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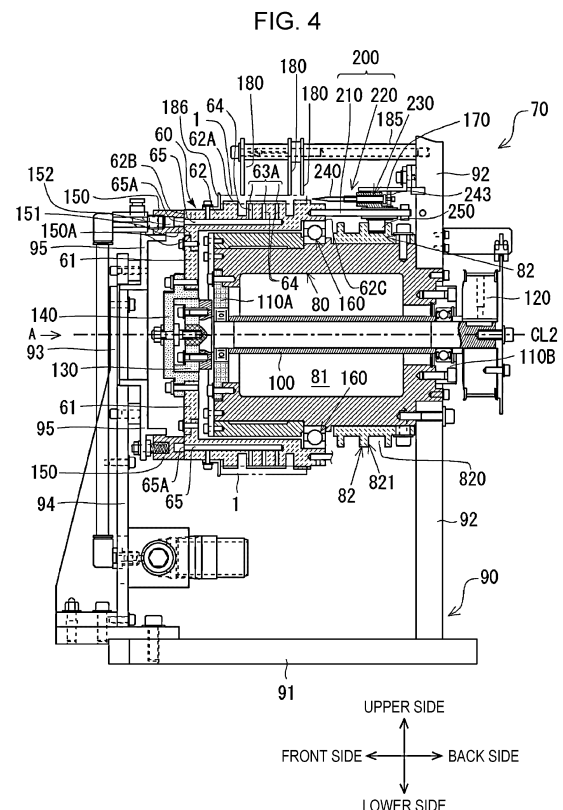
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(54) **PERFORATING DRUM DEVICE AND PERFORATION DEVICE**

(57) A technique is provided by which it is possible, in post-processing, to perforate a cavity in the tip of a tobacco rod in a heated-type tobacco product. This perforating drum is provided with a rotating drum which has a holding part that holds a heated-type tobacco product, a perforation unit which perforates the tobacco rod, and a cam which is provided on a rotating drum base part provided on the rotating drum. The perforation unit comprises a slide rod which is provided on the rotating drum, a perforating slider which has a perforation needle arranged opposite of the tip surface of the tobacco rod and which is slidably held on the slide rod, and a cam follower which is provided on the perforation slider and engages with the cam, and which allows the perforation slider to slide along the slide rod, wherein the cam has an insertion section and a withdrawal section.



Description

Technical Field

[0001] The present invention relates to a perforating drum device and a perforation device.

Background Art

[0002] A heated cigarette having a tobacco rod formed by wrapping a tobacco filler containing a tobacco raw material (for example, cut tobacco, granulated tobacco, a molded tobacco sheet) and an aerosol-source material (e.g., glycerin, propylene glycol) with wrapping paper is known. This kind of heated cigarette is combined with a heating device (heated tobacco instrument) to constitute a heated tobacco product and delivers, to a user, aerosol generated by heating the tobacco filler by an electric heater without burning the tobacco filler. As the electric heater, heaters of various shapes such as a blade shape and a rod shape are available, and to smoke or inhale, the user inserts the electric heater into the tobacco rod from a front end surface of the tobacco rod and thereby the heated cigarette is attached to the heating device.

Citation List

Patent Document

[0003]

Patent Document 1: Japanese Unexamined Patent Application Publication (Translation of PCT Application) No. 2010-514435

Patent Document 2: Japanese Unexamined Patent Application Publication (Translation of PCT Application) No. 2011-507538

Patent Document 3: Japanese Unexamined Patent Application Publication No. 11-266850

Patent Document 4: Japanese Unexamined Patent Application Publication (Translation of PCT Application) No. 2010-514438

Summary of Invention

Technical Problem

[0004] However, according to conventional heated cigarettes, insertion resistance during insertion of an electric heater into a tobacco rod from a front end surface of the tobacco rod is large. This may undesirably cause damage such as bending or curving of the electric heater during insertion into the tobacco rod (tobacco filler), push the tobacco filler forming the tobacco rod toward an inhalation side, and cause buckling distortion of the tobacco rod.

However, no production device that can perforate a front end of a tobacco rod to form a hollow for heater insertion as post-processing has been proposed yet. The "post-processing" indicates not perforating a continuous tobacco rod obtained by rod formation by a continuous-rod formation machine, but perforating a front end of a tobacco rod obtained by cutting a continuous tobacco rod.

[0005] Patent Documents 1 to 4 disclose techniques related to a device and a method for producing a continuous tobacco rod having a hollow passage extending through the rod. For example, Patent Document 1 discloses a device for producing a hollow-core continuous tobacco rod and discloses forming a hollow core at a center of a cross section of a continuous tobacco rod along an axial direction by disposing a mandrel at a portion where a hollow passage is to be formed when wrapping cut tobacco placed on wrapping paper into a rod shape by a garniture.

[0006] Patent Documents 2 to 4 disclose techniques for wrapping up a hollow pipe and cut tobacco together by a production device for forming a coaxial hollow core tobacco rod. However, all of the techniques disclosed in Patent Documents 1 to 4 are techniques for forming a hollow core extending in an axial direction of a continuous tobacco rod in advance or inserting a hollow pipe into the continuous tobacco rod in advance when producing a continuous tobacco rod. Therefore, after the continuous tobacco rod is cut into tobacco rods having a predetermined length, it is impossible to form, for example, a non-through hollow part in a front end side of the tobacco rod although it is possible to form a hollow part passing through the tobacco rod in an axial direction. To form a non-through hollow part at a front end of a tobacco rod, it is necessary to form a hollow part at the front end of the tobacco rod by post-processing, but there is no such a device. In the first place, an idea of forming a hollow part at a front end of a tobacco rod by post-processing (by perforating not a tobacco continuous body but a tobacco rod obtained by cutting the tobacco continuous body) is novel.

[0007] The present invention was accomplished in view of the above circumstances, and an object of the present invention is to provide a technique for forming a hollow part at a front end of a tobacco rod of a heated cigarette by post-processing. Solution to Problem

[0008] In order to solve the above problem, a perforating drum device for forming a hollow part in a tobacco rod of a heated cigarette includes a rotating drum part having, on an outer circumferential surface thereof, a holding part that holds the heated cigarette so that an axial direction of the tobacco rod extends along a drum rotary axis; a perforating unit that is provided on the rotating drum part and perforates a front end of the tobacco rod of the heated cigarette held in the holding part in a process of transporting the heated cigarette; and a cam part that is provided on a rotating drum base part provided beside the rotating drum part, wherein the perforating

unit has a slide rod that circles in synchronization with the rotating drum part and extends parallel with the drum rotary axis, a perforating slider that has a perforating needle part disposed on an outer circumferential side relative to the rotating drum part and is held by the slide rod so as to be slidable back and forth along an axial direction of the slide rod, and a cam follower that is provided on the perforating slider, is engaged with the cam part, and circles in accordance with rotation of the rotating drum part while being guided by the cam part, so that the perforating slider slides back and forth along the axial direction of the slide rod, and the cam part includes at least an insertion section that guides the cam follower so that the perforating needle part is inserted into the tobacco rod from the front end and an extraction section that guides the cam follower so that the perforating needle part is extracted from the tobacco rod.

[0009] The cam part may have a guide rail that extends in an arc shape about the drum rotary axis and accommodates the cam follower.

[0010] The cam part may have a guide rail that extends in an arc shape about the drum rotary axis and accommodates the cam follower.

[0011] The guide rail may be disposed in an annular manner about the drum rotary axis.

[0012] The guide rail may have a three-dimensional curved shape equally distanced from the drum rotary axis and have an inclined guide part that is at least partially inclined with respect to a virtual orthogonal surface orthogonal to the drum rotary axis; and the insertion section and the extraction section may be formed by the inclined guide part.

[0013] The inclined guide part may include at least one of a constant-speed slide region where an inclination angle with respect to the virtual orthogonal surface is constant and a variable-speed slide region where the inclination angle with respect to the virtual orthogonal surface is not constant (i.e., changes).

[0014] An inclination angle of the extraction section with respect to the virtual orthogonal surface may be smaller than an inclination angle of the insertion section with respect to the virtual orthogonal surface.

[0015] The rotating drum base part may have a cylindrical housing that is coaxial with the drum rotary axis, and the guide rail may be provided along an outer circumferential surface of the cylindrical housing.

[0016] The cam part may be configured such that the extraction section is longer than the insertion section.

[0017] The cam part may be disposed in an annular manner about the drum rotary axis and may be configured such that a second central angle ϕ_2 formed between a directional vector of a third virtual perpendicular line extending from a start position of the extraction section toward the drum rotary axis and a directional vector of a fourth virtual perpendicular line extending from an end position of the extraction section toward the drum rotary axis is larger than a first central angle ϕ_1 formed between a directional vector of a first virtual perpendicular line

extending from a start position of the insertion section toward the drum rotary axis and a directional vector of a second virtual perpendicular line extending from an end position of the insertion section toward the drum rotary axis.

[0018] The cam part may be disposed in an annular manner about the drum rotary axis and may be configured such that a first central angle ϕ_1 formed between a directional vector of a first virtual perpendicular line extending from a start position of the insertion section toward the drum rotary axis and a directional vector of a second virtual perpendicular line extending from an end position of the insertion section toward the drum rotary axis is 10° or more and 120° or less.

[0019] The cam part may be disposed in an annular manner about the drum rotary axis and may be configured such that a second central angle ϕ_2 formed between a directional vector of a third virtual perpendicular line extending from a start position of the extraction section toward the drum rotary axis and a directional vector of a fourth virtual perpendicular line extending from an end position of the extraction section toward the drum rotary axis is 10° or more and 180° or less.

[0020] The cam part may include, between the insertion section and the extraction section, an insertion state constant position section that guides the cam follower so that the perforating needle part is kept inserted into the tobacco rod by keeping the perforating slider at a constant position relative to the slide rod.

[0021] A diameter of the perforating needle part may be 3.5 mm or less.

[0022] The perforating slider may have a slider body slidably attached to the slide rod and a needle shaft part that is rotatably held by the slider body and may have the perforating needle part attached to a front end side thereof; the needle shaft part and the perforating needle part may be disposed coaxially with each other and may be rotatable about a rotary axis parallel with the drum rotary axis; and the rotating drum base part may have a guide member that extends in an arc shape about the drum rotary axis and along which a predetermined contact part of the needle shaft part slides to rotate the needle shaft part during a period where the cam follower of the perforating slider that circles in accordance with rotation of the rotating drum part is displaced in at least a part of the insertion section.

[0023] The guide member may be configured to make contact with the contact part during a period where the cam follower of the perforating slider that circles in accordance with rotation of the rotating drum part is displaced in at least a part of the extraction section.

[0024] The contact part may be an annular roller part that is coaxial and integral with the needle shaft part, and the needle shaft part may rotate due to friction generated when the roller part slides on the guide member.

[0025] The guide member may be divided into a plurality of divided guide parts, and the plurality of divided guide parts may be separated away from one another.

[0026] The holding part may be a holding groove having a recessed shape that is capable of holding the tobacco rod; and a needle axis of the perforating needle part may pass a point that is located on a straight line passing an intersection of a virtual perpendicular line extending from a groove bottom center of the holding groove toward the drum rotary axis and the drum rotary axis and passing the groove bottom center and is located outside the groove bottom center and extend parallel with the drum rotary axis.

[0027] A distance between the groove bottom center of the holding groove and the needle axis of the perforating needle part may be set equal to or less than a diameter of the tobacco rod of the heated cigarette held in the holding groove.

[0028] The rotating drum part may have a first stopper member that makes contact with an inhalation end of the heated cigarette so that the heated cigarette becomes less likely to drop off from the holding part when the perforating needle part is inserted into the front end of the tobacco rod.

[0029] The rotating drum part may have a second stopper member that makes contact with the front end of the tobacco rod so that the heated cigarette becomes less likely to drop off from the holding part when the perforating needle part is extracted from the tobacco rod.

[0030] Furthermore, the present invention can be specified as a perforation device including a plurality of perforating drum devices according to any one of the above aspects. In this case, a needle diameter of the perforating needle part provided in a perforating drum device that is located in a relatively later stage may be larger than a needle diameter of the perforating needle part provided in a perforating drum device that is located in a relatively former stage among the plurality of perforating drum devices.

[0031] A needle insertion depth dimension of the perforating needle part provided in a perforating drum device that is located in a relatively later stage may be larger than a needle insertion depth dimension of the perforating needle part provided in a perforating drum device that is located in a relatively former stage among the plurality of perforating drum devices.

[0032] Note that the means to solve the problem in the present invention can be combined as long as possible. Advantageous Effects of Invention

[0033] According to the present invention, it is possible to provide a technique that can form a hollow part in a front end of a tobacco rod of a heated cigarette in post-processing.

Brief Description of Drawings

[0034]

[Fig. 1] Fig. 1 schematically illustrates an internal structure of a heated tobacco product according to Embodiment 1.

[Fig. 2] Fig. 2 schematically illustrates a part of a drum sequence of a filter tip attachment device according to Embodiment 1.

[Fig. 3] Fig. 3 schematically illustrates a part of a perforating drum according to Embodiment 1.

[Fig. 4] Fig. 4 is a vertical cross-sectional view of a perforating drum device according to Embodiment 1.

[Fig. 5] Fig. 5 is a view viewed from a direction indicated by arrow A in Fig. 4 according to Embodiment 1.

[Fig. 6] Fig. 6 is a front view of a control ring according to Embodiment 1.

[Fig. 7] Fig. 7 is a view for explaining a detailed configuration of a perforating unit according to Embodiment 1.

[Fig. 8] Fig. 8 is a top view of the perforating unit according to Embodiment 1.

[Fig. 9] Fig. 9 is a front view of the perforating unit according to Embodiment 1.

[Fig. 10] Fig. 10 illustrates a relationship among a rotation angle of a rotating drum part, a guide rail of a cam part, and a moving trajectory of a needle front end position according to Embodiment 1.

[Fig. 11] Fig. 11 is a view for explaining a relationship between sections of the guide rail of the cam part and a virtual orthogonal surface orthogonal to a drum rotary axis.

[Fig. 12] Fig. 12 is a view for explaining a first central angle formed between a first directional vector of a first virtual perpendicular line extending from an insertion section start end of the guide rail toward the drum rotary axis and a second directional vector of a second virtual perpendicular line extending from an insertion section terminal end toward the drum rotary axis and a second central angle formed between a third directional vector of a third virtual perpendicular line extending from an extraction section start end toward the drum rotary axis and a fourth directional vector of a fourth virtual perpendicular line extending from an extraction section terminal end toward the drum rotary axis.

[Fig. 13] Fig. 13 is a view for explaining a relationship between a needle axis of a perforating needle part and a holding groove in the perforating drum device.

[Fig. 14] Fig. 14 is a view for explaining a modification of Embodiment 1.

[Fig. 15] Fig. 15 is a partially enlarged view of a second stop ring according to the modification of Embodiment 1.

[Fig. 16] Fig. 16 is a view for explaining a perforation device including a plurality of perforating drum devices incorporated into a filter tip attachment device.

Description of Embodiments

[0035] An embodiment of a perforating drum device and a perforation device according to the present invention is described with reference to the drawings. The per-

forating drum device according to the present invention is a device for forming a hollow part for heater insertion in a front end surface of a tobacco rod of a heated cigarette. Note that dimensions, materials, shapes, relative positions, and the like of constituent elements described in the present embodiment do not intend to limit the technical scope of the invention thereto unless otherwise specified.

<Embodiment 1>

[Heated Cigarette]

[0036] Fig. 1 schematically illustrates an internal structure of a heated cigarette 1 having a hollow part for heater insertion formed in a front surface of a tobacco rod by a perforating drum device according to Embodiment 1. The heated cigarette 1 is a tobacco product combined with a heating device to constitute a heated tobacco product. The heated tobacco product including the heated cigarette 1 and the heating device heats a tobacco filler of the heated cigarette by an electric heater of the heating device without burning the tobacco filler and supplies aerosol generated from the tobacco filler to a user.

[0037] The heated cigarette 1 includes a tobacco rod 2 and a filter 3 that are aligned coaxially. The heated cigarette 1 has an inhalation end 1a to be inserted into a user's mouth during use and a front end 1b opposite to the inhalation end 1a. The filter 3 has a support part 4, an aerosol cooling part 5, and a mouthpiece part 6 that are aligned coaxially, and these members are disposed in this order from a front end side of the filter 3. The support part 4, the aerosol cooling part 5, and the mouthpiece part 6 of the filter 3 are wrapped up together with wrapping paper 7. Furthermore, the tobacco rod 2 and the filter 3 are wrapped with tipping paper 8 and are thereby coupled.

[0038] When a user smokes or inhales the heated cigarette 1, air is sucked through the heated cigarette 1 from the front end 1b to the inhalation end 1a by the user. The front end 1b of the heated cigarette 1 can be grasped as a front end or an upstream end of the tobacco rod 2, and the inhalation end 1a of the heated cigarette 1 can be grasped as a back end or a downstream end of the mouthpiece part 6.

[0039] The tobacco rod 2 is disposed at the front end 1b of the heated cigarette 1. The tobacco rod 2 is a rod-shaped member including a tobacco filler 21 containing a tobacco raw material and an aerosol-source material and wrapping paper 22 that covers a side surface of the tobacco filler 21. In the present embodiment, the tobacco material contained in the tobacco filler 21 may include one or more kinds selected from among cut tobacco, granulated tobacco, and a reconstituted tobacco material.

[0040] The reconstituted tobacco material may be, for example, a reconstituted tobacco sheet shredded or crushed into granular or powdery small pieces or a re-

constituted tobacco sheet that is folded without being shredded. The reconstituted tobacco sheet is formed, for example, by mixing additives such as a binder, a gellant, a cross-linker, a perfume, and a viscosity modifier into a tobacco raw material such as homogenized tobacco and then molding the mixture into a sheet shape by using an appropriate method such as a slurry method (cast method), a papermaking method, a rolling method, or an extrusion method. The reconstituted tobacco material is, for example, formed from tobacco materials such as a tobacco stem, a tobacco leaf stalk, a leaf piece, and tobacco dust produced in a manufacturing process of a tobacco product. For example, a reconstituted tobacco material obtained by shredding or crushing a reconstituted tobacco sheet formed by a known method such as a slurry method, a papermaking method, or a rolling method into granular or powdery small pieces is known. The homogenized tobacco is, for example, a tobacco material obtained by crushing or grinding and mixing leaf tobacco, a dried tobacco leaf, cut tobacco, swollen tobacco, reproduced tobacco, and the like.

[0041] The leaf tobacco may be, for example, leaves, leaf stalks, stems, flowers, and the like of tobacco plants *Nicotiana tabacum* and *Nicotiana rustica*, which are cultivated species, or a tobacco plant *Nicotiana glauca*, which is a wild species. The dried tobacco leaf is, for example, obtained by drying the leaf tobacco. The swollen tobacco is, for example, obtained by swelling tobacco stems, leaf stalks, leaf veins, and some mesophylls, and the like by compression decompression processing. The reproduced tobacco is, for example, obtained by dissolving and filtering fragments or powder of dried leaf tobacco, cut tobacco, or swollen tobacco broken in a tobacco production process.

[0042] The binder and the gellant contained in the reconstituted tobacco slurry may contain, for example, a natural polymer, gelatin, chondroitin sulfate, polysaccharides or polysaccharide salt (e.g., alginate, carrageenan, gellan gum, guar gum, agarose, sorbitol, invert sugar, starch, dextrin, a starch decomposed product, oxidized starch). The binder may contain, for example, an inorganic salt, a calcium salt, calcium carbonate, a potassium salt, potassium carbonate, a magnesium salt, magnesium carbonate, a sodium salt, sodium carbonate, or triethyl citrate. The perfume may contain, for example, vegetable essential oil, a leaf tobacco extraction liquid, a leaf tobacco grinding liquid, menthol, synthetic perfume, natural perfume, or essential oil. The perfume may be oleophilic or may be hydrophilic. Examples of the oleophilic perfume include vanillin, ethyl vanillin, guarinalool, thymol methyl salicylate, linalool, eugenol, menthol, clove, anise, cinnamon, bergamot oil, geranium, lemon oil, spearmint, and ginger. Examples of the hydrophilic perfume include glycerin, propylene glycol, ethyl acetate, and isoamyl alcohol. The viscosity modifier may contain, for example, water, fat, fatty acid, hydrophilic solvent, alcohol, ethanol, glycerin, or propylene glycol. The reconstituted tobacco slurry may contain, for example, a

moisturizer such as water, glycerin, or propylene glycol and a reinforcing agent such as tobacco fibers, tobacco cellulose fibers, wood pulp, cellulose fibers, or non-tobacco cellulose fibers.

[0043] The reconstituted tobacco sheet may be, for example, a reconstituted tobacco sheet formed by an appropriate method such as a reconstituted tobacco slurry sheet (reconstituted tobacco cast sheet) formed by a slurry method, a reconstituted tobacco sheet formed by a papermaking method, or a reconstituted tobacco sheet formed by a rolling method. The reconstituted tobacco slurry sheet is, for example, a reconstituted tobacco sheet produced by drying and dehydrating reconstituted tobacco slurry spread on a flat plate. The reconstituted tobacco sheet formed by a papermaking method is a reconstituted tobacco sheet produced by blending pulp (cellulose fibers) with reconstituted tobacco slurry and then performing a papermaking process. The reconstituted tobacco sheet formed by a rolling method is a reconstituted tobacco sheet produced by rolling reconstituted tobacco slurry into a sheet shape by a roller or the like and then drying the sheet.

[0044] The aerosol-source material contained in the tobacco filler 21 is a substance that generates aerosol when a volatile substance that vaporizes and is released is cooled. The kind of aerosol-source material is not limited in particular, and an appropriate one can be selected from among substances extracted from various natural products according to usage. Examples of the aerosol-source material include glycerin, propylene glycol, triacetin, 1,3-butanediol, and mixtures thereof.

[0045] The support part 4 is located next to the tobacco rod 2 on a downstream side and is disposed in contact with a back end of the tobacco rod 2. The support part 4 may be, for example, a hollow cellulose acetate pipe. In other words, the support part 4 may be a columnar cellulose acetate fiber bundle having a center hole passing therethrough at a center of a cross-section thereof. Alternatively, the support part 4 may be a paper filter, a paper pipe, or the like filled with cellulose fibers. The support part 4 is an element for preventing the tobacco filler 21 from being pushed toward a downstream side toward the aerosol cooling part 5 in the heated cigarette 1 when an electric heater of a heating device to which the heated cigarette 1 is applied is inserted into the tobacco rod 2. The support part 4 also functions as a spacer for separating the aerosol cooling part 5 of the heated cigarette 1 from the tobacco rod 2.

[0046] The aerosol cooling part 5 is located next to the support part 4 on a downstream side and is disposed in contact with a back end of the support part 4. A volatile material released from the tobacco rod 2 (tobacco filler 21) when a user smokes or inhales the heated cigarette 1 flows toward a downstream side along the aerosol cooling part 5. The volatile material released from the tobacco rod 2 (tobacco filler 21) is cooled by the aerosol cooling part 5 and thereby forms aerosol to be inhaled by the user. In the form illustrated in Fig. 1, the aerosol cooling

part 5 is a hollow paper pipe having a ventilation hole 5a through which outside air can be introduced. Note, however, that the aerosol cooling part 5 may be configured not to have the ventilation hole 5a.

[0047] The mouthpiece part 6 is a segment located next to the aerosol cooling part 5 on a downstream side. The mouthpiece part 6 may be disposed in contact with a back end of the aerosol cooling part 5. In the form illustrated in Fig. 1, the mouthpiece part 6 may include, for example, a filter material formed from cellulose acetate fibers molded into a columnar shape. Alternatively, the mouthpiece part 6 may be a center-hole filter, a paper filter filled with cellulose fibers, or a paper pipe including no filtering material.

[0048] As illustrated in Fig. 1, the tobacco rod 2 (the tobacco filler 21) has a hollow part for heater insertion 23 opened on a front end surface 2a thereof. The hollow part for heater insertion 23 is a recessed part recessed along an axial direction of the tobacco rod 2 (the tobacco filler 21). The hollow part for heater insertion 23 has a cone shape whose diameter decreases from the front end surface 2a (the front end 1b) of the tobacco rod 2 (the tobacco filler 21) toward a back end side but may have a truncated cone shape whose diameter decreases from the front end surface 2a toward the back end side. The shape of the hollow part for heater insertion 23 is not limited in particular, and the hollow part for heater insertion 23 may have a shape other than a cone shape and a truncated cone shape. The sign "CL1" in Fig. 1 represents a central axis of the tobacco rod 2. The hollow part for heater insertion 23 may be coaxial with the central axis CL1 of the tobacco rod 2.

[0049] According to the heated cigarette 1 configured as above, the hollow part for heater insertion 23 in the tobacco rod 2 (the tobacco filler 21) can reduce resistance of insertion into the tobacco rod 2 (the tobacco filler 21) when the tobacco rod 2 is attached to the heating device. This can improve usability in attaching the tobacco rod 2 to the heating device (inserting the electric heater into the tobacco rod 2). Furthermore, this can suppress occurrence of breakage or the like of the electric heater and buckling distortion of the tobacco rod 2 when the electric heater is inserted into the tobacco rod 2. Furthermore, since resistance of insertion of the electric heater can be reduced by the hollow part for heater insertion 23 of the tobacco rod 2 (the tobacco filler 21), heat conduction from the electric heater to the tobacco filler 21 can be improved by bringing the tobacco filler 21 and the electric heater into close contact with each other while more suitably keeping the tobacco filler 21 from being pushed toward the support part 4 when the electric heater is inserted into the tobacco rod 2. Furthermore, when the tobacco rod 2 of the heated cigarette 1 is taken out from the heating device after smoking or inhalation, the tobacco filler 21 is less likely to come off since frictional force generated between the electric heater and the tobacco filler 21 is small. Furthermore, burn sticking of the tobacco filler 21 is less likely to occur during smoking or inhalation,

and therefore the tobacco filler 21 is less likely to come off when the tobacco rod 2 is taken out from the heating device after smoking or inhalation.

[Perforating Drum Device]

[0050] Next, a perforating drum device 70 for forming the hollow part for heater insertion 23 in the tobacco rod 2 of the heated cigarette 1 is described.

[0051] Fig. 2 schematically illustrates a part of a drum sequence of a filter tip attachment device 50 according to Embodiment 1. Figs. 3 to 10 are views for explaining the perforating drum device 70 according to Embodiment 1. The perforating drum device 70 is incorporated into the filter tip attachment device 50. The filter tip attachment device 50 is a device that receives a tobacco rod obtained by cutting a tobacco rod produced by a tobacco wrapping machine (continuous rod forming machine device) (not illustrated) and a filter rod produced by a filter production device (not illustrated) and wraps the tobacco rod and the filter rod together with a tipping material (tipping paper).

[0052] As illustrated in Fig. 2, the filter tip attachment device 50, for example, cuts a double tobacco rod DR received from the tobacco wrapping machine (not illustrated) into two single tobacco rods 2 in a transportation process using a drum or the like (not illustrated). The double tobacco rod DR is a rod-shaped member having the tobacco filler 21 wrapped with the wrapping paper 22 that is two times as long as the tobacco rod 2. Hereinafter, the single tobacco rod 2 is simply referred to as a "tobacco rod 2". The two tobacco rods 2 obtained by cutting the double tobacco rod DR are aligned so as to be spaced apart from each other in an axial direction.

[0053] The filter tip attachment device 50 has a transport drum 51 that transports a double filter rod DF. The double filter rod DF is a filter rod that is two times as long as the filter 3, and two filters 3 are obtained by cutting the double filter rod DF into halves. The double filter rod DF is transported to a hopper drum 52 by the transport drum 51.

[0054] The two tobacco rods 2 are aligned so that a space that can accommodate the filters 3 is formed between the tobacco rods 2 and are supplied to the hopper drum 52 while keeping this space. The double filter rod DF is disposed between the tobacco rods 2, and the tobacco rods 2 are aligned on the same axis as the double filter rod DF. The hopper drum 52 has a pair of floating discs (not illustrated) on both sides in a rotational direction, and the tobacco rods 2 are held between the floating discs on both sides and an interval therebetween is narrowed in the axial direction as the hopper drum 52 rotates.

[0055] The filter tip attachment device 50 continuously feeds out a web (hereinafter referred to as a "tipping paper web") TW of the tipping paper 8 wound up in a roll around a bobbin, applies glue onto one side of the tipping paper web TW, and then cuts the tipping paper web TW into pieces of tipping paper 8 each having a predeter-

mined length from a top side. The cut tipping paper 8 is fed to the hopper drum 52 and is attached onto external surfaces of the tobacco rods 2 and the double filter rod DF on the hopper drum 52. Then, the two tobacco rods 2, the double filter rod DF sandwiched between the two tobacco rods 2, and the tipping paper 8 attached on the external surfaces of the two tobacco rods 2 and the double filter rod DF are supplied to a rolling drum 53 close to the hopper drum 52.

[0056] The tobacco rods 2 and others roll on an outer circumferential surface of the rolling drum 53 as the rolling drum 53 rotates, and the tipping paper 8, which follows this rolling, is wound around the external surfaces of the double filter rod DF and the two tobacco rods 2 disposed at both ends of the double filter rod DF. When the winding of the tipping paper 8 is completed, base ends of the double filter rod DF and the tobacco rods 2 at both ends of the double filter rod DF are glued so as to be wrapped up together by the tipping paper 8. This obtains a double roll DS in which the tobacco rod 2 is connected to both sides of the double filter rod DF.

[0057] In a next step, the double roll DS is delivered from the rolling drum 53 to a checking drum 54. On the checking drum 54, a ventilation test of the double roll DS is conducted to remove defective products such as a perforated roll product with punctured wrapping paper and a product with excessive dilution. The double roll DS that has passed the ventilation test is then delivered from the checking drum 54 to a cutting drum 55. On the cutting drum 55, the double roll DS is cut into halves at a center position of the double filter rod DF by a cutting knife (not illustrated). This cuts the double roll DS into two heated cigarettes 1. At this stage, each of the heated cigarettes 1 is merely configured such that the tobacco rod 2 and the filter 3 are wrapped up together with the tipping paper 8, and the hollow part for heater insertion 23 is not formed yet at a front end of the heated cigarette 1.

[0058] The two heated cigarettes 1 obtained by cutting the double roll DS is delivered from the cutting drum 55 to a turning drum 56 and then to a perforating drum 60. The turning drum 56 has a large number of holding grooves on an outer circumferential surface thereof, and each of these holding grooves can accommodate a pair of heated cigarettes 1.

[0059] By cutting of the double roll DS, the pair of heated cigarettes 1 that face opposite sides is delivered from the cutting drum 55 to the turning drum 56. On the turning drum 56, one of the pair of heated cigarettes 1 that face opposite sides is reversed and is displaced so as to be located on the same line as the other heated cigarette 1 on an outer circumferential surface of the turning drum 56. Then, the heated cigarettes 1 are sequentially transported to the perforating drum 60. The perforating drum 60 perforates the front end surface 2a of the tobacco rod 2 to form the hollow part for heater insertion 23 described with reference to Fig. 1 in a transportation process of delivering the heated cigarette 1 received from the preceding drum to a following drum 59. The perforating drum

60 constitutes a part of the perforating drum device 70.

[0060] Fig. 3 schematically illustrates a part of the perforating drum 60 according to Embodiment 1. The perforating drum 60 has a large number of holding grooves on an outer circumferential surface thereof, and each of the holding grooves accommodates the heated cigarette 1 having the tobacco rod 2. Suction air is supplied to the holding grooves of the perforating drum 60, and thereby the heated cigarette 1 in each of the holding grooves is held in the holding groove by suction. Furthermore, the perforating drum 60 has a needle member 240 for perforation on a line extended from each of the holding grooves. The perforating drum 60 perforates the front end surface 2a of the tobacco rod 2 by inserting the needle member 240 for perforation into the front end surface 2a of the tobacco rod 2 in a process of transporting the heated cigarette 1. As a result, the heated cigarette 1 having the tobacco rod 2 having the hollow part for heater insertion 23 is obtained.

[0061] Fig. 4 is a vertical cross-sectional view of the perforating drum device 70 according to Embodiment 1. In Fig. 4, up, down, front, and back directions of the perforating drum device 70 are illustrated for convenience. The perforating drum device 70 includes the perforating drum 60, a fixed housing 80, and a frame member 90 that supports the perforating drum 60 and the fixed housing 80. The frame member 90 includes a bottom plate frame part 91, a rear frame part 92, and a front frame part 93. The rear frame part 92 and the front frame part 93 are frame members that stand on the bottom plate frame part 91 so as to extend upward from the bottom plate frame part 91.

[0062] The fixed housing 80 is an unmoving fixed member fixed to the rear frame part 92 of the frame member 90 and is provided beside the perforating drum 60. The fixed housing 80 corresponds to a rotating drum base part. Fig. 5 is a view viewed in a direction indicated by arrow A in Fig. 4. The fixed housing 80 is a substantially cylindrical housing member and is hollow inside. The sign "81" represents a hollow part of the fixed housing 80. The sign "CL2" represents a rotary axis of the perforating drum 60. In the present embodiment, the fixed housing 80 is disposed coaxially with the rotary axis (hereinafter also referred to as a "drum rotary axis") CL2 of the perforating drum 60, and a central axis of the fixed housing 80 coincides with the drum rotary axis CL2. Bearing housings 110A and 110B are attached at respective end positions of the fixed housing 80 in the axial direction, and a rotary driving shaft 100 for driving the perforating drum 60 to rotate is rotatably supported by the bearing housings 110A and 110B. A central axis of the rotary driving shaft 100 coincides with the drum rotary axis CL2. The bearing housings 110A and 110B rotatably support the rotary driving shaft 100, for example, by bearings. A timing pulley 120 is attached to a back end side of the rotary driving shaft 100. A timing belt (not illustrated) is suspended around the timing pulley 120. The timing belt is also suspended around a motor side pulley (not illustrated)

attached to a rotary shaft of a driving motor (not illustrated), and rotary output of the driving motor is transmitted to the timing pulley 120 through the timing belt, and thereby the rotary driving shaft 100 is driven to rotate.

[0063] The perforating drum 60 is a substantially cylindrical drum with a bottom and has a bottom plate part 61 and a cylindrical rotating drum part 62, which is a side circumferential wall standing on the bottom plate part 61. A plurality of holding grooves (holding parts) 63 are provided at constant intervals in a circumferential direction on an outer circumferential surface 62A of the rotating drum part 62 (see Fig. 5). Each of the holding grooves 63 is a recessed part that can accommodate the heated cigarette 1 (the tobacco rod 2) and has, for example, a semi-circular shape. Although the number of holding grooves 63 is not limited in particular, 20 holding grooves 63 are provided at constant intervals on the outer circumferential surface 62A of the rotating drum part 62 in the example illustrated in Fig. 5. The holding grooves 63 of the rotating drum part 62 extend parallel with the drum rotary axis CL2. Accordingly, each of the holding grooves 63 of the rotating drum part 62 can hold the heated cigarette 1 (the tobacco rod 2) so that the central axis CL1 of the tobacco rod 2 extends along the drum rotary axis CL2.

[0064] As illustrated in Fig. 5, each of the holding grooves 63 has, in a bottom surface thereof, a suction hole 63A for supplying suction air for sucking the heated cigarette 1 accommodated in the holding groove 63. Inside the rotating drum part 62 of the perforating drum 60, a first suction passage 64 whose one end is connected to the suction hole 63A is provided so as to extend in a radial direction of the rotating drum part 62 (see Figs. 4 and 5 and other drawings).

[0065] As illustrated in Fig. 4, each of the holding grooves 63 of the rotating drum part 62 has three suction holes 63A, and the first suction passages 64 are connected to the respective suction holes 63A. Note, however, that the number of suction holes 63A provided in each of the holding grooves 63 is not limited in particular. The rotating drum part 62 has a second suction passage 65 that is connected to the other ends of the first suction passages 64 and extends along the drum rotary axis CL2. The second suction passage 65 is opened on a front end surface 62B of the rotating drum part 62. The sign "65A" represents an opening hole where the second suction passage 65 is opened on the front end surface 62B of the rotating drum part 62. As illustrated in Fig. 5, the opening holes 65A are arranged in an annular manner at constant intervals on the front end surface 62B of the rotating drum part 62.

[0066] A disc plate 130 is integrally attached to a front end side of the rotary driving shaft 100. The disc plate 130 of the rotary driving shaft 100 is fastened integrally with an end plate 140 with use of a connecting pin. Furthermore, the end plate 140 is fastened integrally with the bottom plate part 61 of the perforating drum 60 with use of a connecting pin. As described above, the rotary

driving shaft 100 according to the present embodiment is fixed integrally with the bottom plate part 61 of the perforating drum 60 with the disc plate 130 and the end plate 140 interposed therebetween. With this configuration, when the rotary driving shaft 100 rotates, the perforating drum 60 is driven to rotate in synchronization with the rotary driving shaft 100. As illustrated in Fig. 4, a bearing 160 is interposed between an inner circumferential surface, on a back end side, of the rotating drum part 62 of the perforating drum 60 and an outer circumferential surface of the fixed housing 80, and therefore the perforating drum 60 can be driven to rotate smoothly in synchronization with the rotary driving shaft 100. In the present embodiment, a case where the perforating drum 60 is driven to rotate in counterclockwise direction when the perforating drum device 70 is viewed from a front surface side is described for convenience.

[0067] Next, a control ring 150 provided on a front side of the perforating drum 60 and the fixed housing 80 of the perforating drum device 70 is described. A front surface plate 94 is attached to the front frame part 93 of the frame member 90, and a ring holder 95 is fixed to the front surface plate 94. The control ring 150 is fixed to the ring holder 95. The control ring 150 is an annular member disposed so that a center thereof coincides with the drum rotary axis CL2, and is fixed to the ring holder 95 so that a rear surface 150A thereof faces the front end surface 62B of the rotating drum part 62 of the perforating drum 60. In the present embodiment, the perforating drum 60 is driven to rotate while the front end surface 62B of the rotating drum part 62 is in sliding contact with the rear surface 150A of the control ring 150. The control ring 150 has a suction supply channel 151 that is recessed in a groove shape in the rear surface 150A and is for supplying suction air to the second suction passages 65 of the rotating drum part 62.

[0068] Fig. 6 is a front view of the control ring 150 according to Embodiment 1. The sign "150B" in Fig. 6 represents a front surface of the control ring 150. The suction supply channel 151 is opened on the rear surface 150A of the control ring 150. The suction supply channel 151 is provided in an arc shape along a circumferential direction of the control ring 150. In the present embodiment, the suction supply channel 151 is provided along a substantially half of the circumference of the control ring 150. Note, however, that a range where the suction supply channel 151 is provided in the control ring 150 can be changed as appropriate. The sign "152" in Fig. 6 represents a suction hole for supplying a suction pressure to the second suction passages 65 of the rotating drum part 62. The suction hole 152 is opened on the front surface 150B of the control ring 150 and is communicated with the suction supply channel 151.

[0069] The sign "153" represents an atmosphere open hole that supplies an atmospheric pressure to the second suction passages 65 of the rotating drum part 62. The atmosphere open hole 153 passes through the control ring 150 from the front surface 150B to the rear surface

150A of the control ring 150 in a thickness direction and is opened to the atmosphere. The sign "154" represents a blow air supply hole that supplies blow air to the second suction passages 65 of the rotating drum part 62. The blow air supply hole 154 passes through the control ring 150 from the front surface 150B to the rear surface 150A of the control ring 150 in the thickness direction. The sign "155" in Fig. 5 represents an elbow pipe linked to the suction hole 152 of the control ring 150. The sign "156" represents an elbow pipe connected to the blow air supply hole 154 of the control ring 150. A suction pressure is supplied to the elbow pipe 155 from a suction source (not illustrated) through a tube or the like. Air for air blow is supplied to the elbow pipe 156 from an air supply source (not illustrated) through a tube or the like.

[0070] In Fig. 6, the sign "151A" represents a start end of the suction supply channel 151, and the sign "151B" represents a terminal end of the suction supply channel 151. A suction pressure is introduced into the suction supply channel 151 of the control ring 150 through the elbow pipes 155 and the suction holes 152 illustrated in Fig. 5 while the perforating drum 60 is being driven to rotate. In the present embodiment, a distance between the suction supply channel 151 of the control ring 150 and the drum rotary axis CL2 in a radial direction and a distance between the second suction passages 65 of the rotating drum part 62 and the drum rotary axis CL2 in a radial direction are set equal to each other. Accordingly, a suction pressure is supplied to the suction holes 63A of each holding groove 63 through the second suction passage 65 and the first suction passage 64 that are communicated with the suction supply channel 151 over a distance over which the second suction passage 65 of the rotating drum part 62 is communicated with the suction supply channel 151 of the control ring 150, that is, throughout a suction section from a suction start position to a suction end position illustrated in Fig. 6 while the perforating drum 60 is being driven to rotate. As a result, the suction pressure acts on the holding grooves 63 located in the suction section of the control ring 150 from the suction holes 63A.

[0071] The perforating drum 60 according to the present embodiment may be, for example, designed to receive the heated cigarette 1 from the preceding turning drum 56 when the holding groove 63 of the perforating drum 60 reach a rotation angle 0°, hold the heated cigarette 1 by suction, and deliver the heated cigarette 1 held in the holding groove 63 to the succeeding drum 59 when the holding groove 63 reaches the rotation angle 180° (see Fig. 6). In the example illustrated in Fig. 6, supply of the suction pressure to the suction holes 63A is finished when the holding groove 63 of the perforating drum 60 reaches a rotation angle 170°. After the suction holes 63A of the holding groove 63 are opened to the atmosphere, the heated cigarette 1 held in the holding groove 63 is delivered to the succeeding drum 59. Note that after the perforating drum 60 delivers the heated cigarette 1 held in the holding groove 63 by suction to

the succeeding drum 59, blow air is supplied to the suction holes 63A at a timing when the suction holes 63A of the holding groove 63 are communicated with the blow air supply hole 154 through the first suction passages 64 and the second suction passage 65. An injection pressure of this blow air is used to clean the first suction passages 64, the second suction passage 65, and the like corresponding to the holding groove 63 of the perforating drum 60. Note that the timings of the suction, opening to the atmosphere, and blow air are illustrative and can be changed as appropriate.

[0072] As illustrated in Figs. 4 and 5, the perforating drum device 70 according to the present embodiment includes a guide plate 180 that guides the heated cigarette 1 held by suction in each of the holding grooves 63 of the perforating drum 60. The guide plate 180 is supported by a stud 185 fixed to the rear frame part 92. The sign "186" in Figs. 4 and 5 represents an annular stop ring attached to the outer circumferential surface 62A of the rotating drum part 62, and the stop ring 186 is disposed on a front side relative to the holding grooves 63. The stop ring 186 is a first stopper member that has a contact surface 186A that makes contact with the inhalation end 1a (an end surface on the filter 3 side) of the heated cigarette 1 held by suction in each of the holding grooves 63 to determine a position of the heated cigarette 1 (see Fig. 7).

[0073] Next, a perforating unit 200 for perforating the tobacco rod 2 of the heated cigarette 1 held in each of the holding grooves 63 is described. As illustrated in Fig. 3, the perforating unit 200 is a unit that is provided on the rotating drum part 62 and is for perforating the front end surface of the tobacco rod 2 of the heated cigarette 1 held in each of the holding grooves 63 in a process of transporting the heated cigarette 1 (the tobacco rod 2) by the rotating drum part 62. The perforating unit 200 includes a pair of slide rods 210 provided on the rotating drum part 62 and a perforating slider 220 that is slidably held by the pair of slide rods 210 (see Fig. 3). Fig. 7 is a view for explaining a detailed configuration of the perforating unit 200. Fig. 8 is a top view of the perforating unit 200. Fig. 9 is a front view of the perforating unit 200.

[0074] The slide rods 210 protrude toward the front side from a back end surface 62C of the rotating drum part 62 so as to extend parallel with the drum rotary axis CL2. In the present embodiment, the pair of slide rods 210 are disposed so that two holding grooves 63 are included in a region sandwiched between the pair of slide rods 210 in a circumferential direction of the rotating drum part 62, and the slide rods 210 are configured to circle in synchronization with the rotating drum part 62 of the perforating drum 60.

[0075] The perforating slider 220 has a slider body 230 (see Fig. 3) slidably attached to the pair of slide rods 210 and a pair of needle members 240 attached to the slider body 230. The slider body 230 functions as a casing that holds the pair of needle members 240. The slider body 230 has a pair of rod attachment parts 231 slidably held

by the pair of slide rods 210 and a linking part 232 that links the pair of rod attachment parts 231. For example, each of the rod attachment parts 231 is slidable back and forth with respect to a corresponding slide rod 210 with a slide ball bearing or the like interposed therebetween. In this way, the slider body 230 of the perforating slider 220 is attached so as to be suspended between the pair of slide rods 210 and is slidable back and forth with respect to the pair of slide rods 210.

[0076] Furthermore, as illustrated in Fig. 3, the slider body 230 has a pair of needle holding parts 233 that hold the needle members 240. The pair of needle holding parts 233 are provided close to left and right ends of the slider body 230, respectively. Each of the needle members 240 includes a needle shaft part 241 and a perforating needle part 242 attached to a front end side of the needle shaft part 241. The needle shaft part 241 has a columnar shape. The shape of the perforating needle part 242 is not limited in particular, but the perforating needle part 242 has a front end having a pointed needle shape suitable for forming the hollow part for heater insertion 23 in the tobacco rod 2. In the present embodiment, the front end side of the perforating needle part 242 has a cone shape because the tobacco rod 2 is perforated while rotating the perforating needle part 242 when the hollow part for heater insertion 23 is formed in the tobacco rod 2, as described later. The perforating needle part 242 and the needle shaft part 241 of the needle member 240 are disposed coaxially with each other. As illustrated in Fig. 4, the perforating needle part 242 of the needle member 240 is disposed on an outer circumferential side relative to the rotating drum part 62 of the perforating drum 60.

[0077] In the present embodiment, the needle shaft part 241 of each needle member 240 is rotatably held by the needle holding part 233. A central axis (needle axis) CL3 of each needle member 240 (the needle shaft part 241 and the perforating needle part 242) is parallel with the drum rotary axis CL2 and is coaxial with the central axis CL1 of the tobacco rod 2 of the heated cigarette 1 held by suction in the holding groove 63 of the rotating drum part 62 of the perforating drum 60.

[0078] Furthermore, an annular roller part 243 (contact part) that makes contact with a roller guide 170 (see Fig. 4) is provided on a base end side of the needle shaft part 241 of each needle member 240. In the present embodiment, the roller guide 170 corresponds to a guide member. The roller part 243 is an annular member that has an outer circumferential surface having a larger external diameter than the needle shaft part 241. As illustrated in Fig. 4, the roller guide 170 is attached to the rear frame part 92 of the frame member 90. The roller guide 170 is provided in an arc shape about the drum rotary axis CL2.

[0079] As illustrated in Fig. 9, the roller guide 170 is divided into first to third roller guide parts 170A to 170C, and the roller guide parts 170A to 170C are fixed to the rear frame part 92 so as to be separated away from one another. In the present embodiment, the first to third roller

guide parts 170A to 170C correspond to a plurality of divided guide parts. Furthermore, the first to third roller guide parts 170A to 170C of the roller guide 170 have a guide surface 171 having an arc shape about the drum rotary axis CL2. When the perforating slider 220 circles in synchronization with the rotating drum part 62, the roller part 243 of the needle member 240 of the perforating slider 220 slides on the guide surface 171 of the roller guide 170 (the first to third roller guide parts 170A to 170C). Friction generated when the roller part 243 of the needle member 240 slides on the guide surface 171 of the roller guide 170 generates rotating torque for rotating the needle shaft part 241 about the central axis CL3 of the needle member 240, thereby rotating the needle member 240 about the central axis CL3. In this way, in the present embodiment, the needle member 240 can be rotated while the roller part 243 of the needle member 240 of the perforating slider 220 is in contact with the guide surface 171 of the roller guide 170.

[0080] Next, a configuration for driving the perforating slider 220 to slide along an axial direction of the slide rod 210 (i.e., along the drum rotary axis CL2) in synchronization with rotary driving of the rotating drum part 62 is described. As illustrated in Fig. 7, a cam follower 250 that is engaged with a cam part 82 provided on an outer circumferential part of the fixed housing 80 (rotating drum base part) is provided on a lower surface of the slider body 230. The cam follower 250 is disposed at a substantially central part of the slider body 230 as illustrated in Fig. 8, and the cam follower 250 protrudes from the slider body 230 toward the outer circumferential surface of the fixed housing 80 as illustrated in Fig. 7 and other drawings. The shape of the cam follower 250 is not limited in particular. In the present embodiment, the cam follower 250 has a substantially cylindrical shape.

[0081] Next, the cam part 82 provided on the outer circumferential part of the fixed housing 80 is described. As illustrated in Figs. 4 and 7 and other drawings, the cam part 82 that is engaged with the cam follower 250 provided on the perforating slider 220 is provided on the outer circumferential surface of the fixed housing 80 on a back end side. The cam part 82 may constitute the outer circumferential surface of the fixed housing 80. The cam part 82 has an arc-shaped guide rail 821 provided so that a recessed part 820 that can accommodate the cam follower 250 (in which the cam follower 250 can fit) extends in a circumferential direction of the fixed housing 80. In the present embodiment, the guide rail 821 is disposed in an annular manner about the drum rotary axis CL2. In other words, the guide rail 821 is provided throughout the entire circumference of the outer circumferential surface of the fixed housing 80. The guide rail 821 has a three-dimensional curved shape that is equally distanced from the drum rotary axis CL2. The perforating slider 220 circles about the drum rotary axis CL2 in accordance with rotary driving of the rotating drum part 62 in a state where the cam follower 250 is engaged with the guide rail 821 of the cam part 82. The cam follower

250 is guided along the guide rail 821, and thereby the perforating slider 220 can slide back and forth along the axial direction of the slide rods 210. Details of the sliding action of the perforating slider 220 will be described later.

[0082] As described above, the perforating slider 220 according to the present embodiment includes two needle members 240. Accordingly, half as many perforating sliders 220 (10 perforating sliders 220) as the holding grooves 63 provided on the rotating drum part 62 are disposed in an annular manner on the rotating drum part 62, as illustrated in Fig. 9. Note that the central axis CL3 of each needle member 240 of each perforating slider 220 is coaxial with the central axis CL1 of the heated cigarette 1 (the tobacco rod 2) held in a corresponding one of the holding grooves 63. That is, the needle member 240 is disposed coaxially with the heated cigarette 1 (the tobacco rod 2) held in a corresponding one of the holding grooves 63 provided on the rotating drum part 62, and thereby the perforating needle part 242 is disposed so as to face the front end surface 2a of the tobacco rod 2. Note that the sign "190" in Figs. 7 and 9 represents an annular ring member that links back ends of the slide rods 210 provided on the rotating drum part 62.

[0083] Next, details of the sliding action of the perforating slider 220 are described. Fig. 10 illustrates a relationship among the rotation angle of the rotating drum part 62, the guide rail 821 in the cam part 82, and a moving trajectory of a front end position (hereinafter referred to as a "needle front end position") PN of the perforating needle part 242.

[0084] As illustrated in Fig. 10, the guide rail 821 of the cam part 82 has an evacuation state constant position section R1, an insertion section R2, an insertion state constant position section R3, and an extraction section R4. The "FRONT SIDE" in Fig. 10 means a front side along the drum rotary axis CL2 and corresponds to the "FRONT SIDE" in Fig. 4. The "BACK SIDE" in Fig. 10 means a back side along the drum rotary axis CL2 and corresponds to the "BACK SIDE" in Fig. 4. The drum rotation angle illustrated in Fig. 10 corresponds to the rotation angle of the rotating drum part 62 described in Fig. 6.

[0085] As described above, the rotating drum part 62 of the perforating drum 60 transports the heated cigarette 1 while sucking the heated cigarette 1 in the holding groove 63 in a section (hereinafter also referred to as a "transport section") corresponding to rotation angles from 0° to 180°. Hereinafter, a position corresponding to a rotation angle 0°, which is a start point of the transport section, is defined as a "transport start position", and a position corresponding to a rotation angle 180°, which is a terminal point of the transport section, is defined as a "transport end position". As illustrated in Fig. 10, the evacuation state constant position section R1 and the insertion state constant position section R3 of the guide rail 821 are sections where the cam follower 250 is guided so that a position of the cam follower 250 on a displacement axis (hereinafter referred to as a "slide axis") parallel

with the drum rotary axis CL2 is not displaced irrespective of an increase in rotation angle. The insertion state constant position section R3 is located on a front side by a predetermined slide displacement amount $\delta 1$ relative to the evacuation state constant position section R1. The insertion section R2 of the guide rail 821 is a section where the cam follower 250 is guided so that the position of the cam follower 250 on the slide axis is displaced frontward in accordance with an increase in rotation angle. The extraction section R4 is a section where the cam follower 250 is guided so that the position of the cam follower 250 on the slide axis is displaced backward in accordance with an increase in rotation angle.

[0086] The guide rail 821 according to the present embodiment is formed so that a section corresponding to rotation angles of 165° to 15° of the rotating drum part 62 is the evacuation state constant position section R1, a section corresponding to rotation angles of 15° to 65° is the insertion section R2, a section corresponding to rotation angles of 65° to 115° is the insertion state constant position section R3, and a section corresponding to rotation angles of 115° to 165° is the extraction section R4. Accordingly, from the transport start position to the transport end position, the cam follower 250 is sequentially guided by the evacuation state constant position section R1 (rotation angles 0° to 15°), the insertion section R2 (rotation angles 15° to 65°), the insertion state constant position section R3 (rotation angles 65° to 115°), the extraction section R4 (rotation angle 115° to 165°), and the evacuation state constant position section R1 (rotation angle 165° to 180°) of the guide rail 821.

[0087] Note that the sign "VP" in Fig. 10 represents a virtual orthogonal surface orthogonal to the drum rotary axis CL2. Fig. 11 is a view for explaining a relationship between the sections R1 to R4 of the guide rail 821 provided in the cam part 82 and the virtual orthogonal surface VP orthogonal to the drum rotary axis CL2. As described above, the guide rail 821 has a three-dimensional curved shape that is equally distanced from the drum rotary axis CL2. As illustrated in Fig. 11, the evacuation state constant position section R1 and the insertion state constant position section R3 of the guide rail 821 are parallel guide parts 821A parallel with the virtual orthogonal surface VP. The parallel guide parts 821A of the guide rail 821 are within a virtual plane parallel with the virtual orthogonal surface VP. More specifically, assume that a first coordinate axis (the Z axis in the example illustrated in Fig. 11), which is one coordinate axis in a three-dimensional orthogonal coordinate system XYZ, is the drum rotary axis CL2, coordinates (Z coordinates), on a first coordinate axis, of the parallel guide parts 821A (the evacuation state constant position section R1 and the insertion state constant position section R3) are constant throughout all sections of the parallel guide part 821A. Meanwhile, the insertion section R2 and the extraction section R4 of the guide rail 821 are inclined guide parts 821B that are inclined with respect to (not parallel with) the virtual orthogonal surface VP. Assume that the first

coordinate axis (the Z axis in Fig. 11) in the three-dimensional orthogonal coordinate system XYZ is the drum rotary axis CL2, coordinates (Z coordinates), on the first coordinate axis (Z axis), of the inclined guide parts 821B (the insertion section R2 and the extraction section R4) are not constant (change) along a direction in which the inclined guide parts 821B extend. In the present embodiment, it is only necessary that at least parts of the guide rail 821 are the inclined guide parts 821B, and the inclined guide parts 821B form the insertion section R2 and the extraction section R4.

[0088] In the present embodiment, the perforating slider 220 in each perforating unit 200 is held by the slide rods 210 so as to be slidable back and forth along the drum rotary axis CL2. Accordingly, during circling action of the perforating unit 200 (the perforating slider 220) in synchronization with rotation of the rotating drum part 62, when the cam follower 250 guided by the guide rail 821 is displaced along the drum rotary axis CL2 (slide axis), the perforating slider 220 slides to be displaced along the drum rotary axis CL2 (slide axis) in accordance with the displacement of the cam follower 250. Since the needle member 240 is held in the perforating slider 220, when the perforating slider 220 slides to be displaced along the drum rotary axis CL2 (slide axis), the needle member 240 held in the perforating slider 220 also slides to be displaced along the drum rotary axis CL2 (slide axis). As a result, as illustrated in Fig. 10, the needle front end position PN of the perforating needle part 242 in the needle member 240 is displaced along the drum rotary axis CL2 (slide axis) so as to follow the displacement of the cam follower 250 along the drum rotary axis CL2 (slide axis).

[0089] In the present embodiment, as illustrated in Fig. 10, the needle front end position PN of the perforating needle part 242 is maintained at a position receded backward relative to the front end position of the tobacco rod 2 while the cam follower 250 is being guided by the evacuation state constant position section R1. That is, the needle front end position PN of the perforating needle part 242 is kept away from the front end surface 2a of the tobacco rod 2 while the cam follower 250 is being guided by the evacuation state constant position section R1.

[0090] Next, when an engagement position of the cam follower 250 shifts from the evacuation state constant position section R1 to the insertion section R2 of the guide rail 821, the cam follower 250 is displaced forward along the drum rotary axis CL2 (slide axis) in accordance with an increase in rotation angle. Accordingly, the needle front end position PN of the perforating needle part 242 is gradually displaced frontward along the drum rotary axis CL2 (slide axis), that is, toward the front end surface 2a of the tobacco rod 2 while the cam follower 250 is being guided by the insertion section R2. In the present embodiment, the slide displacement amount $\delta 1$ is set so that the perforating needle part 242 is inserted into the front end surface 2a of the tobacco filler 21 of the tobacco

rod 2 in a process in which the cam follower 250 is guided by the insertion section R2. That is, the insertion section R2 of the guide rail 821 serves as a section where the cam follower 250 is guided so that the perforating needle part 242 is inserted into the tobacco rod 2 from the front end surface 2a. In this way, the front end surface 2a of the tobacco rod 2 (the tobacco filler 21) is perforated by the perforating needle part 242, and thereby the hollow part for heater insertion 23 can be formed in the tobacco rod 2 (the tobacco filler 21).

[0091] Note that a slide stroke (hereinafter referred to as a "needle slide stroke") $\delta 3$ of the needle member 240 (the perforating needle part 242) is substantially equal to the slide displacement amount $\delta 1$. Accordingly, the hollow part for heater insertion 23 can be formed as a recessed part having a desired depth by adjusting the slide displacement amount $\delta 1$. For example, the hollow part for heater insertion 23 having a depth of 20 mm can be formed in the tobacco rod 2 by setting a distance (hereinafter referred to as an "initial needle distance") $\delta 2$ between the front end surface 2a of the tobacco rod 2 during transport of the cam follower 250 through the evacuation state constant position section R1 and the needle front end position PN and the slide stroke (i.e., the needle slide stroke) $\delta 3$ of the needle member 240 (the perforating needle part 242) to 5 mm and 25 mm, respectively. Needless to say, the setting values of the initial needle distance $\delta 2$ and the needle slide stroke $\delta 3$ are illustrative and can be changed as appropriate.

[0092] Furthermore, in the present embodiment, the roller part 243 (contact part) of the needle member 240 provided in the perforating slider 220 slides along the guide surface 171 of the roller guide 170 (guide member) and thereby the needle member 240 is driven to rotate while the cam follower 250 of the perforating slider 220 that circles in accordance with rotation of the rotating drum part 62 is being displaced through at least a part of the insertion section R2. In the example illustrated in Fig. 10, during a "first needle rotation period T1", which is a period corresponding to rotation angles 25° to 65° of the rotating drum part 62, the roller part 243 of the needle member 240 provided in the perforating slider 220 slides along the guide surface 171 of the first roller guide part 170A, and thereby the needle member 240 can be rotated by frictional force generated between the roller part 243 and the guide surface 171 during the sliding. In the present embodiment, the perforating needle part 242 that is rotating is inserted into the front end surface 2a of the tobacco rod 2 (the tobacco filler 21) to perforate the front end surface 2a, and thereby insertion resistance (perforation resistance) during insertion of the perforating needle part 242 into the tobacco rod 2 (the tobacco filler 21) can be reduced. As a result, the perforating needle part 242 can be smoothly inserted into the tobacco rod 2 (the tobacco filler 21). This can make it less likely that a posture of the heated cigarette 1 (the tobacco rod 2) held by suction in the holding groove 63 is deviated and the heated cigarette 1 (the tobacco rod 2) drops off from the hold-

ing groove 63 when the hollow part for heater insertion 23 is formed in the tobacco rod 2. Furthermore, it is possible to suppress occurrence of deformation such as buckling of the tobacco rod 2 when the perforating needle part 242 is inserted into the tobacco rod 2.

[0093] Next, when the cam follower 250 guided by the guide rail 821 shifts from the insertion section R2 to the insertion state constant position section R3, the position of the cam follower 250 on the slide axis is kept at a constant position, and thereby the perforating slider 220 is kept at a constant position relative to the slide rods 210. As a result, the needle front end position PN on the slide axis is kept at a constant position while the cam follower 250 is being guided by the insertion state constant position section R3. In this way, the insertion state constant position section R3 of the guide rail 821 serves as a section where the cam follower 250 is guided so that the position of the perforating slider 220 is kept at a constant position relative to the slide rods 210 and thereby the perforating needle part 242 is kept inserted into the tobacco rod 2. As a result, in the insertion state constant position section R3, the perforating needle part 242 can be kept inserted into the tobacco rod 2.

[0094] Furthermore, in the present embodiment, the roller part 243 (contact part) of the needle member 240 provided in the perforating slider 220 slides along the guide surface 171 of the roller guide 170 (guide member) and thereby the needle member 240 is driven to rotate while the cam follower 250 of the perforating slider 220 is being displaced in at least a part of the insertion state constant position section R3. In the example illustrated in Fig. 10, during a "second needle rotation period T2" corresponding to rotation angles 70° to 110° of the rotating drum part 62, the roller part 243 of the needle member 240 provided in the perforating slider 220 slides along the guide surface 171 of the second roller guide part 170B and the needle member 240 is rotated by frictional force generated between the roller part 243 and the guide surface 171 during the sliding. By thus driving the perforating needle part 242 to rotate in a state where the perforating needle part 242 is in the tobacco rod 2, the hollow part for heater insertion 23 can be formed to proper size and shape. That is, by driving the perforating needle part 242 to rotate while the cam follower 250 of the perforating slider 220 is in the insertion state constant position section R3 of the guide rail 821, the hollow part for heater insertion 23 having a shape and a size matching the perforating needle part 242 inserted into the tobacco rod 2 can be formed neatly, and the hollow part for heater insertion 23 becomes less likely to be formed in a distorted manner.

[0095] Next, when the cam follower 250 guided by the guide rail 821 shifts from the insertion state constant position section R3 to the extraction section R4, the cam follower 250 is displaced backward along the drum rotary axis CL2 (slide axis) in accordance with an increase in rotation angle. Accordingly, the needle front end position PN of the perforating needle part 242 is displaced back-

ward along the drum rotary axis CL2 (slide axis), that is, in a direction in which the perforating needle part 242 is extracted from the tobacco rod 2 while the cam follower 250 is being guided by the extraction section R4. In this way, the extraction section R4 of the guide rail 821 serves as a section in which the cam follower 250 is guided so that the perforating needle part 242 is extracted from the tobacco rod 2. As a result, the perforating needle part 242 can be suitably extracted from the tobacco rod 2 in a process in which the cam follower 250 is guided by the extraction section R4.

[0096] Furthermore, the roller part 243 (contact part) of the needle member 240 provided in the perforating slider 220 slides along the guide surface 171 of the roller guide 170 (guide member) and thereby the needle member 240 is driven to rotate while the cam follower 250 of the perforating slider 220 is being displaced in at least a part of the extraction section R4. In the example illustrated in Fig. 10, during a "third needle rotation period T3" corresponding to rotation angles 115° to 155° of the rotating drum part 62, the roller part 243 of the needle member 240 provided in the perforating slider 220 slides along the guide surface 171 of the third roller guide part 170C and the needle member 240 is rotated by frictional force generated between the roller part 243 and the guide surface 171 during the sliding. By thus extracting the perforating needle part 242 from the tobacco rod 2 (the tobacco filler 21) while rotating the perforating needle part 242, extraction resistance of the perforating needle part 242 can be reduced. As a result, the perforating needle part 242 can be smoothly extracted from the tobacco rod 2 (the tobacco filler 21). This can make it less likely that the tobacco filler 21 is attached to the perforating needle part 242 when the perforating needle part 242 is extracted from the tobacco rod 2. As a result, the hollow part for heater insertion 23 can be made less likely to be out of shape or distorted. Furthermore, the heated cigarette 1 (the tobacco rod 2) can be suitably made less likely to drop off from the holding groove 63 when the perforating needle part 242 is extracted from the tobacco rod 2.

[0097] The needle front end position PN of the perforating needle part 242 is kept separated away from the front end surface 2a of the tobacco rod 2 after the cam follower 250 guided by the guide rail 821 shifts from the extraction section R4 to the evacuation state constant position section R1. Specifically, the needle front end position PN of the perforating needle part 242 is kept separated away from the front end surface 2a of the tobacco rod 2 by the initial needle distance $\delta 2$. Then, when the rotation angle of the rotating drum part 62 reaches the transport end position, the heated cigarette 1 having the hollow part for heater insertion 23 in the tobacco rod 2 is delivered from the perforating drum 60 to the succeeding drum 59.

[0098] In the present embodiment, in the example illustrated in Figs. 10 and 11, the inclined guide parts 821B (the insertion section R2 and the extraction section R4) of the guide rail 821 are formed as constant-speed slide

regions where an inclination angle with respect to the virtual orthogonal surface VP is constant. The state where the inclination angle with respect to the virtual orthogonal surface VP is constant means that an amount of change of a coordinate (z coordinate) on the first coordinate axis (Z axis) per unit rotation angle of the rotating drum part 62 is constant. In a case where the insertion section R2 of the guide rail 821 is formed as a constant-speed slide region, the perforating needle part 242 slides forward along the drum rotary axis CL2 (slide axis) at a constant speed when the cam follower 250 is guided along the insertion section R2. As a result, the perforating needle part 242 is inserted into the tobacco rod 2 at a constant speed. Similarly, in a case where the extraction section R4 of the guide rail 821 is formed as a constant-speed slide region, the perforating needle part 242 slides backward along the drum rotary axis CL2 (slide axis) at a constant speed when the cam follower 250 is guided along the extraction section R4. As a result, the perforating needle part 242 is extracted from the tobacco rod 2 at a constant speed. In a case where the insertion section R2 and the extraction section R4 of the guide rail 821 are formed as constant-speed slide regions as described above, an inclination angle (hereinafter referred to as an "insertion section inclination angle") of the insertion section R2 with respect to the virtual orthogonal surface VP and an inclination angle (hereinafter referred to as a "extraction section inclination angle") of the extraction section R4 with respect to the virtual orthogonal surface VP may be equal or may be different. In a case where the insertion section inclination angle and the extraction section inclination angle of the guide rail 821 are equal, an insertion speed at which the perforating needle part 242 is inserted into the tobacco rod 2 and an extraction speed at which the perforating needle part 242 is extracted from the tobacco rod 2 are equal. Meanwhile, in a case where the insertion section inclination angle and the extraction section inclination angle of the guide rail 821 are different, the insertion speed at which the perforating needle part 242 is inserted into the tobacco rod 2 and the extraction speed at which the perforating needle part 242 is extracted from the tobacco rod 2 can be set different.

[0099] Furthermore, in the present embodiment, the inclined guide parts 821B (the insertion section R2 and the extraction section R4) of the guide rail 821 may be formed as variable-speed slide regions where the inclination angle with respect to the virtual orthogonal surface VP is not constant (changes). The state where the inclination angle with respect to the virtual orthogonal surface VP is not constant (changes) means that an amount of change of a coordinate (z coordinate) on the first coordinate axis (Z axis) per unit rotation angle of the rotating drum part 62 is not constant and changes. For example, in a case where the insertion section R2 of the guide rail 821 is formed as a variable-speed slide region, the perforating needle part 242 slides forward along the drum rotary axis CL2 (slide axis) while changing a sliding speed thereof when the cam follower 250 is guided along the

insertion section R2. As a result, the perforating needle part 242 is inserted into the tobacco rod 2 while changing an insertion speed thereof. Similarly, in a case where the extraction section R4 of the guide rail 821 is formed as a variable-speed slide region, the perforating needle part 242 slides backward along the drum rotary axis CL2 (slide axis) while changing a sliding speed thereof when the cam follower 250 is guided along the extraction section R4. As a result, the perforating needle part 242 is extracted from the tobacco rod 2 while changing an extraction speed thereof. In the present embodiment, it is only necessary that the inclined guide parts 821B of the guide rail 821 include at least one of the "constant-speed slide region" and the "variable-speed slide region". That is, all of the inclined guide parts 821B of the guide rail 821 may be either the "constant-speed slide region" or the "variable-speed slide region". Alternatively, the inclined guide parts 821B of the guide rail 821 may include both of the "constant-speed slide region" and the "variable-speed slide region". In this case, a ratio of the "constant-speed slide region" and the "variable-speed slide region" can be freely set.

[0100] It is preferable that the extraction section inclination angle (an inclination angle of an extraction section with respect to the virtual orthogonal surface VP) of the guide rail 821 is smaller than the insertion section inclination angle (an inclination angle of an insertion section with respect to the virtual orthogonal surface VP). This can make a speed at which the perforating needle part 242 is extracted from the tobacco rod 2 lower than a speed at which the perforating needle part 242 is inserted into the tobacco rod 2. Extraction resistance during extraction of the perforating needle part 242 from the tobacco rod 2 tends to be relatively larger than insertion resistance during insertion of the perforating needle part 242 into the tobacco rod 2. In view of this, by setting a speed at which the perforating needle part 242 is extracted from the tobacco rod 2 lower than a speed at which the perforating needle part 242 is inserted into the tobacco rod 2, the perforating needle part 242 can be extracted from the tobacco rod 2 slowly. This can make it less likely that the heated cigarette 1 (the tobacco rod 2) drops off from the holding groove 63, the tobacco filler 21 is attached to the perforating needle part 242, and shape of the hollow part for heater insertion 23 is distorted when the perforating needle part 242 is extracted from the tobacco rod 2.

[0101] Furthermore, the cam part 82 (the guide rail 821) of the present embodiment is preferably configured such that the extraction section R4 is longer than the insertion section R2. This can make a time taken to extract the perforating needle part 242 from the tobacco rod 2 longer than a time taken to insert the perforating needle part 242 into the tobacco rod 2. Accordingly, the perforating needle part 242 can be extracted from the tobacco rod 2 slowly. This can suitably make it less likely that the heated cigarette 1 (the tobacco rod 2) drops off from the holding groove 63, the tobacco filler 21 is at-

tached to the perforating needle part 242, and the shape of the hollow part for heater insertion 23 is distorted when the perforating needle part 242 is extracted from the tobacco rod 2.

[0102] Fig. 12 is a view for explaining a first central angle (hereinafter referred to as an "insertion section central angle") $\phi 1$ formed between a first directional vector V1 of a first virtual perpendicular line VL1 extending from a start position (hereinafter referred to as an "insertion section start end") P1 of the insertion section R2 of the guide rail 821 toward the drum rotary axis CL2 and a second directional vector V2 of a second virtual perpendicular line VL2 extending from an end position (hereinafter referred to as an "insertion section terminal end") P2 of the insertion section R2 toward the drum rotary axis CL2 and a second central angle (hereinafter referred to as an "extraction section central angle") $\phi 2$ formed between a third directional vector V3 of a third virtual perpendicular line VL3 extending from a start position (hereinafter referred to as an "extraction section start end") P3 of the extraction section R4 toward the drum rotary axis CL2 and a fourth directional vector V4 of a fourth virtual perpendicular line VL4 extending from an end position (hereinafter referred to as an "extraction section terminal end") P4 of the extraction section R4 toward the drum rotary axis CL2. Note that the insertion section start end P1, the insertion section terminal end P2, the extraction section start end P3, and the extraction section terminal end P4 are also illustrated in Fig. 11. In a case where a section corresponding to rotation angles 15° to 65° of the rotating drum part 62 is set as the insertion section R2 and a section corresponding to rotation angles 115° to 165° of the rotating drum part 62 is set as the extraction section R4 as in the example described in Fig. 10, both of the insertion section central angle $\phi 1$ and the extraction section central angle $\phi 2$ are set to 50° . In the present embodiment, the insertion section central angle $\phi 1$ and the extraction section central angle $\phi 2$ may be set to different angles. In this case, it is preferable that the extraction section central angle $\phi 2$ is relatively larger than the insertion section central angle $\phi 1$. With this configuration, the perforating needle part 242 can be extracted from the tobacco rod 2 slowly. This can make it less likely that the heated cigarette 1 (the tobacco rod 2) drops off from the holding groove 63, the tobacco filler 21 is attached to the perforating needle part 242, and the shape of the hollow part for heater insertion 23 is distorted when the perforating needle part 242 is extracted from the tobacco rod 2. In the present embodiment, an aspect in which the insertion section central angle (first central angle) $\phi 1$ is 10° or more and 120° or less can be presented as an example. Furthermore, an aspect in which the extraction section central angle (second central angle) $\phi 2$ is 10° or more and 180° or less can be presented as an example.

[0103] As described above, according to the present embodiment, it is possible to provide the perforating drum device 70 suitable for forming the hollow part for heater insertion 23 opened in the front end surface 2a of the

tobacco rod 2.

[0104] Furthermore, the roller guide 170 of the perforating drum device 70 according to the present embodiment is divided into the first to third roller guide parts 170A to 170C (a plurality of divided guide parts), and these roller guide parts 170A to 170C are separated away from one another. This can make it easy to finely adjust the position and the like of the guide surface 171 in a case where frictional force changes, for example, due to wear of the roller part 243 of the needle member 240 caused by friction with the guide surface 171. Furthermore, it becomes easy to finely adjust rotary torque of the needle member 240 in accordance with an amount of the tobacco filler 21 with which the tobacco rod 2 is filled.

[0105] Various modifications can be employed as the perforating drum device 70 according to the present embodiment. For example, various modification can be employed as the stroke operation of the needle member 240 in a process of transporting the heated cigarette 1 by the perforating drum 60. For example, the stroke operation of the needle member 240 may be changed by changing lengths or a ratio of the evacuation state constant position section R1, the insertion section R2, the insertion state constant position section R3, and the extraction section R4 of the guide rail 821. For example, the guide rail 821 may be configured such that the insertion state constant position section R3 is not formed between the insertion section R2 and the extraction section R4. By thus forming the guide rail 821, the perforating needle part 242 may be extracted from the tobacco rod 2 immediately after the hollow part for heater insertion 23 is formed by inserting the perforating needle part 242 of the needle member 240 into the tobacco rod 2.

[0106] Furthermore, an aspect in which the diameter of the tobacco rod 2 is approximately 7 mm to 8 mm is presented as an example. In view of this, it is preferable that the diameter of the perforating needle part 242 of the needle member 240 is 3.5 mm or less in the perforating drum device 70. This makes it possible to form the hollow part for heater insertion 23 having a suitable diameter with respect to the tobacco rod 2.

[0107] Although the hollow part for heater insertion 23 is a non-through recessed part opened in the front end surface 2a of the tobacco rod 2 in the heated cigarette 1 illustrated in Fig. 1, the hollow part for heater insertion 23 may be formed as a through-hole passing through the tobacco rod 2 in an axial direction.

[0108] Fig. 13 is a view for explaining a relationship between a needle axis AN of the perforating needle part 242 and the holding grooves 63 (holding parts) in the perforating drum device 70. The sign "Pcb" in Fig. 13 represents a center of a groove bottom (hereinafter referred to as a "groove bottom center") of each of the holding grooves 63 (holding parts). In Fig. 13, the groove bottom center Pcb is located at a deepest part of each holding groove 63 having a semi-circular cross-sectional shape. The sign "VL5" represents a virtual perpendicular

line extending from the groove bottom center Pcb of each holding groove 63 (holding part) toward the drum rotary axis CL2. The sign "Pcc" represents an intersection of the virtual perpendicular line VL5 and the drum rotary axis CL2. That is, the intersection Pcc is located on the drum rotary axis CL2. The sign "VL6" represents a straight line passing the intersection Pcc and the groove bottom center Pcb. In the present embodiment, it is preferable that the needle axis AN of the perforating needle part 242 is set so as to pass a point located on the straight line VL6 and outside the groove bottom center Pcb and extend parallel with the drum rotary axis CL2. In this case, it is more preferable that a distance between the groove bottom center Pcb of the holding groove 63 and the needle axis AN of the perforating needle part 242 is set equal to or less than a diameter of the tobacco rod 2 held in the holding groove 63. In the present embodiment, the distance between the groove bottom center Pcb of the holding groove 63 and the needle axis AN of the perforating needle part 242 is, for example, set equal to a radius of the tobacco rod 2 held in the holding groove 63, and as a result, the needle axis AN of the perforating needle part 242 is set so as to be coaxial with the central axis CL1 of the tobacco rod 2 held in the holding groove 63. By thus setting the position of the needle axis AN, the hollow part for heater insertion 23 of the tobacco rod 2 can be formed so as to be coaxial with the central axis CL1 of the tobacco rod 2.

[0109] Fig. 14 is a view for explaining a modification of Embodiment 1. Fig. 14 corresponds to Fig. 7 and illustrates a detailed configuration of the perforating unit 200. The rotating drum part 62 according to this modification has a second stop ring 187. The second stop ring 187 is an annular ring member attached to the outer circumferential surface 62A of the rotating drum part 62 and is disposed so as to face the stop ring 186. The second stop ring 187 is attached on a back side of the holding groove 63. The second stop ring 187 is a second stopper member that makes it less likely that the heated cigarette 1 drops off from the holding groove 63 by making contact with the front end surface 2a of the tobacco rod 2 when the perforating needle part 242 is extracted from the tobacco rod 2.

[0110] Fig. 15 is a partial enlarged view of the second stop ring 187 according to the modification of Embodiment 1. Fig. 15 illustrates the second stop ring 187 viewed parallel with the drum rotary axis CL2. As illustrated in Fig. 15, the second stop ring 187 has cutouts 187A provided at positions corresponding to the holding grooves 63. Each of the cutouts 187A of the second stop ring 187 overlaps the perforating needle part 242 in a direction of the drum rotary axis CL2 so that the perforating needle part 242 does not interfere (collide) with the second stop ring 187 when the perforating needle part 242 slides along the needle axis AN. In Fig. 15, the broken line indicates a contour of the tobacco rod 2, and the dot-dash-line indicates a contour of the perforating needle part 242. As illustrated in Fig. 15, each of the cutouts 187A

of the second stop ring 187 is smaller than the contour of the tobacco rod 2. With this configuration, the front end surface 2a makes contact with the second stop ring 187 (more specifically, for example, an edge part of the cutout 187A) and thereby the tobacco rod 2 can be made less likely to drop off from the holding groove 63 even in a case where the tobacco rod 2 is displaced backward due to extraction resistance during extraction of the tobacco rod 2 from the perforating needle part 242. Although the front end surface 2a of the tobacco rod 2 and the second stop ring 187 are separated away from each other in the drum rotary axis CL2 direction in a state where the tobacco rod 2 is held in the holding groove 63 in the example illustrated in Fig. 14, the second stop ring 187 may be disposed so that the front end surface 2a and the second stop ring 187 make contact with each other when the tobacco rod 2 is held in the holding groove 63.

[0111] Note that the present invention may be provided as a perforation device including a plurality of perforating drum devices 70 according to the above embodiment. In such a perforation device, the perforating drum devices 70 may be incorporated into the filter tip attachment device 50. Fig. 16 is a view for explaining a perforation device including a plurality of perforating drum devices 70 incorporated into the filter tip attachment device 50. In the example illustrated in Fig. 16, the perforation device includes two perforating drum devices 70. The individual perforating drum devices 70 have been described above in the embodiment. The sign "70A" represents a perforating drum device located in a relatively former stage in the filter tip attachment device 50, and the perforating drum device 70A is hereinafter referred to as a "former-stage perforating drum device". The sign "70B" represents a perforating drum device located in a later stage relative to the former-stage perforating drum device 70A, and the perforating drum device 70B is hereinafter referred to as a "later-stage perforating drum device". A needle diameter of the perforating needle part 242 provided in the later-stage perforating drum device 70B located in a relatively later stage may be larger than a needle diameter of the perforating needle part 242 provided in the former-stage perforating drum device 70A located in a relatively former stage among the plurality of perforating drum devices 70. By thus arranging the plurality of perforating drum devices 70 and forming the hollow part for heater insertion 23 by using the perforating needle parts 242 whose diameters increase in stages in the tobacco rod 2 of the heated cigarette 1 sequentially transported through a drum sequence, the diameter of the hollow part for heater insertion 23 can be increased in stages. Specifically, the hollow part for heater insertion 23 is formed as a base hole in the tobacco rod 2 by the former-stage perforating drum device 70A, and then the tobacco rod 2 is further perforated by the perforating needle part 242 of the later-stage perforating drum device 70B. As a result, the hollow part for heater insertion 23 having a desired diameter and neatly shaped can be formed with higher precision.

[0112] Furthermore, a needle insertion depth dimension of the perforating needle part 242 provided in the later-stage perforating drum device 70B located in a relatively later stage may be larger than a needle insertion depth dimension of the perforating needle part 242 provided in the former-stage perforating drum device 70A located in a relatively former stage among the plurality of perforating drum devices 70. In this case, the hollow part for heater insertion 23 is formed as a base hole in the tobacco rod 2 by the former-stage perforating drum device 70A, and then the tobacco rod 2 can be further perforated deeper by the perforating needle part 242 of the later-stage perforating drum device 70B. Although an example in which two perforating drum devices 70 are arranged serially has been described in the example illustrated in Fig. 16, the perforation device may include three or more perforating drum devices 70. The needle diameter of the perforating needle part 242 may be increased in stages or the needle insertion depth dimension of the perforating needle part 242 may be increased in stages from a most upstream perforating drum device 70 to a most downstream perforating drum device 70, and thereby the hollow part for heater insertion 23 in the tobacco rod 2 may be increased in diameter in stages or may be made deeper in stages.

[0113] Although the drum 59 is interposed between the perforating drums 60 of the perforating drum devices 70 in the example illustrated in Fig. 16, the perforating drums 60 of the perforating drum devices 70 may be disposed successively. Furthermore, a plurality of drums 59 may be interposed between the perforating drums 60 of the perforating drum devices 70.

[0114] Although the embodiment and modifications according to the present invention have been described above, the perforating drum device and the perforation device according to the present invention are not limited to these, and these can be combined as long as possible.

Reference Signs List

[0115]

- | | |
|-----|----------------------------------|
| 1 | heated cigarette |
| 2 | tobacco rod |
| 3 | filter |
| 21 | tobacco filler |
| 23 | hollow part for heater insertion |
| 50 | filter tip attachment |
| 60 | perforating drum |
| 62 | rotating drum part |
| 63 | holding groove |
| 70 | perforating drum device |
| 80 | fixed housing |
| 82 | cam part |
| 200 | perforating unit |
| 210 | slide rod |
| 220 | perforating slider |

- 230 slider body
 240 needle member
 242 perforating needle part

Claims

1. A perforating drum device for forming a hollow part in a tobacco rod of a heated cigarette, comprising:

a rotating drum part having, on an outer circumferential surface thereof, a holding part that holds the heated cigarette so that an axial direction of the tobacco rod extends along a drum rotary axis;

a perforating unit that is provided on the rotating drum part and perforates a front end of the tobacco rod of the heated cigarette held in the holding part in a process of transporting the heated cigarette; and

a cam part that is provided on a rotating drum base part provided beside the rotating drum part, wherein

the perforating unit has a slide rod that circles in synchronization with the rotating drum part and extends parallel with the drum rotary axis, a perforating slider that has a perforating needle part disposed on an outer circumferential side relative to the rotating drum part and is held by the slide rod so as to be slidable back and forth along an axial direction of the slide rod, and a cam follower that is provided on the perforating slider, is engaged with the cam part, and circles in accordance with rotation of the rotating drum part while being guided by the cam part, so that the perforating slider slides back and forth along the axial direction of the slide rod, and the cam part includes at least an insertion section that guides the cam follower so that the perforating needle part is inserted into the tobacco rod from the front end and an extraction section that guides the cam follower so that the perforating needle part is extracted from the tobacco rod.

2. The perforating drum device according to Claim 1, wherein

the cam part has a guide rail that extends in an arc shape about the drum rotary axis and accommodates the cam follower.

3. The perforating drum device according to Claim 2, wherein

the guide rail is disposed in an annular manner about the drum rotary axis.

4. The perforating drum device according to Claim 2 or 3, wherein

the guide rail has a three-dimensional curved shape equally distanced from the drum rotary axis and has an inclined guide part that is at least partially inclined with respect to a virtual orthogonal surface orthogonal to the drum rotary axis; and

the insertion section and the extraction section are formed by the inclined guide part.

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5. The perforating drum device according to Claim 4, wherein

the inclined guide part includes at least one of a constant-speed slide region where an inclination angle with respect to the virtual orthogonal surface is constant and a variable-speed slide region where the inclination angle with respect to the virtual orthogonal surface is not constant.

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6. The perforating drum device according to Claim 4 or 5, wherein

an inclination angle of the extraction section with respect to the virtual orthogonal surface is smaller than an inclination angle of the insertion section with respect to the virtual orthogonal surface.

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7. The perforating drum device according to any one of Claims 2 to 6, wherein

the rotating drum base part has a cylindrical housing that is coaxial with the drum rotary axis, and the guide rail is provided along an outer circumferential surface of the cylindrical housing.

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8. The perforating drum device according to any one of Claims 1 to 7, wherein

the cam part is configured such that the extraction section is longer than the insertion section.

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9. The perforating drum device according to any one of Claims 1 to 8, wherein

the cam part is disposed in an annular manner about the drum rotary axis and is configured such that a second central angle ϕ_2 formed between a directional vector of a third virtual perpendicular line extending from a start position of the extraction section toward the drum rotary axis and a directional vector of a fourth virtual perpendicular line extending from an end position of the extraction section toward the drum rotary axis is larger than a first central angle ϕ_1 formed between a directional vector of a first virtual perpendicular line extending from a start position of the insertion section toward the drum rotary axis and a directional vector of a second virtual perpendicular line extending from an end position of the insertion section toward the drum rotary axis.

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10. The perforating drum device according to any one of Claims 1 to 9, wherein

the cam part is disposed in an annular manner about

the drum rotary axis and is configured such that a first central angle ϕ_1 formed between a directional vector of a first virtual perpendicular line extending from a start position of the insertion section toward the drum rotary axis and a directional vector of a second virtual perpendicular line extending from an end position of the insertion section toward the drum rotary axis is 10° or more and 120° or less.

11. The perforating drum device according to any one of Claims 1 to 10, wherein

the cam part is disposed in an annular manner about the drum rotary axis and is configured such that a second central angle ϕ_2 formed between a directional vector of a third virtual perpendicular line extending from a start position of the extraction section toward the drum rotary axis and a directional vector of a fourth virtual perpendicular line extending from an end position of the extraction section toward the drum rotary axis is 10° or more and 180° or less.

12. The perforating drum device according to any one of Claims 1 to 11, wherein

the cam part includes, between the insertion section and the extraction section, an insertion state constant position section that guides the cam follower so that the perforating needle part is kept inserted into the tobacco rod by keeping the perforating slider at a constant position relative to the slide rod.

13. The perforating drum device according to any one of Claims 1 to 12, wherein

a diameter of the perforating needle part is 3.5 mm or less.

14. The perforating drum device according to any one of Claims 1 to 13, wherein

the perforating slider has a slider body slidably attached to the slide rod and a needle shaft part that is rotatably held by the slider body and has the perforating needle part attached to a front end side thereof;

the needle shaft part and the perforating needle part are disposed coaxially with each other and are rotatable about a rotary axis parallel with the drum rotary axis; and

the rotating drum base part has a guide member that extends in an arc shape about the drum rotary axis and along which a predetermined contact part of the needle shaft part slides to rotate the needle shaft part during a period where the cam follower of the perforating slider that circles in accordance with rotation of the rotating drum part is displaced in at least a part of the insertion section.

15. The perforating drum device according to Claim 14,

wherein

the guide member is configured to make contact with the contact part during a period where the cam follower of the perforating slider that circles in accordance with rotation of the rotating drum part is displaced in at least a part of the extraction section.

16. The perforating drum device according to Claim 14 or 15, wherein

the contact part is an annular roller part that is coaxial and integral with the needle shaft part, and the needle shaft part rotates due to friction generated when the roller part slides on the guide member.

17. The perforating drum device according to any one of Claims 14 to 16, wherein

the guide member is divided into a plurality of divided guide parts, and the plurality of divided guide parts are separated away from one another.

18. The perforating drum device according to any one of Claims 1 to 17, wherein

the holding part is a holding groove having a recessed shape that is capable of holding the heated cigarette; and

a needle axis of the perforating needle part passes a point that is located on a straight line passing an intersection of a virtual perpendicular line extending from a groove bottom center of the holding groove toward the drum rotary axis and the drum rotary axis and passing the groove bottom center and is located outside the groove bottom center and extends parallel with the drum rotary axis.

19. The perforating drum device according to Claim 18, wherein

a distance between the groove bottom center of the holding groove and the needle axis of the perforating needle part is set equal to or less than a diameter of the tobacco rod of the heated cigarette held in the holding groove.

20. The perforating drum device according to any one of Claims 1 to 19, wherein

the rotating drum part has a first stopper member that makes contact with an inhalation end of the heated cigarette so that the heated cigarette becomes less likely to drop off from the holding part when the perforating needle part is inserted into the front end of the tobacco rod.

21. The perforating drum device according to any one of Claims 1 to 20, wherein

the rotating drum part has a second stopper member that makes contact with the front end of the tobacco rod so that the heated cigarette becomes less likely

to drop off from the holding part when the perforating needle part is extracted from the tobacco rod.

- 22.** A perforation device comprising a plurality of perforating drum devices according to any one of Claims 1 to 21, wherein
a needle diameter of the perforating needle part provided in a perforating drum device that is located in a relatively later stage is larger than a needle diameter of the perforating needle part provided in a perforating drum device that is located in a relatively former stage among the plurality of perforating drum devices.
- 23.** A perforation device comprising a plurality of perforating drum devices according to any one of Claims 1 to 21, wherein
a needle insertion depth dimension of the perforating needle part provided in a perforating drum device that is located in a relatively later stage is larger than a needle insertion depth dimension of the perforating needle part provided in a perforating drum device that is located in a relatively former stage among the plurality of perforating drum devices.

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FIG. 1

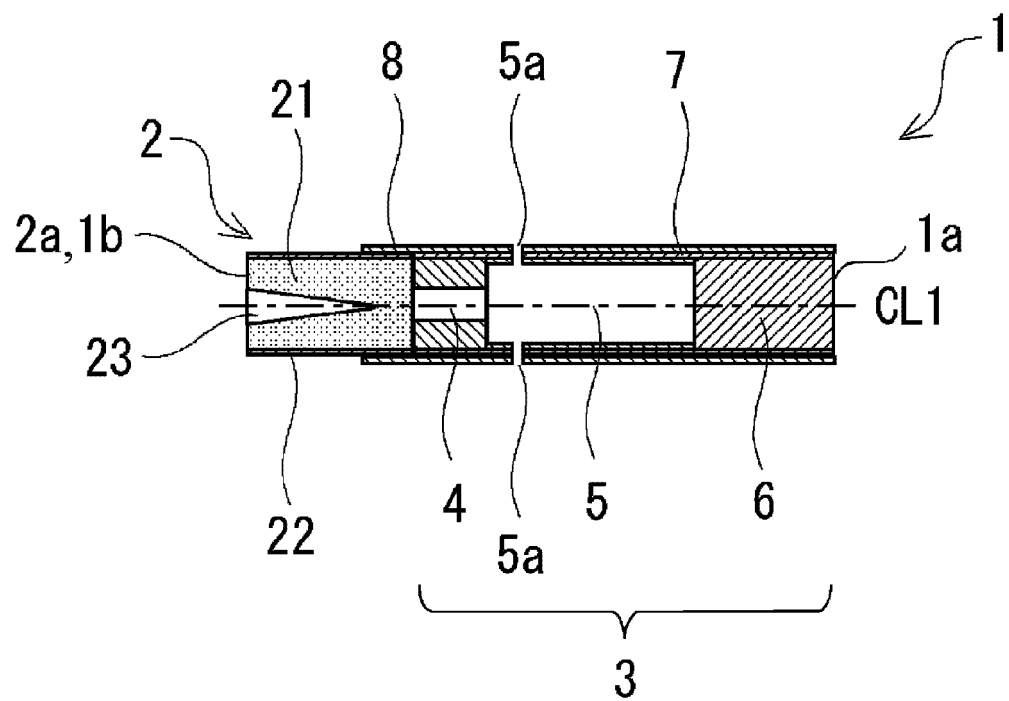


FIG. 2

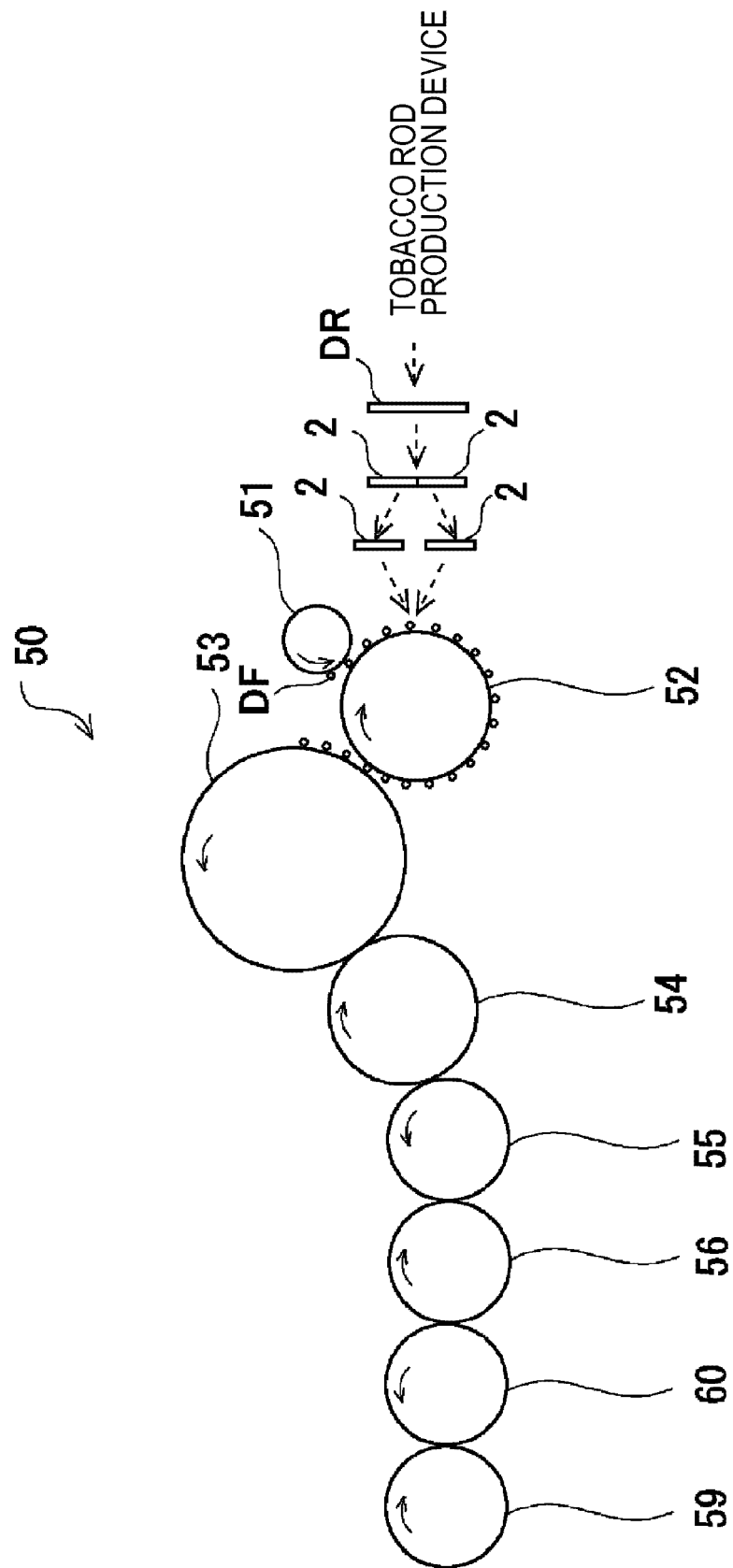


FIG. 3

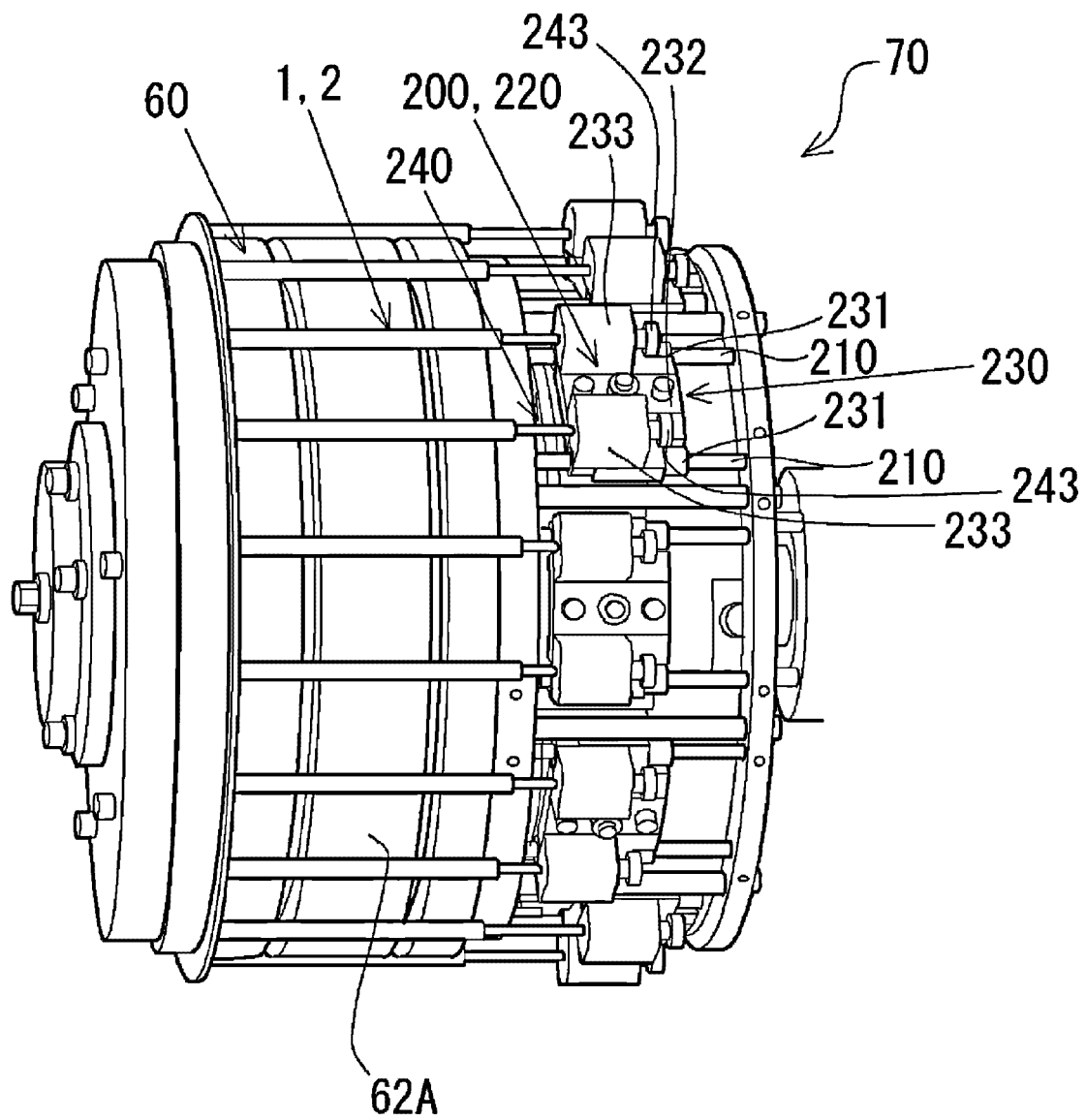


FIG. 4

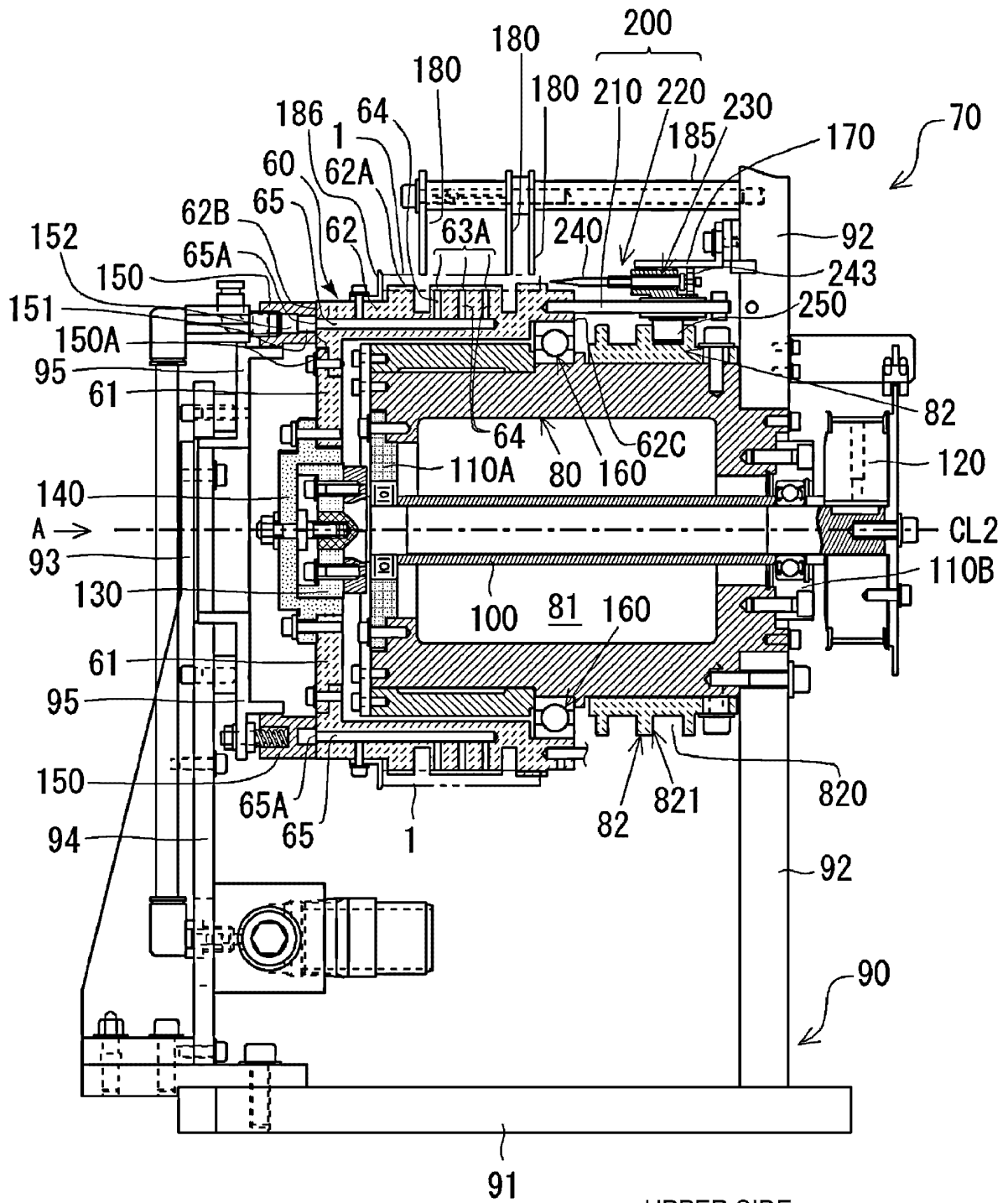


FIG. 5

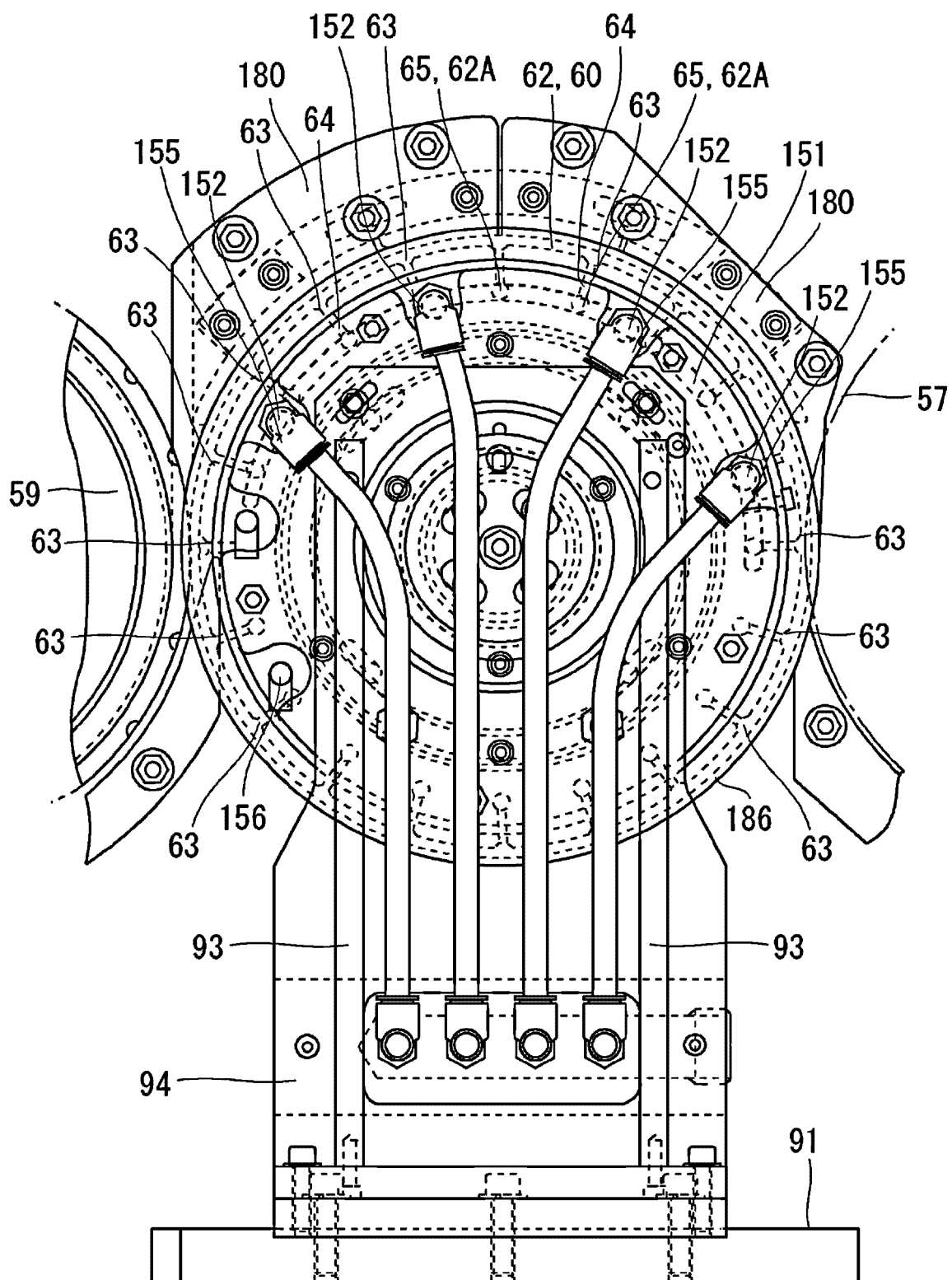


FIG. 6

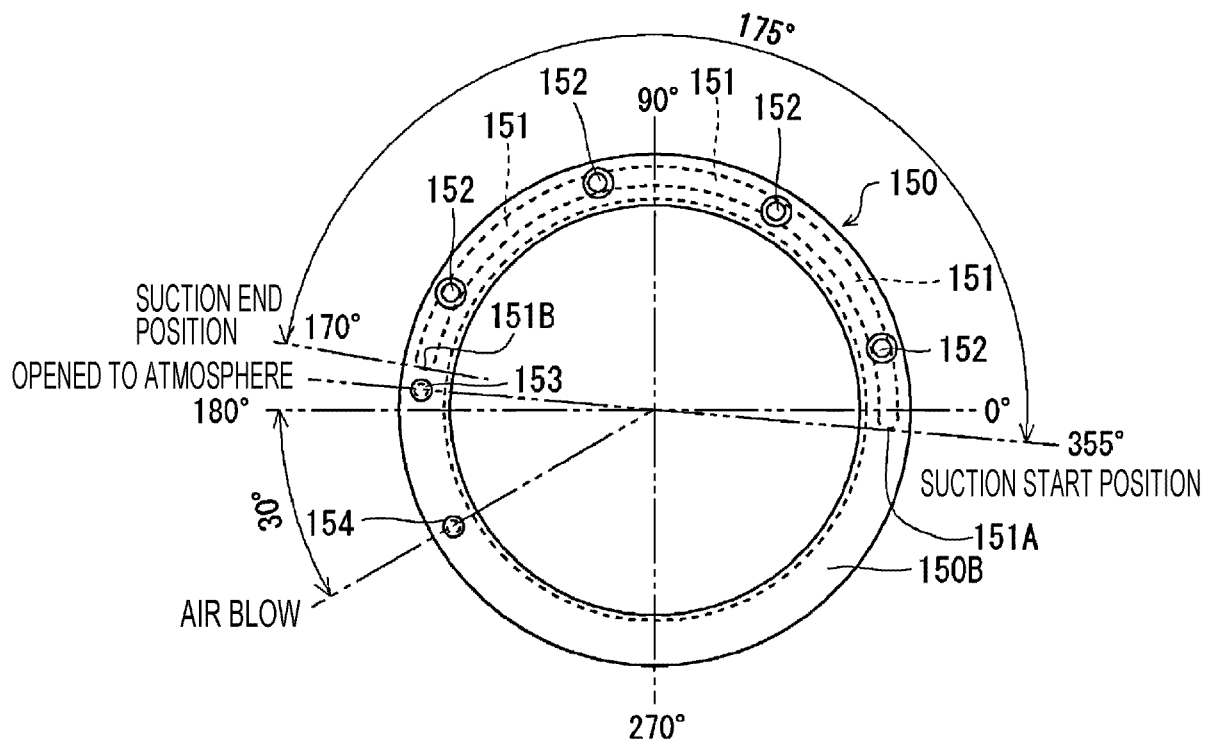


FIG. 7

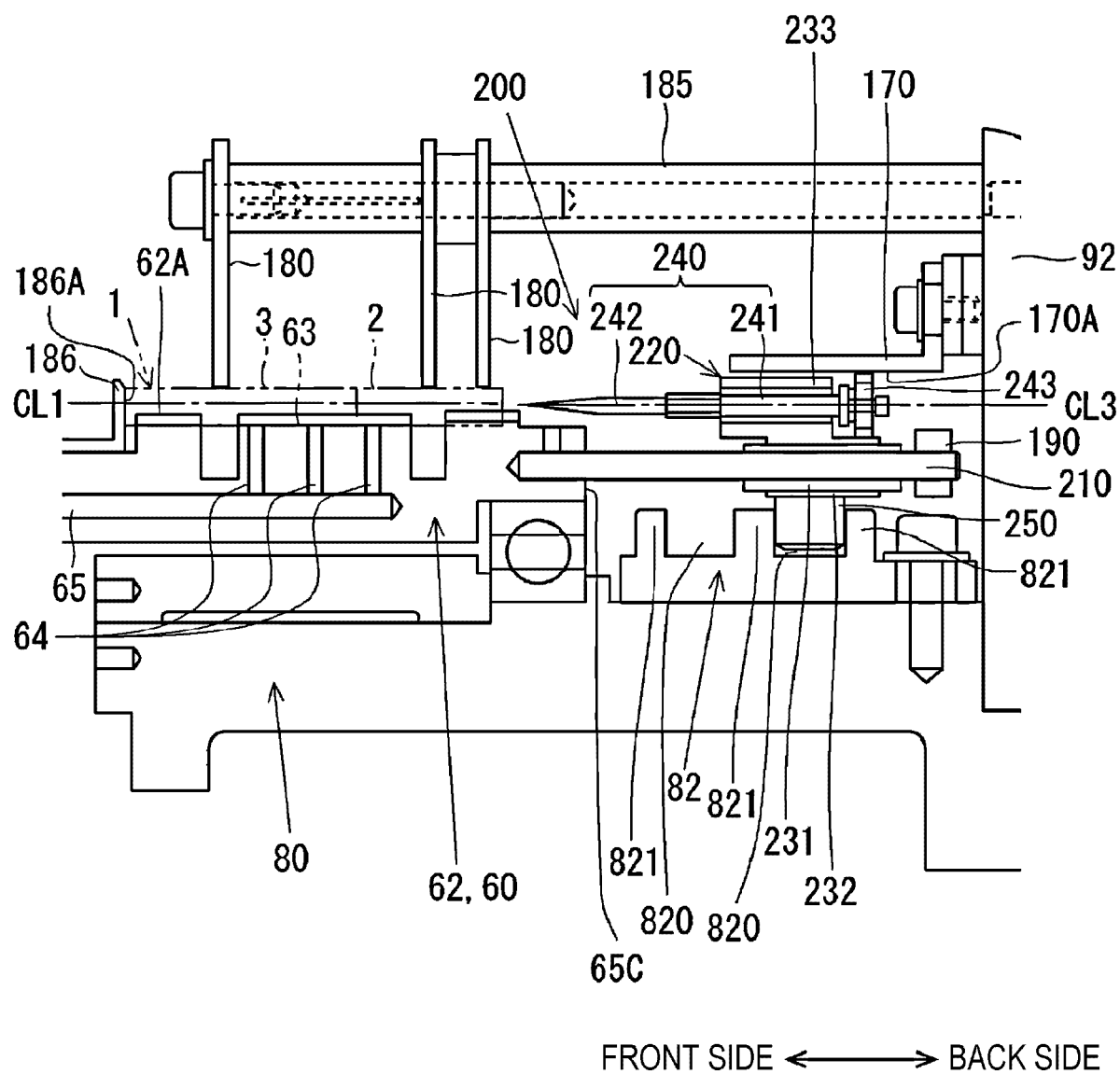


FIG. 8

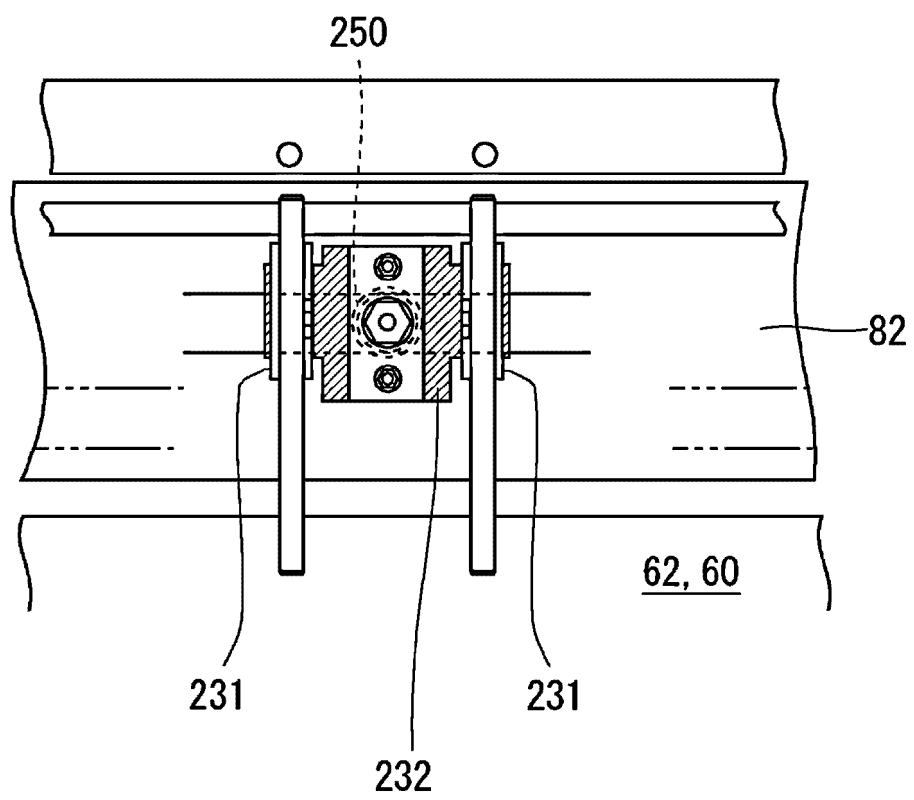


FIG. 9

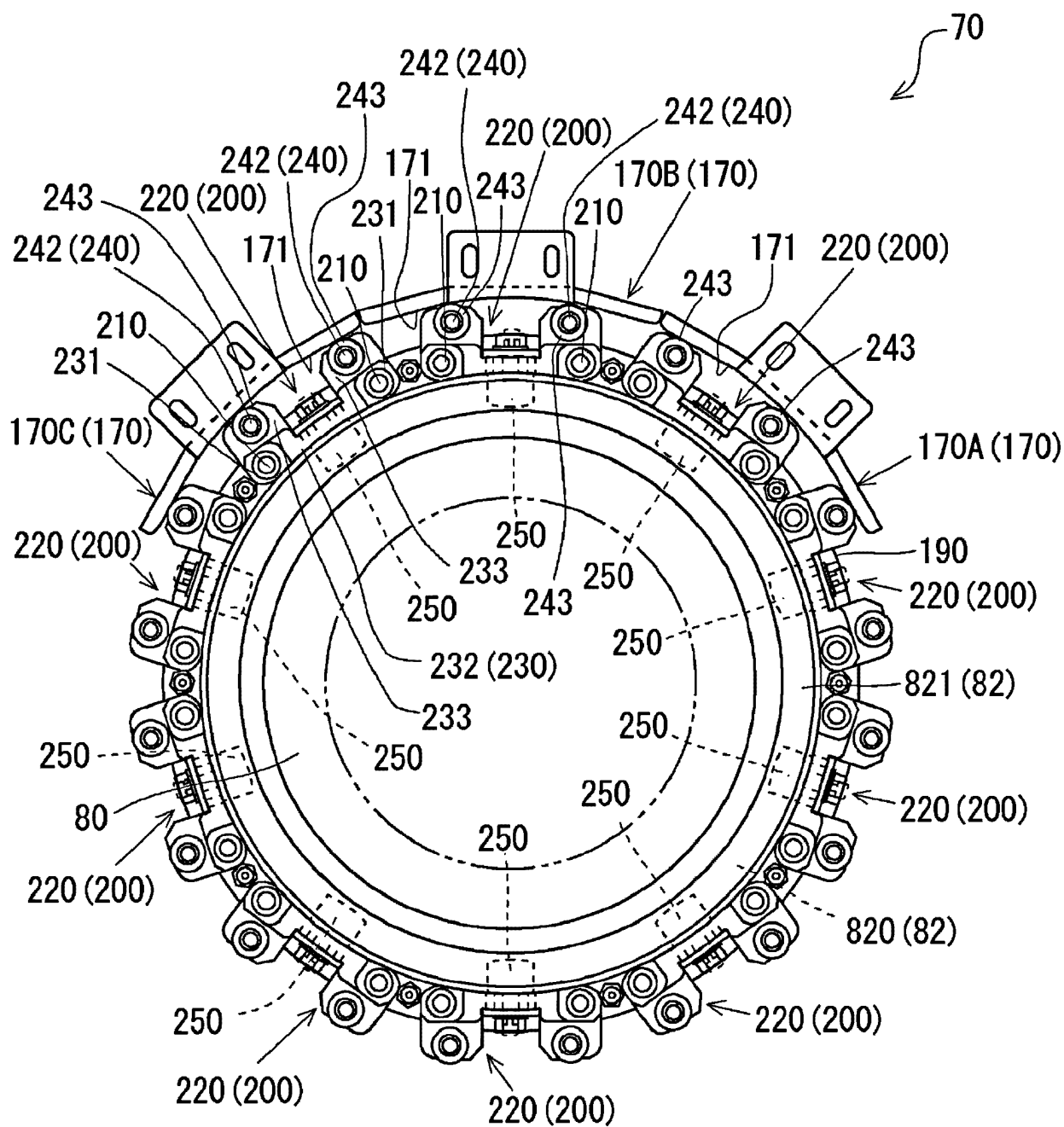


FIG. 10

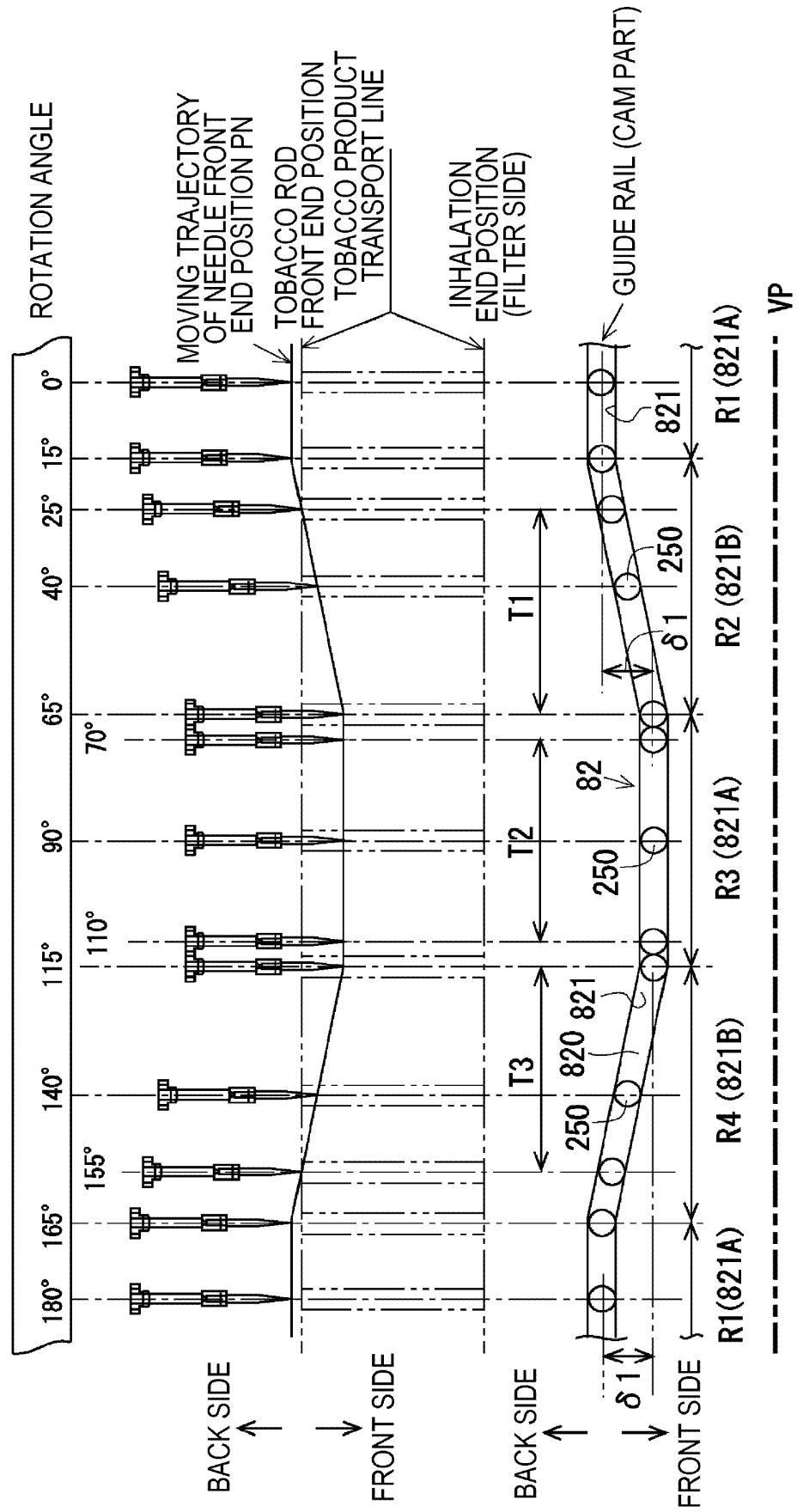


FIG. 11

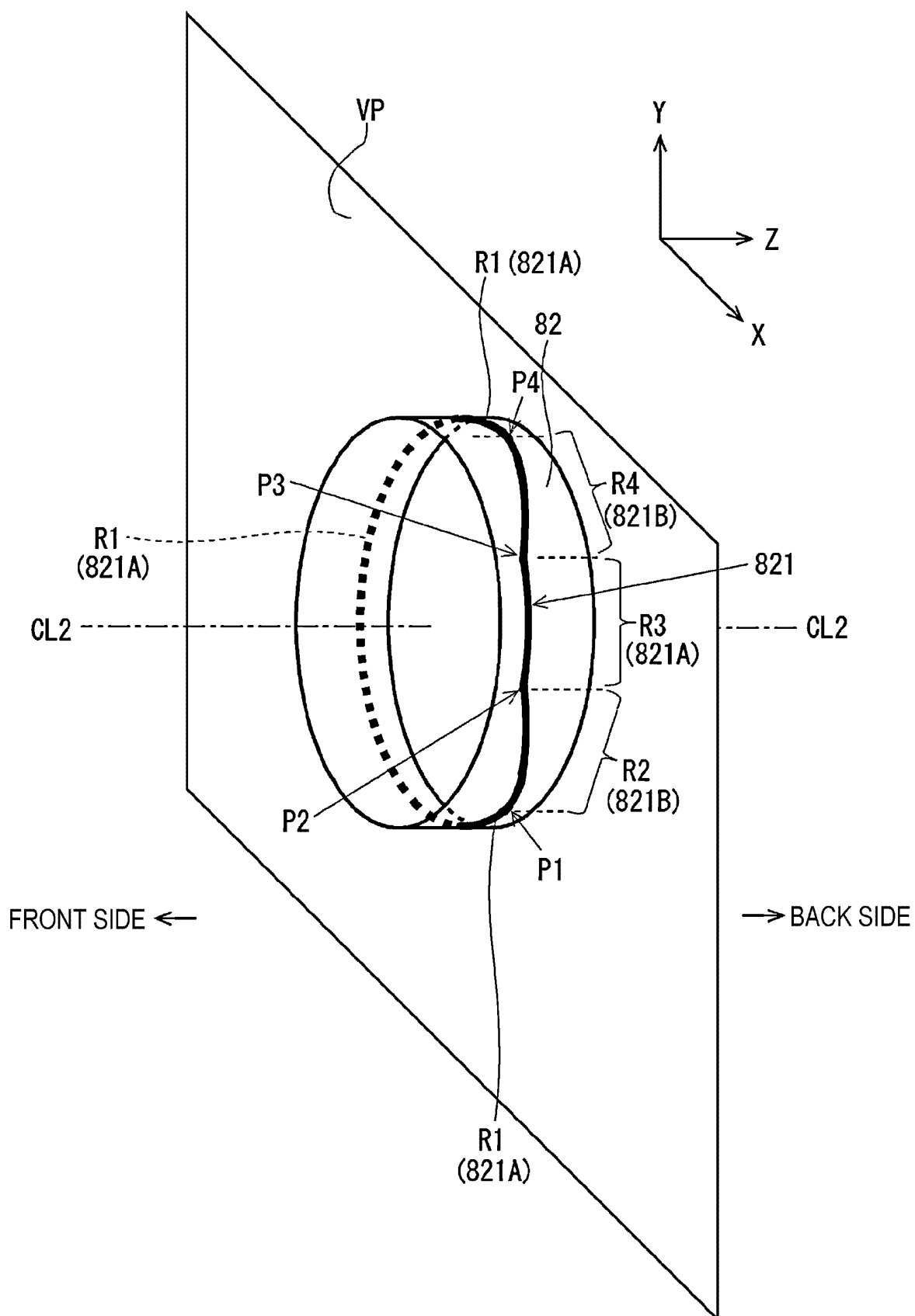


FIG. 12

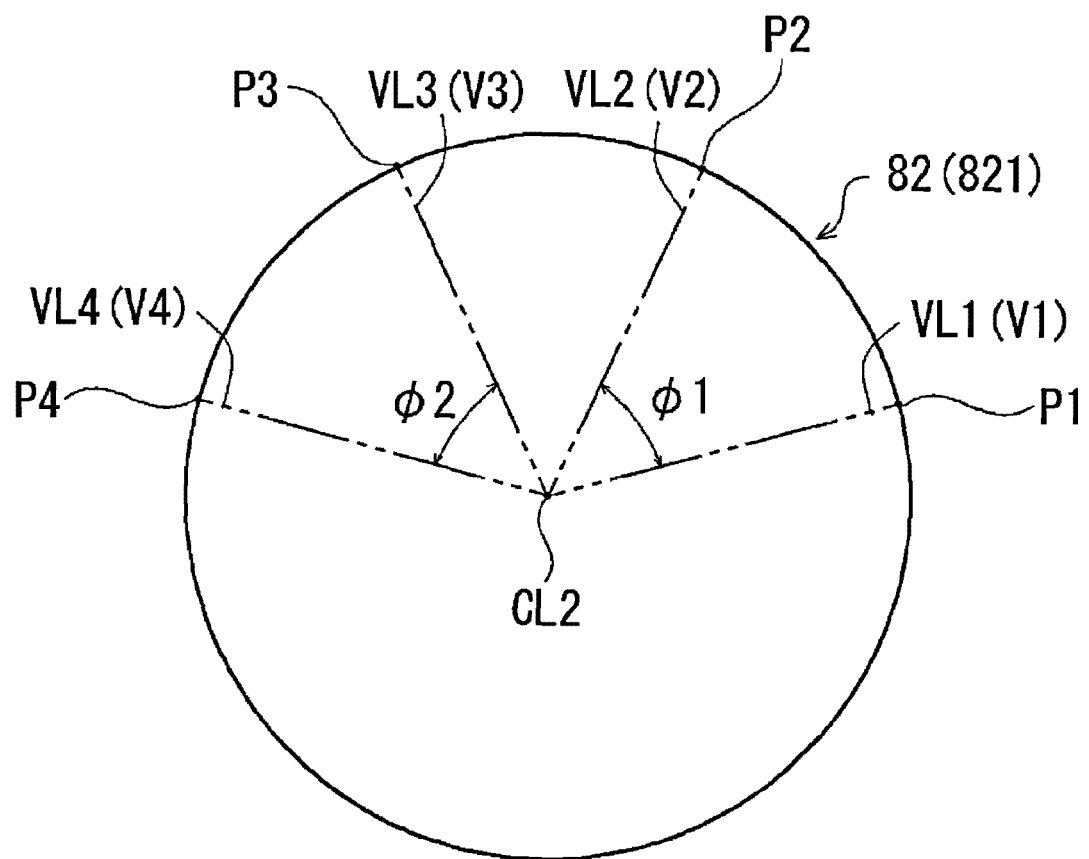


FIG. 13

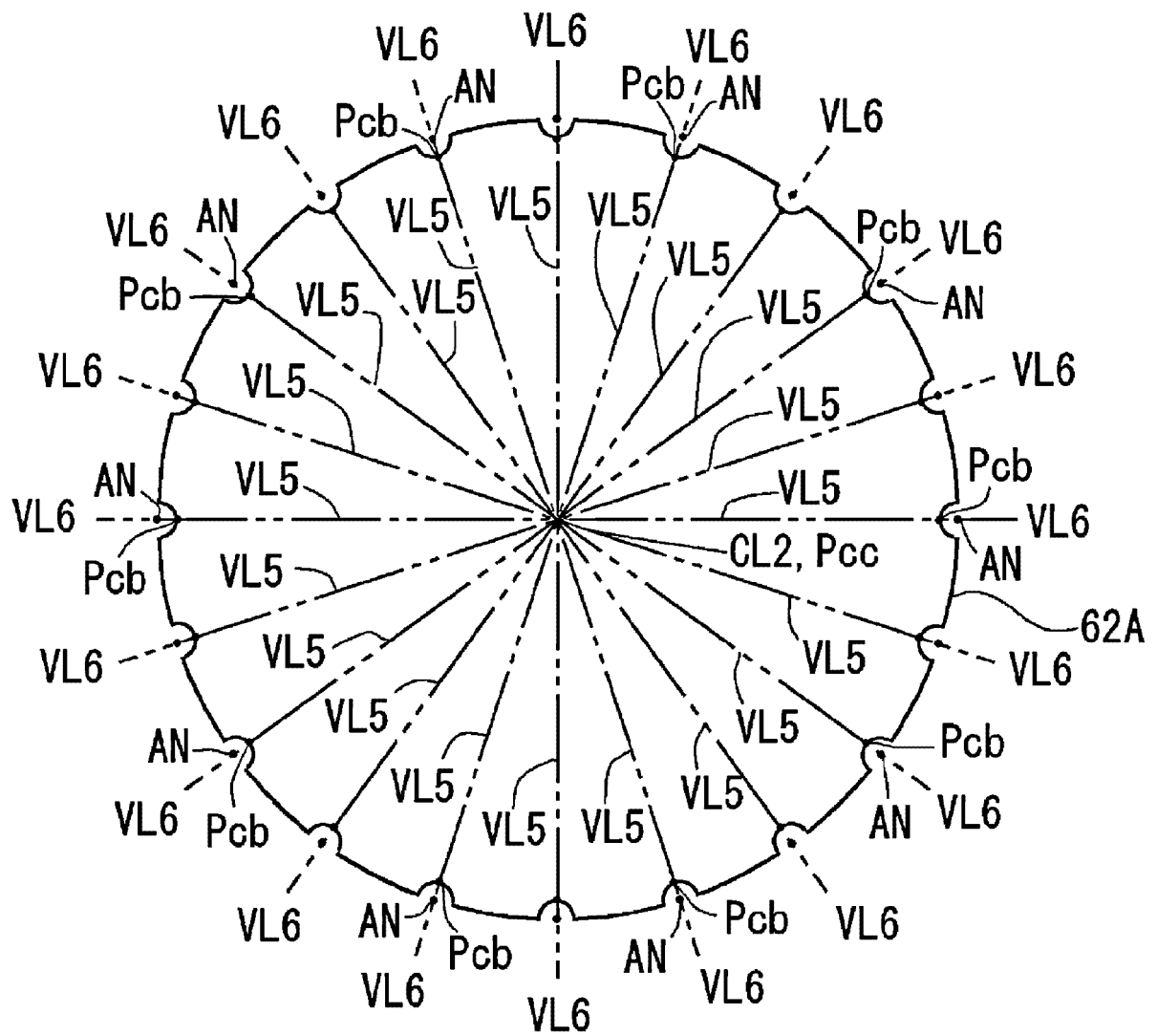


FIG. 14

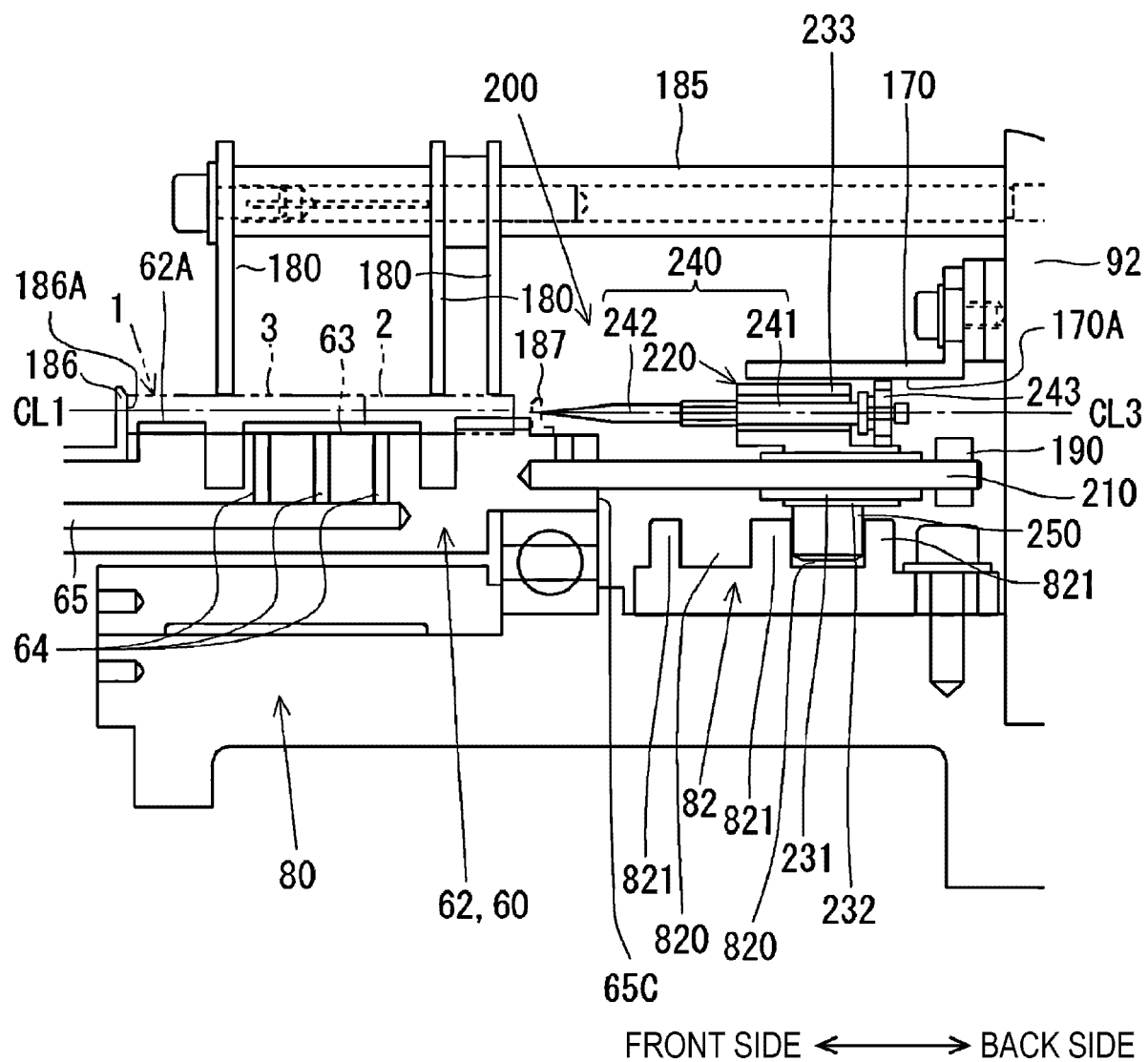


FIG. 15

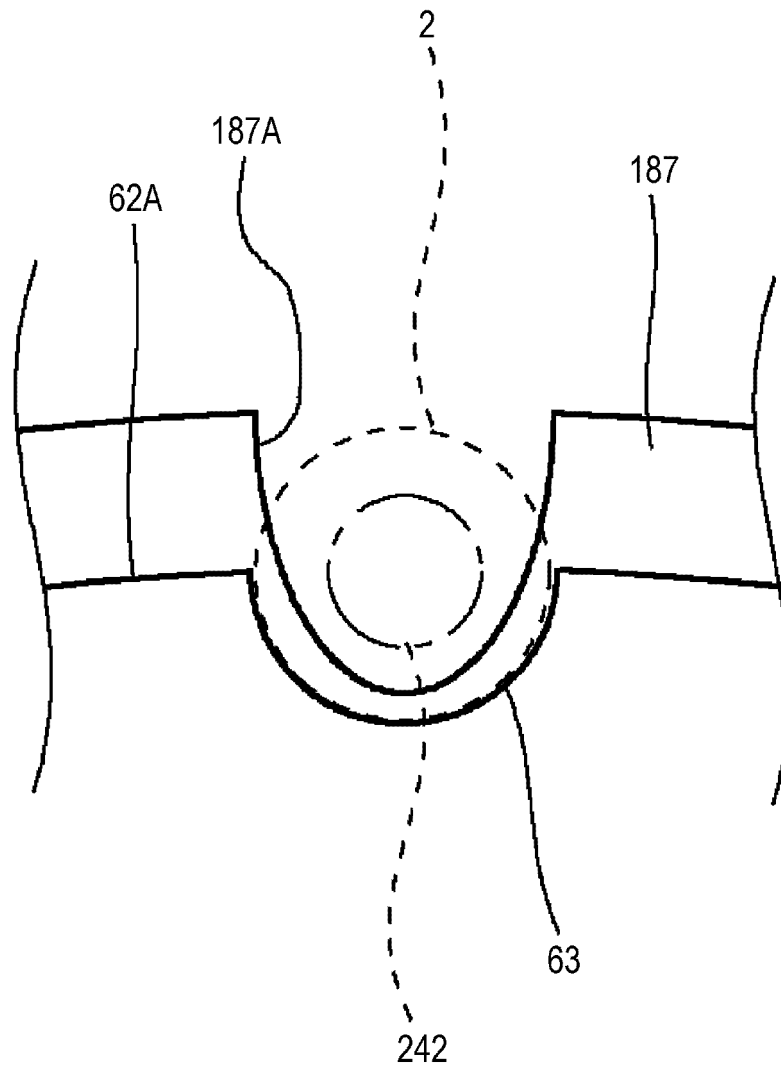
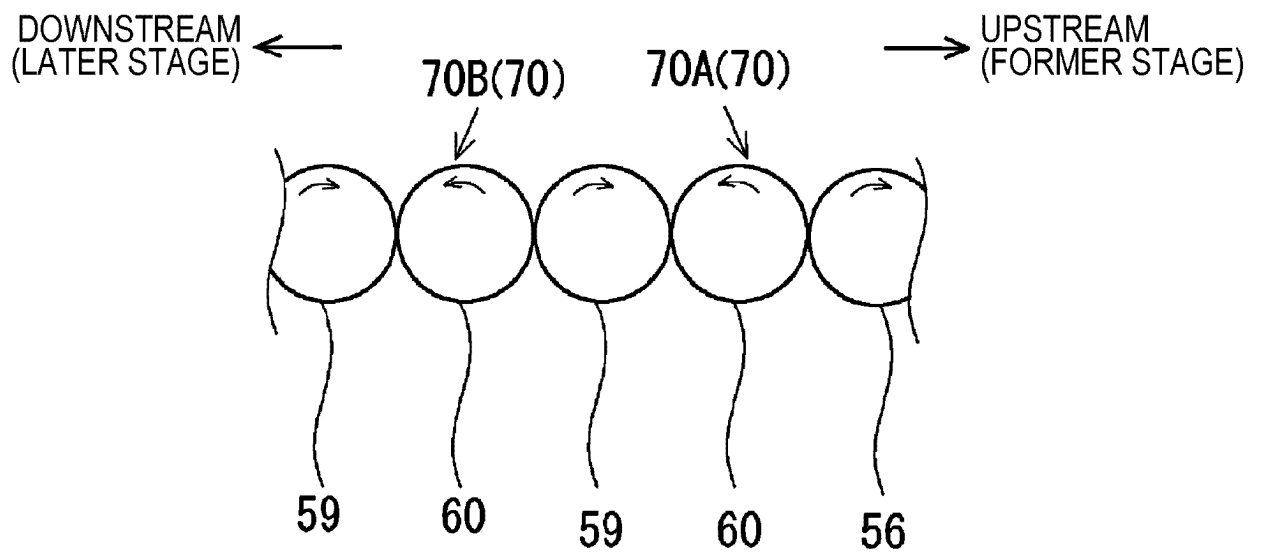


FIG. 16



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2020/013651

A. CLASSIFICATION OF SUBJECT MATTER

A24C 5/01 (2020.01) i; A24F 40/20 (2020.01) i
FI: A24C5/01; A24F40/20

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)
A24C5/01; A24F40/20

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2020
Registered utility model specifications of Japan	1996-2020
Published registered utility model applications of Japan	1994-2020

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	DE 2715994 A1 (HAUNI WERKE KOERBER & CO KG)	1-21
A	12.10.1978 (1978-10-12) specification, page 12, line 1 to page 16, line 21, fig. 1-3	22-23
Y	US 2017/0340016 A1 (THORENS, Michel) 30.11.2017 (2017-11-30) paragraphs [0160]-[0162], fig. 1-2	1-21
A	JP 64-037276 A (R J REYNOLDS TOBACCO CO.) 07.02.1989 (1989-02-07) entire text, all drawings	1-23



Further documents are listed in the continuation of Box C.



See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search
03 June 2020 (03.06.2020)Date of mailing of the international search report
16 June 2020 (16.06.2020)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2020/013651

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
DE 2715994 A1	12 Oct. 1978	(Family: none)	
US 2017/0340016 A1	30 Nov. 2017	JP 2019-521650 A	
		WO 2017/207580 A1	
JP 64-037276 A	07 Feb. 1989	US 4870748 A	
		EP 299260 A2	

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2010514435 W [0003]
- JP 2011507538 W [0003]
- JP 11266850 A [0003]
- JP 2010514438 W [0003]