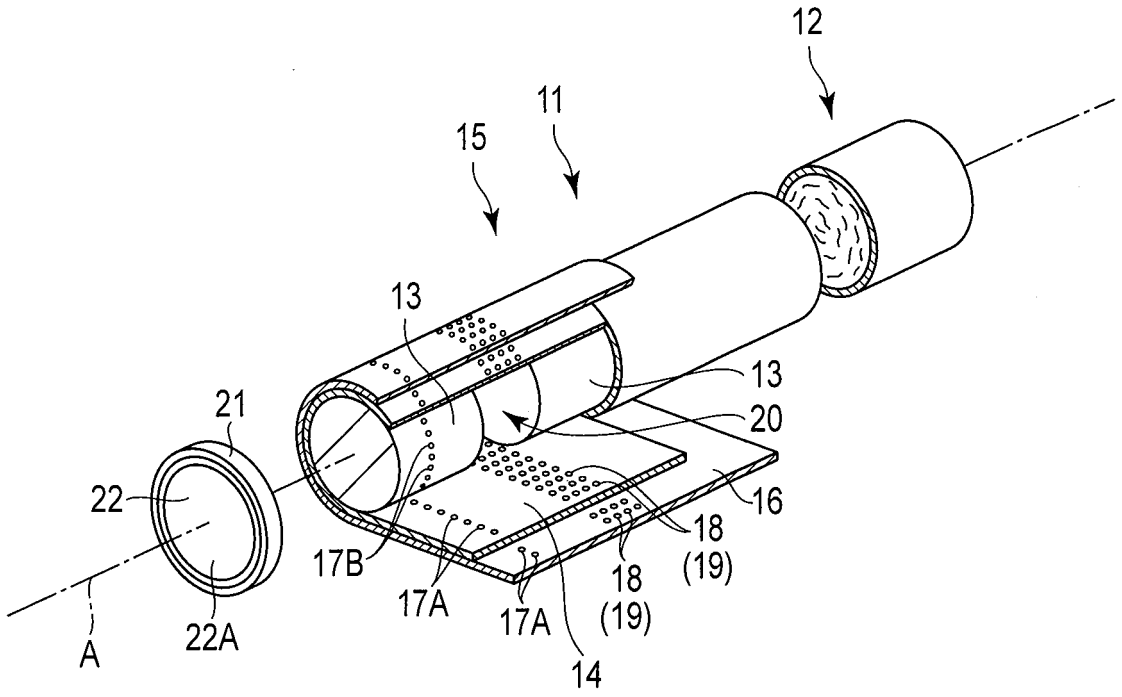

FIG. 48

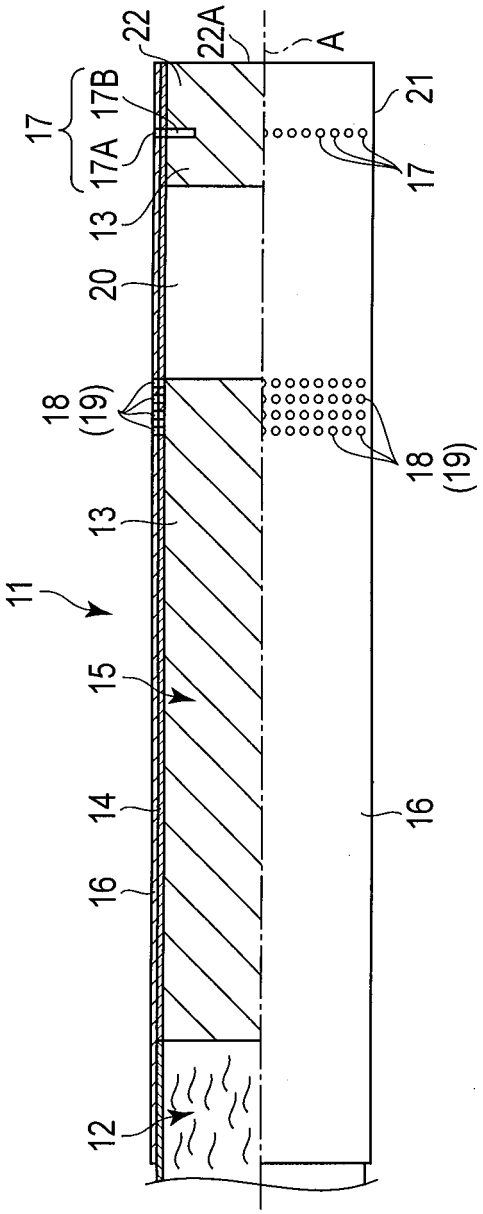

FIG. 49

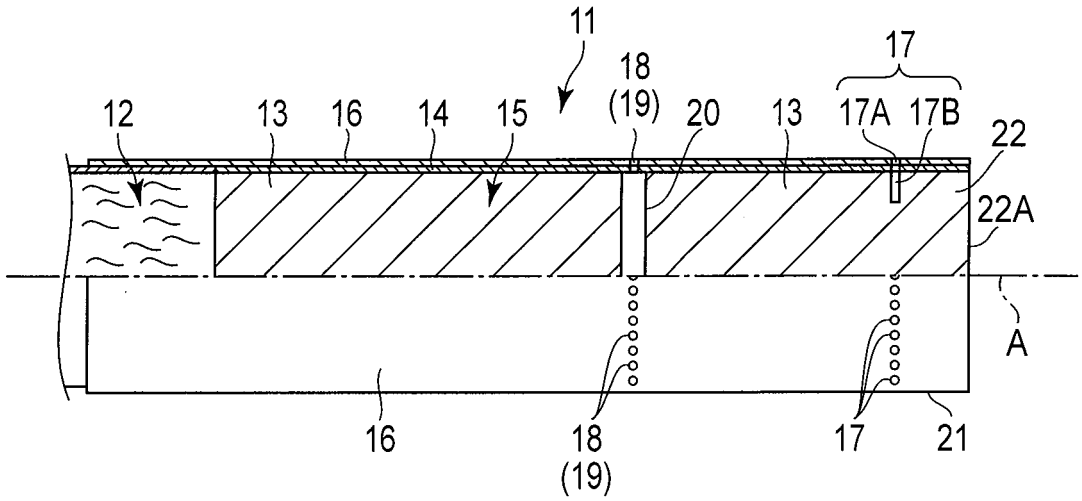
11
17
18
(19)
12
13
16
14
15
20
13
17A
17B
22
22A
A
16
18
(19)
17
21

FIG. 50

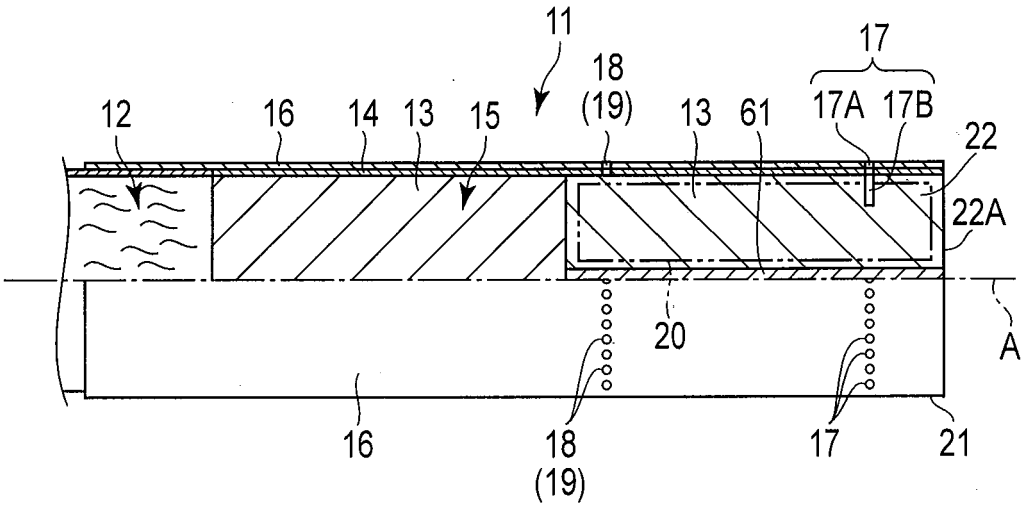
11
17
18
(19)
12
16
14
13
15
13
61
17A
17B
22
22A
20
A
16
18
(19)
17
21

FIG. 51

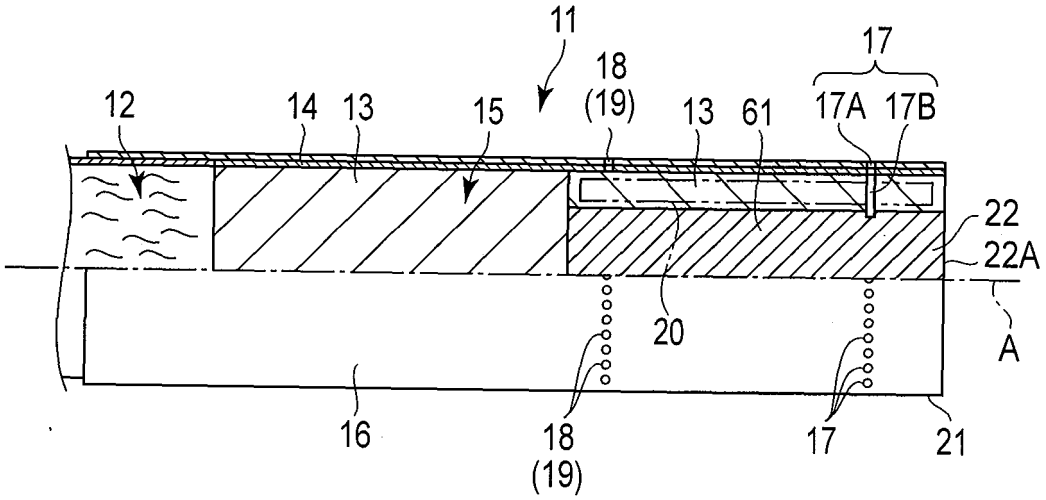
11
17
18
(19)
12
14
13
15
13
61
17A
17B
22
22A
20
A
16
18
(19)
17
21

FIG. 52

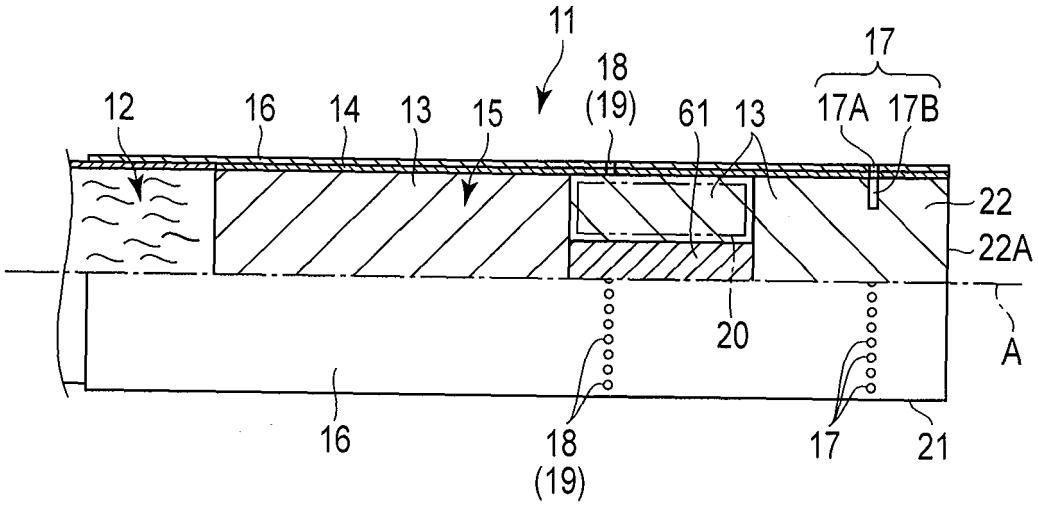
11
17
18
(19)
12
16
14
13
15
61
13
17A
17B
22
22A
20
A
16
18
(19)
17
21

FIG. 53

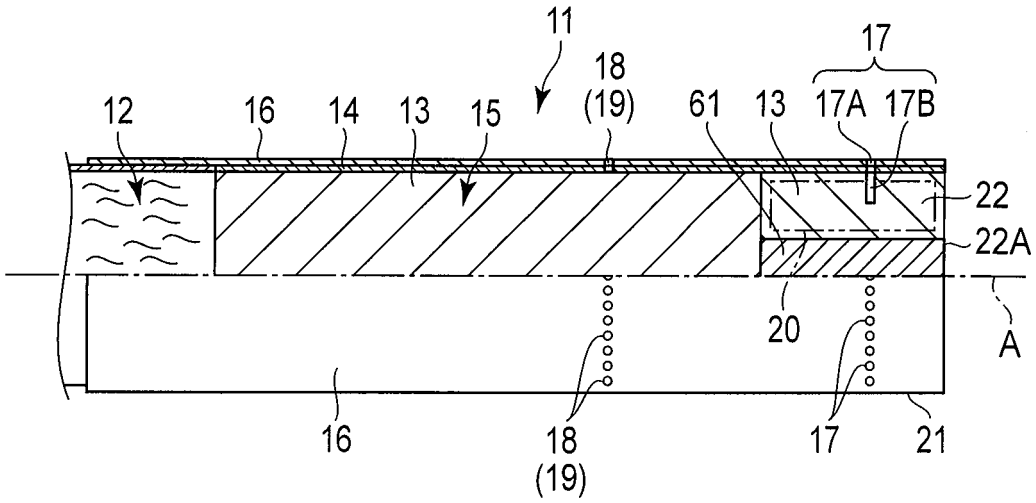
11
17
18
(19)
12
16
14
13
15
61
13
17A
17B
22
22A
20
A
16
18
(19)
17
21

FIG. 54

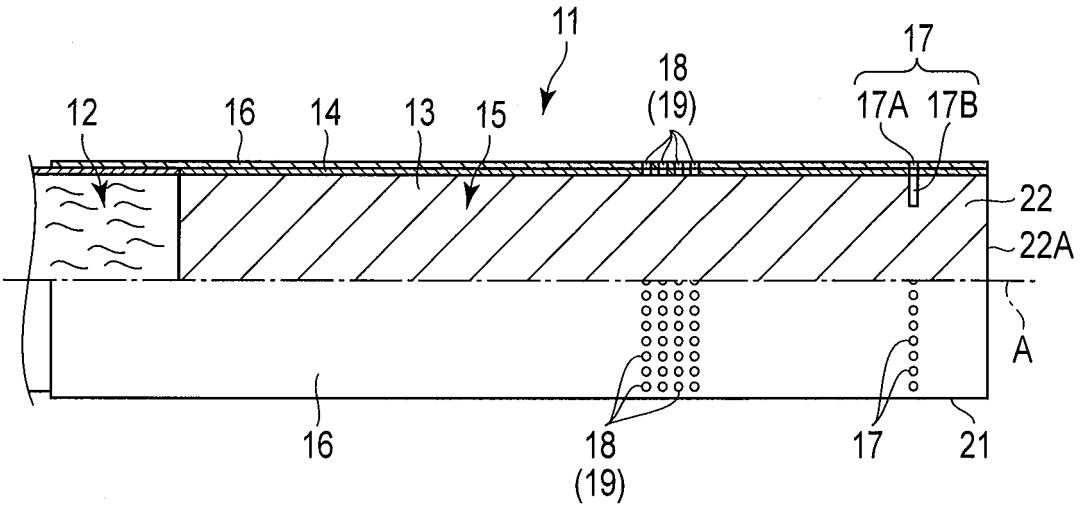
11
17
18
(19)
12
16
14
13
15
17A
17B
22
22A
A
16
18
(19)
17
21

FIG. 55

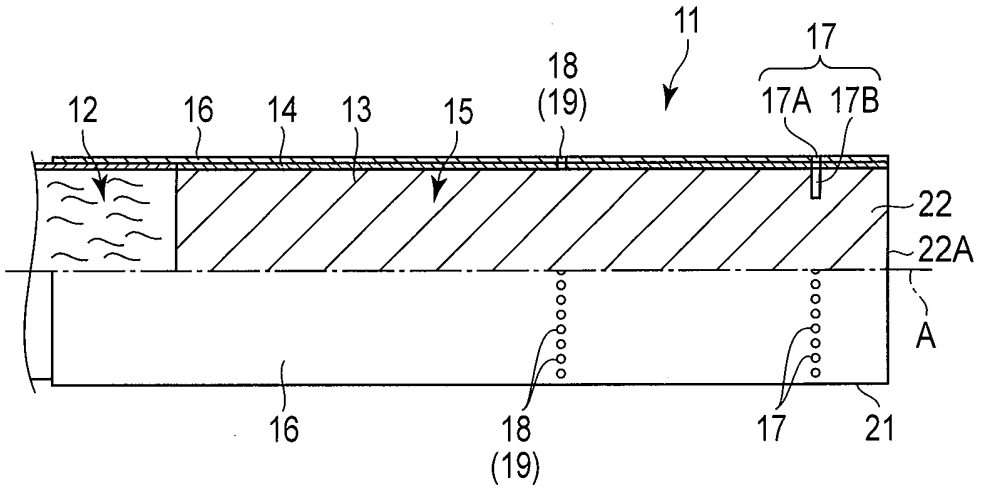
11
17
18
(19)
12
16
14
13
15
17A
17B
22
22A
A
16
18
(19)
17
21

FIG. 56

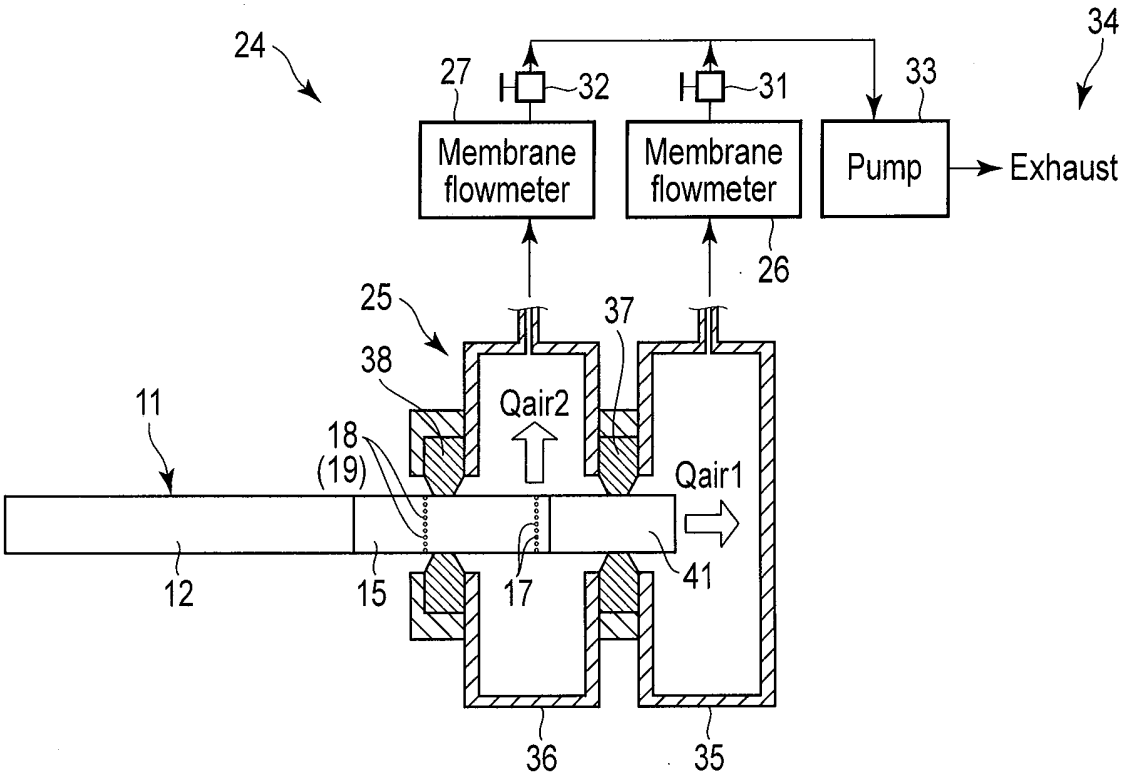
24
34
27
32
31
33
Membrane flowmeter
Membrane flowmeter
Pump
Exhaust
26
25
37
38
11
18
(19)
Qair2
Qair1
12
15
17
41
36
35

FIG. 57

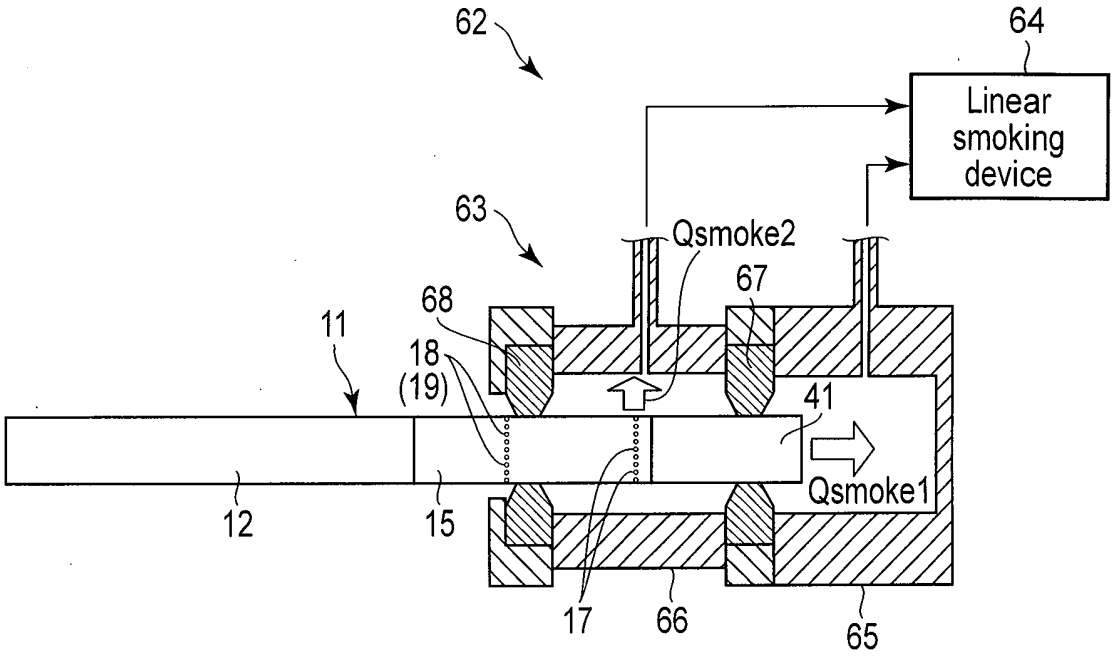
62
64
Linear smoking device
63
Qsmoke2
67
68
11
18
(19)
41
Qsmoke1
12
15
17
66
65

FIG. 58

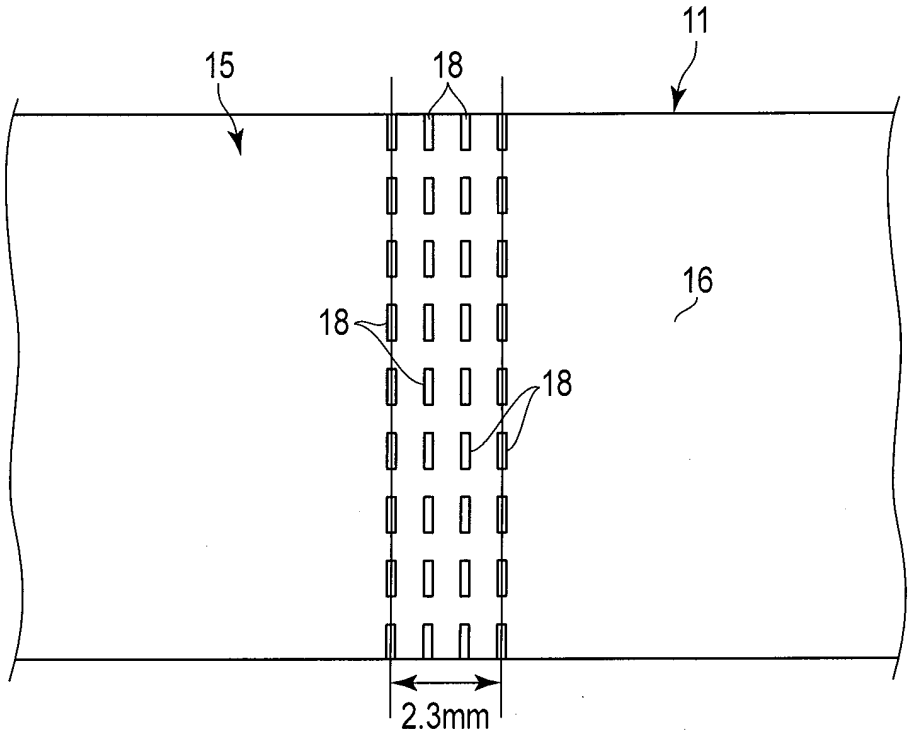

FIG. 59

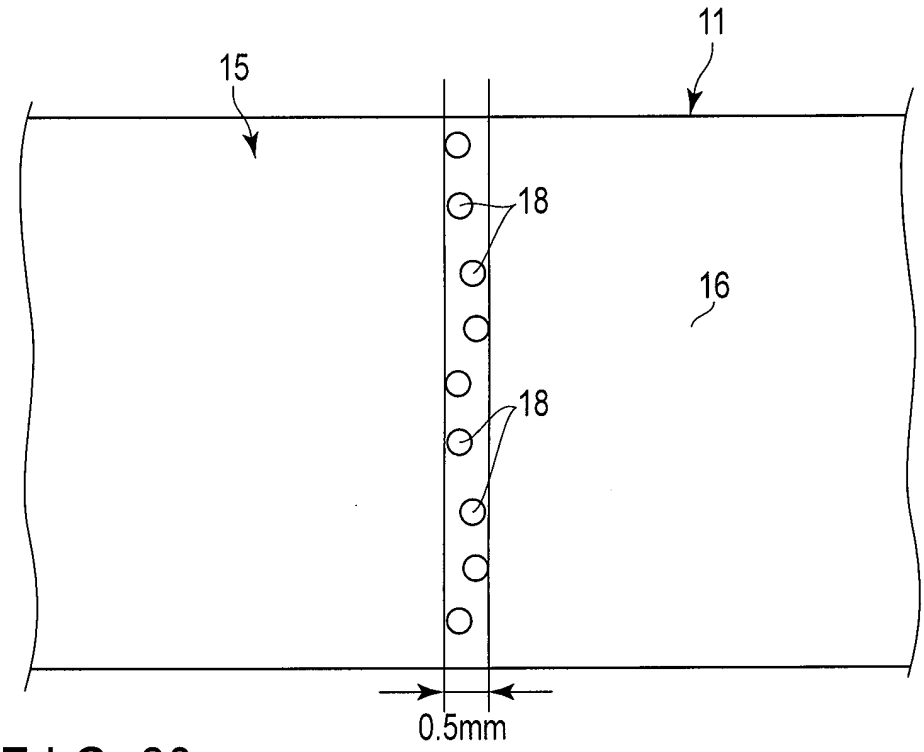

FIG. 60

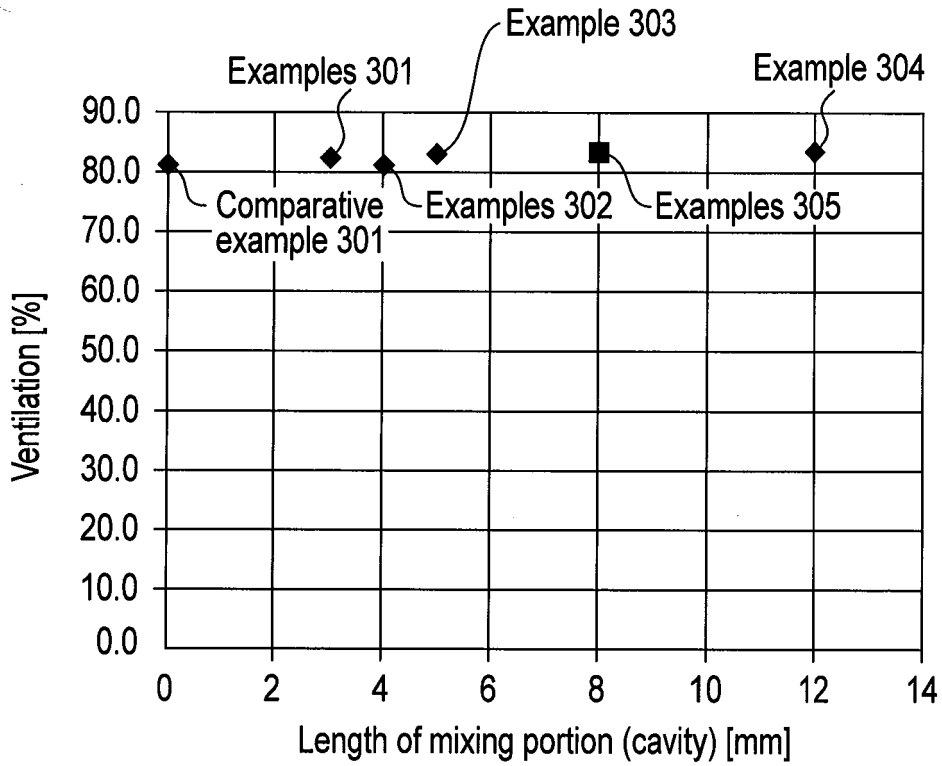
Example 303
Examples 301
Example 304
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Comparative example 301
Examples 302
Examples 305
Ventilation [%]
0
2
4
6
8
10
12
14
Length of mixing portion (cavity) [mm]

FIG. 61

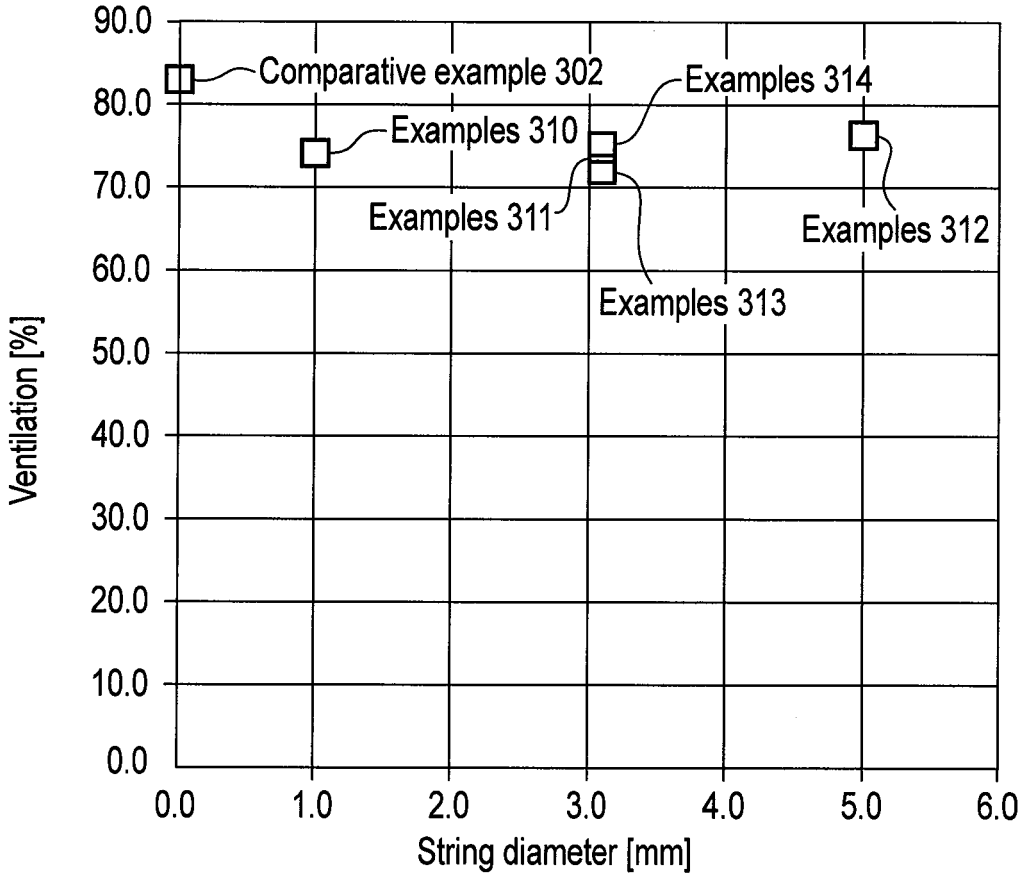
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Ventilation [%]
0.0
1.0
2.0
3.0
4.0
5.0
6.0
String diameter [mm]
Comparative example 302
Examples 310
Examples 311
Examples 313
Examples 314
Examples 312

FIG. 62

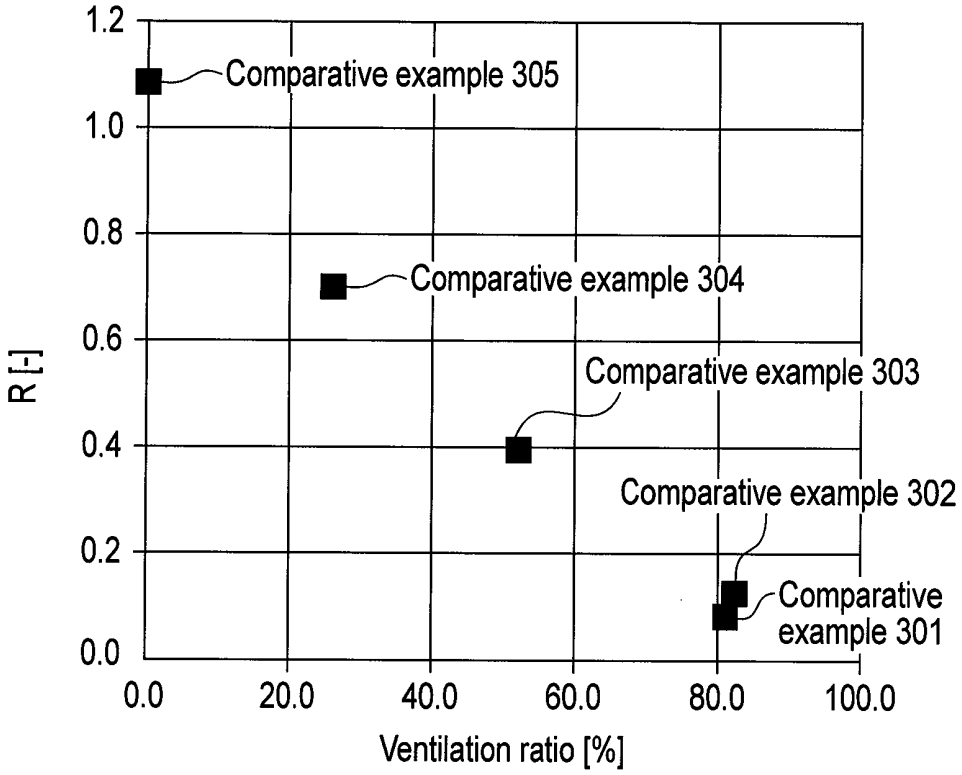
1.2
1.0
0.8
0.6
0.4
0.2
0.0
R [-]
Comparative example 305
Comparative example 304
Comparative example 303
Comparative example 302
Comparative example 301
0.0
20.0
40.0
60.0
80.0
100.0
Ventilation ratio [%]

FIG. 63

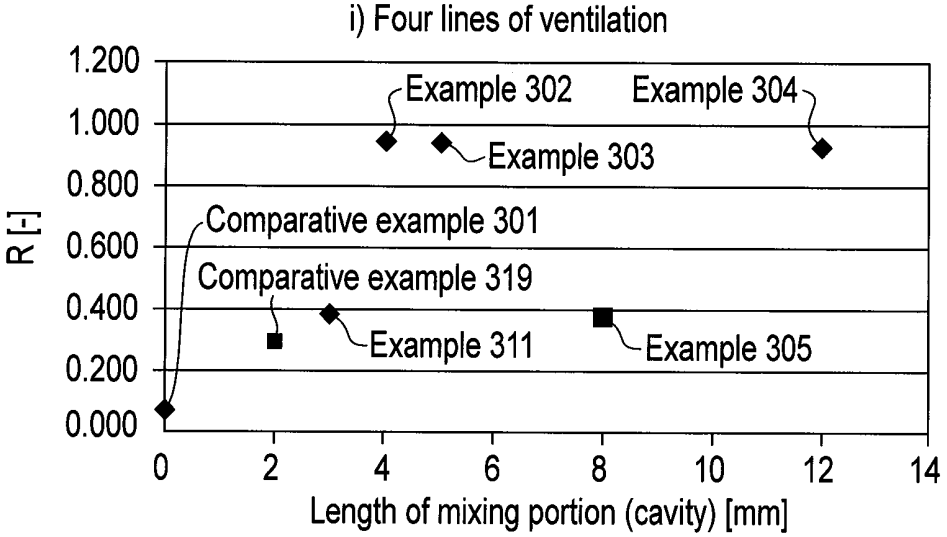
i) Four lines of ventilation
1.200
1.000
0.800
0.600
0.400
0.200
0.000
R [-]
Example 302
Example 304
Example 303
Comparative example 301
Comparative example 319
Example 311
Example 305
0
2
4
6
8
10
12
14
Length of mixing portion (cavity) [mm]

FIG. 64

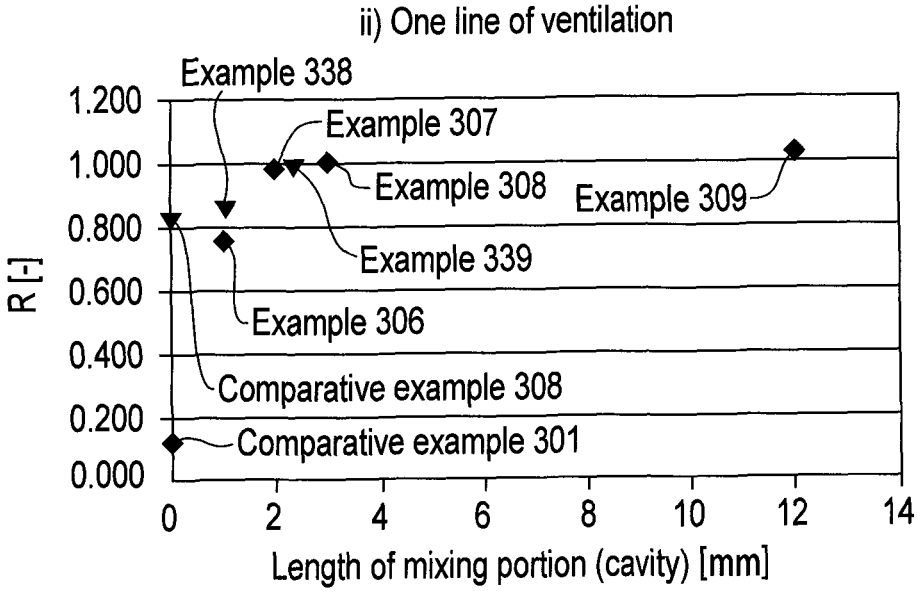
ii) One line of ventilation
Example 338
Example 307
Example 308
Example 309
Example 339
Example 306
Comparative example 308
Comparative example 301
R [-]
1.200
1.000
0.800
0.600
0.400
0.200
0.000
0
2
4
6
8
10
12
14
Length of mixing portion (cavity) [mm]

FIG. 65

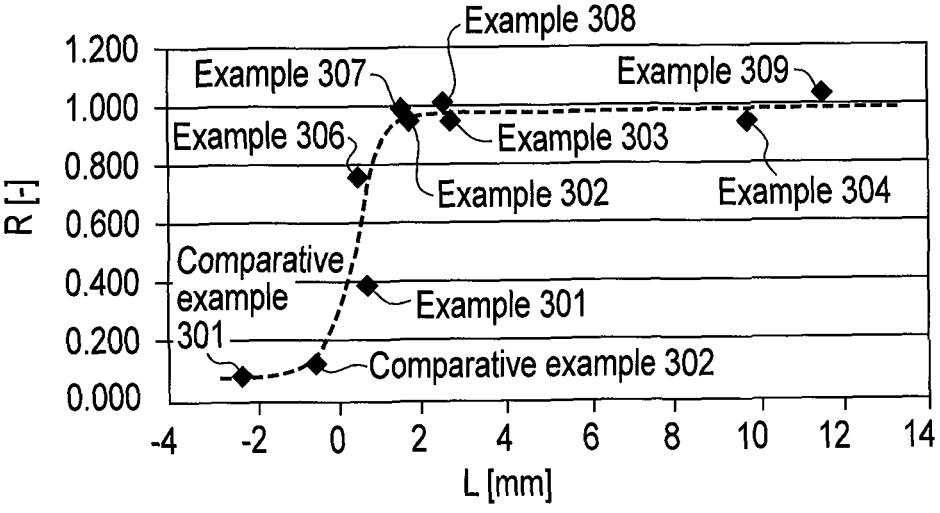
Example 308
Example 307
Example 309
Example 306
Example 303
Example 302
Example 304
Comparative example 301
Example 301
Comparative example 302
R [-]
1.200
1.000
0.800
0.600
0.400
0.200
0.000
-4
-2
0
2
4
6
8
10
12
14
L [mm]

FIG. 66

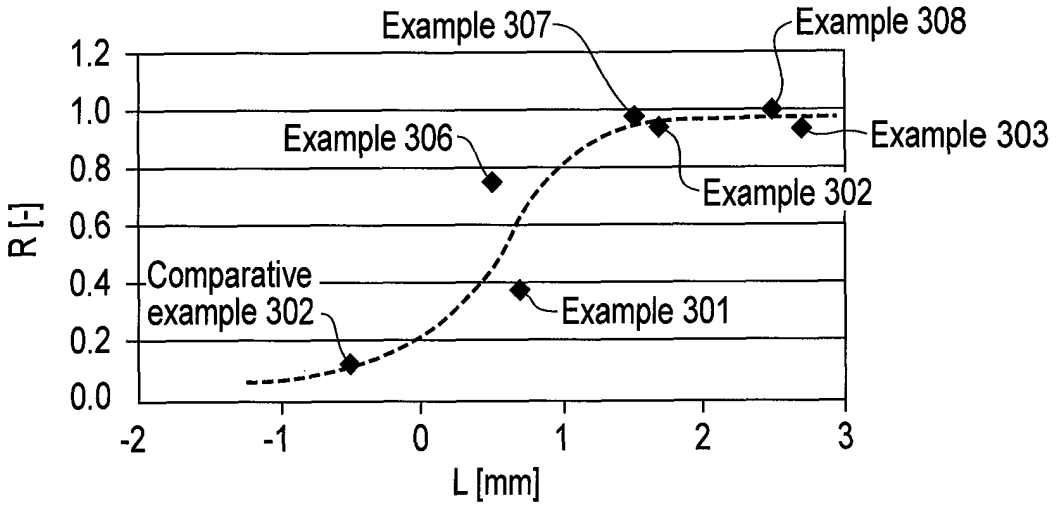
Example 307
Example 308
Example 306
Example 303
Example 302
Comparative example 302
Example 301
R [-]
L [mm]
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-2
-1
0
1
2
3

FIG. 67

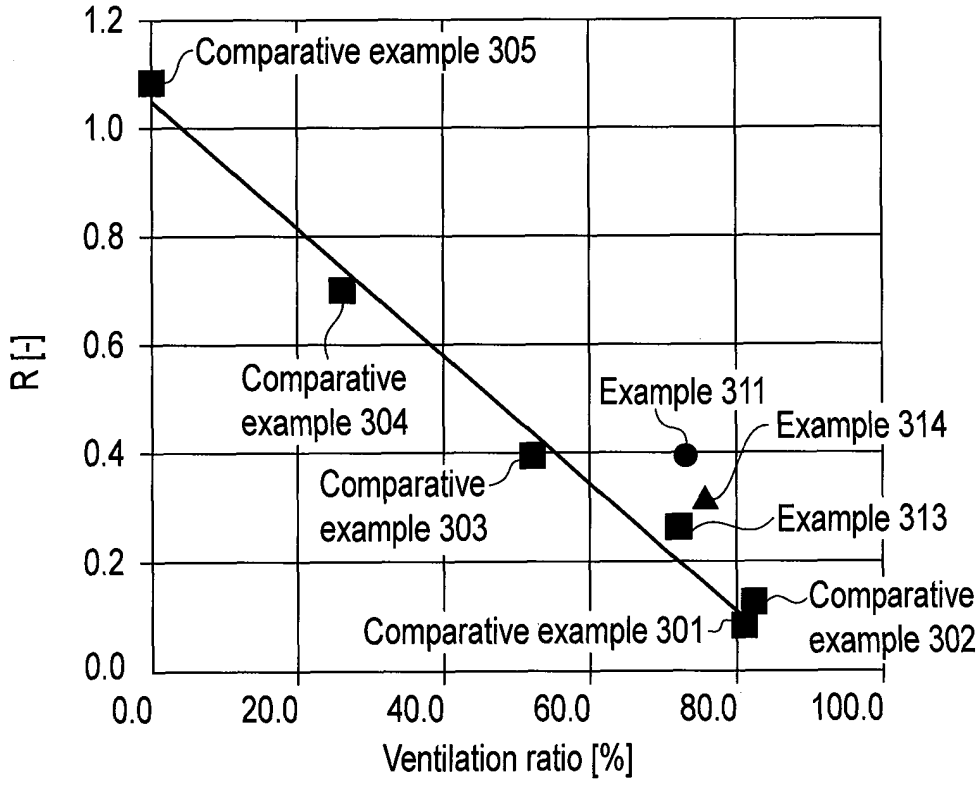
Comparative example 305
Comparative example 304
Comparative example 303
Example 311
Example 314
Example 313
Comparative example 301
Comparative example 302
R [-]
Ventilation ratio [%]
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.0
20.0
40.0
60.0
80.0
100.0

FIG. 68

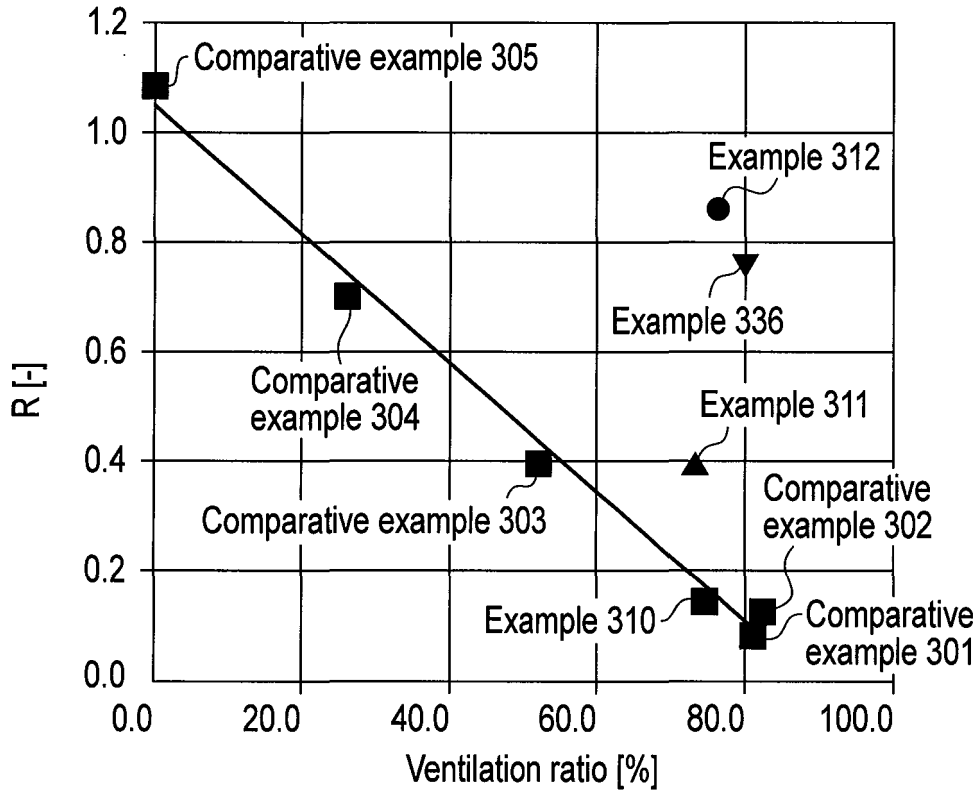
1.2
1.0
0.8
0.6
0.4
0.2
0.0
R [-]
0.0
20.0
40.0
60.0
80.0
100.0
Ventilation ratio [%]
Comparative example 305
Example 312
Example 336
Comparative example 304
Example 311
Comparative example 303
Comparative example 302
Example 310
Comparative example 301

FIG. 69

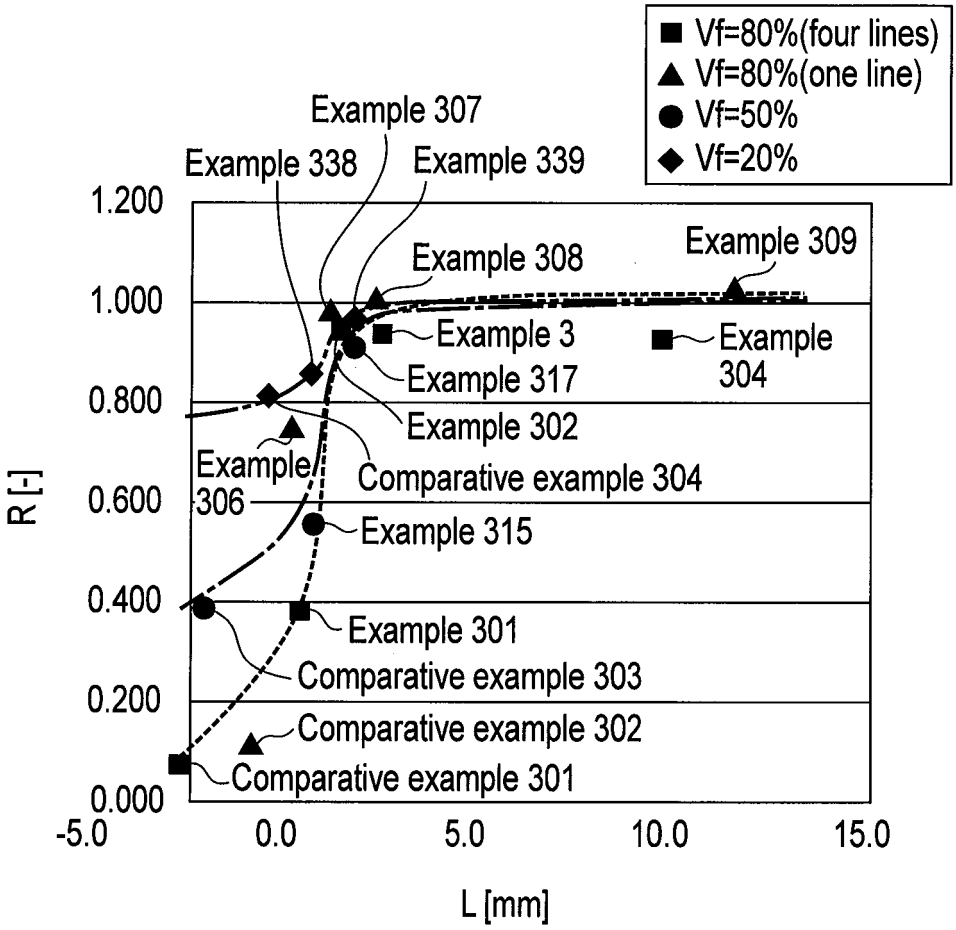
Vf=80%(four lines)
Vf=80%(one line)
Vf=50%
Vf=20%
Example 307
Example 338
Example 339
Example 308
Example 309
Example 3
Example 304
Example 317
Example 302
Example 306
Comparative example 304
Example 315
Example 301
Comparative example 303
Comparative example 302
Comparative example 301
R [-]
1.200
1.000
0.800
0.600
0.400
0.200
0.000
-5.0
0.0
5.0
10.0
15.0
L [mm]

FIG. 70

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/080905

A. CLASSIFICATION OF SUBJECT MATTER
A24D3/04(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A24D1/02, A24D3/04

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	1996-2013
Kokai Jitsuyo Shinan Koho	1971-2013	Toroku Jitsuyo Shinan Koho	1994-2013

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 04-211356 A (Gallaher Ltd.), 03 August 1992 (03.08.1992), entire text; all drawings & US 5150725 A & GB 9003248 A & GB 9003248 A0 & EP 442722 A1 & DE 69106544 C & DE 69106544 D & AT 116815 E & PT 8586 U & AU 7102591 A & ES 2067853 T & IE 910463 A & AT 116815 T & CA 2036202 A & PT 96758 A & GR 3015557 T	1-3,9-15, 21-24

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
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"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
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 February, 2013 (21.02.13)	05 March, 2013 (05.03.13)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/080905

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 031329/1983(Laid-open No. 136992/1984) (Takaaki TAKAHASHI), 12 September 1984 (12.09.1984), entire text; fig. 3 (Family: none)	1-3,9-15, 21-24
Y	JP 05-023158 A (Daicel Chemical Industries, Ltd.), 02 February 1993 (02.02.1993), fig. 1 to 2 (Family: none)	9-15
Y	JP 2011-508608 A (British American Tobacco (Investments) Ltd.), 17 March 2011 (17.03.2011), entire text; all drawings & JP 4965714 B & US 2011/0048436 A1 & GB 800216 D & GB 800216 D0 & EP 2240037 A & WO 2009/087042 A1 & AR 70114 A & AU 2008346372 A & CA 2711476 A & KR 10-2010-0101686 A & CN 101959432 A & TW 200950713 A & RU 2010132703 A	22
Y	JP 58-008071 Y2 (Nippon Senbai Kosha), 14 February 1983 (14.02.1983), entire text; all drawings & JP 56-158197 U	23
A	JP 59-102386 A (B.A.T. Cigaretten-Fabriken GmbH), 13 June 1984 (13.06.1984), entire text; all drawings & US 4621651 A & GB 2132467 A & EP 108975 A1 & DE 3362038 D & NO 834077 A & AU 2042883 A & NZ 206239 A & PT 77625 A & ES 284462 U & FI 833690 A & BR 8306221 A & CA 1210296 A & DK 515383 A & ZA 8307885 A & AU 557200 B & FI 833690 A0	1-25

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Patent documents cited in the description

- JP 59102386 A **[0003]**
- JP 4262247 B **[0023]**