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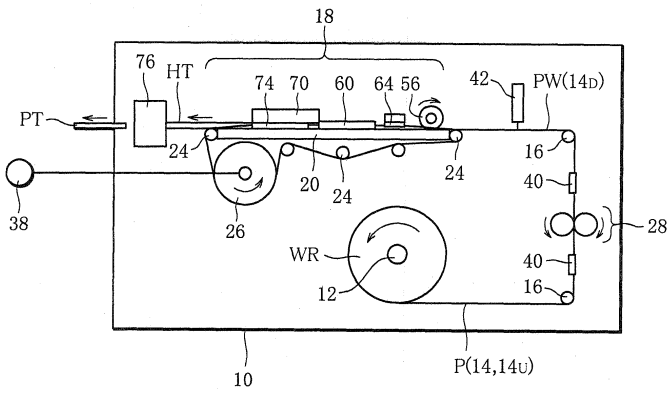
(54) PAPER TUBE MANUFACTURING MACHINE, MANUFACTURING METHOD FOR SAME, AND PAPER TUBE MANUFACTURED BY SAID MANUFACTURING METHOD

(57) A paper tube manufacturing machine of the present invention has: a transfer path for guiding transfer of a paper web having multiple cut grooves; and a web bending device for bendings the paper web and forming the paper web into a paper tube, and the web bending device includes a garniture belt, a tube forming section, and an applicator. The tube forming section, in the course of the transfer of the paper web, forms the paper web continuously into a paper tube using the garniture belt while maintaining the inner surface of the paper web in a free state, and thereby the paper tube has a lapped portion where both side edges of the paper web are lapped. Meanwhile, the applicator applies an adhesive to one of both side edges of the paper web before the lapped portion is formed, to thereby bond the both side edges with each other in the lapped portion.

FIG. 1



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Description

Technical Field

[0001] The present invention relates to a paper tube manufacturing machine, which continuously manufactures single-layered flatwise paper tubes from a paper web made of thick paper, a paper tube manufacturing method, and a paper tube manufactured by the manufacturing method.

Background Art

[0002] A flavor inhaler disclosed in Patent Document 1 listed below, for example, includes a heat source disposed at the distal end thereof and a flavor generation source disposed downstream from the heat source therein, and the flavor generation source generates flavor components using the heat of the heat source. This type of flavor inhaler further includes a pipe member for supporting or housing the heat source, the flavor generation source, etc., and in the case of Patent Document 1, a paper tube is used for the pipe member. The following are two requirements for such a paper tube used as the pipe member.

[0003] First, the paper tube must be rigid enough not to be easily crushed when held between the fingers of a user.

[0004] Secondly, it is desirable that the paper tube contain as little adhesive as possible, since the adhesive used in manufacture of the paper tube has the property of sorbing the flavor components generated from the flavor generation source.

[0005] The paper tubes are broadly classified into a spiral type and a flatwise type. The spiral paper tube is formed by spirally winding a thin paper web around the outer circumference of a mandrel to a predetermined thickness. In contrast, the flatwise paper tube is formed by winding a paper web around the outer circumference of a mandrel in a direction perpendicular to the axis of the mandrel.

[0006] The flatwise paper tubes are further classified into a multi-layer type with a paper web wound in several layers to a predetermined thickness, and a single-layer type with a paper web wound in a single layer. The single-layer flatwise paper tube has a lapped portion where both side edges of the paper web are lapped and bonded with each other.

Prior Art Document

Patent Document

[0007] Patent Document 1: JP 2010-535530A

Summary of the Invention

Problems to be solved by the Invention

[0008] The spiral paper tube and the multi-layered flatwise paper tube have a rigidity which allows them to serve as the pipe member of the flavor inhaler. However, since such paper tubes are manufactured with an adhesive applied to the entire surface of the paper web, they contain a large amount of the adhesive which sorbs flavor components, and are therefore unsuitable as the pipe member of the flavor inhaler.

[0009] On the other hand, the single-layered flatwise paper tube contains an adhesive only in the lapped portion, and is suitable as the pipe member of the flavor inhaler in terms of sorption of flavor components. However, due to its lower rigidity compared with that of the spiral paper tube or the multi-layered flatwise paper tube, the single-layered flatwise paper tube is not suitable as the pipe member of the flavor inhaler. In this regard, using a thick paper web to manufacture the single-layered flatwise paper tube is likely to increase the rigidity of the flatwise paper tube.

[0010] However, the low flexibility of a thick paper web makes it difficult to manufacture a flatwise paper tube with a small inner diameter which is suitable as the pipe member of the flavor inhaler. Specifically, the paper web develops creases when the paper web is wound around the mandrel, and the lapped portion of the paper tube bursts open due to the repulsive force of the wound paper web after completion of winding of the paper web, so that stable manufacture of the flat-wound paper tube is not secured. Moreover, unlike the spiral paper tube, the flatwise paper tube is removed from the mandrel each time the flatwise paper tube is manufactured, and cannot be continuously manufactured on the mandrel.

[0011] An object of the present invention is to provide a paper tube manufacturing machine, which can continuously manufacture a slim , single-layered flatwise paper tube having a desired rigidity while reducing the amount of adhesive used, a paper tube manufacturing method, and a paper tube manufactured by the manufacturing method.

Means for Solving the Problems

[0012] The above-described object is achieved by a paper tube manufacturing machine of the present invention. This paper tube manufacturing machine is equipped with: a transfer path for guiding transfer of a paper web, the paper web having multiple grooves which extend along a transfer direction of the paper web and increase the flexibility of the paper web; and a web bending device disposed on the transfer path, for bending the paper web, wherein the web bending device includes: an endless garniture belt for transferring the paper web along the transfer path; a tube forming section for forming the paper web continuously into a hollow cylindrical paper tube through the garniture belt while maintaining the inner surface of the paper web in a free state in the cource of the transfer of the paper web, the paper tube having a lapped portion where both side edges of the paper web are lapped; and an applicator for applying an adhesive to one of both side edges of the paper web before the lapped portion is formed, to thereby bond both side edges with each other in the lapped portion.

[0013] According to the above-described paper tube manufacturing machine, even when the paper material for forming the paper web is thick and highly rigid, the multiple grooves impart a desired softness to the paper web. Therefore, when the paper web passes through the tube forming section, the tube forming section can form the paper web continuously and stably into a paper tube.

[0014] Since such a paper tube is a single-layer flatwise paper tube, the paper web forming the paper tube has both side edges just bonded through the adhesive in the lapped portion, and the amount used of the adhesive required for forming the paper tube is small. In addition, since the paper material for forming the paper web is itself highly rigid and, moreover, the paper tube has a closed shape, the paper tube is highly rigid in both directions of the radial direction and the axial direction regardless of with or without the grooves.

[0015] In particular, it is preferable that the paper web has a basis weight of 100 to 300 g/m^2, a thickness of 150 to 500 μm, and a density of 0.5 g/cm^3 or higher, and the paper tube can have a diameter of, for example, 5 to 8 mm.

[0016] The groove can be formed by cutting or using an impression line, and particularly a cut groove formed by cutting is preferable in order to effectively increase the flexibility of the paper web. More particularly, in the case of a cut groove, the cut groove can have a depth of 60 to 90% of the thickness of the paper web, and the interval between adjacent grooves is preferably 2 mm or smaller.

[0017] The paper tube manufacturing machine can be further equipped with: a guide path disposed upstream from the transfer path, for guiding a web-like paper material for forming the paper web onto the transfer path; and a groove forming device disposed on the guide path, for forming multiple grooves in the inner surface of the paper material. In this case, the paper tube manufacturing machine forms online a paper web having multiple grooves.

[0018] The above-described groove forming device includes: a pair of groove processing rollers, which cooperat together to pinch the paper material on the guide path between them, for example, a cutting roller and a receiving roller if a cut groove is to be formed. Such a cutting roller has multiple circular cutting blades arranged in the axial direction thereof, and these circular cutting blades rotate together with the cutting roller to form grooves in the paper material. It is preferable that the circular cutting blade has a cutting edge angle of, for example, 14 to 30°.

[0019] The groove forming device can further include a drive source for rotating the cutting roller so as to make the circumferential speed of the circular cutting blade equal to the feeding speed of the paper material. In this case, as long as the circumferential speed of the circular cutting blade and the feeding speed of the paper material in the cutting roller are equal, the circular cutting blade create no resistance to the feed of the paper material. Therefore, the circular cutting blades can stably form the grooves in the paper material.

[0020] The web bending device can further include a press roller disposed upstream from the tube forming section, and the press roller presses the paper web against the garniture belt. Such a press roller increases the frictional force between the garniture belt and the paper web, thereby assisting the garniture belt in transferring the paper web.

[0021] In this case, the web bending device can further include a drive source for rotating the press roller so as to make the circumferential speed of the press roller equal to the transfer speed of the paper web. When the press roller is rotated in this way, the press roller creates no resistance to the transfer of the paper web and the transfer of the paper web is stabilized.

[0022] In particular, the web bending device further includes: a forming bed extending along the transfer direction of the paper web; and a forming groove formed in the forming bed, for guiding the transfer of the paper web and the garniture belt and forming the paper web through the garniture belt into a U-shape before the paper web and the garniture belt pass through the tube forming section. In this case, the above-described press roller is disposed in the forming groove and presses the U-shaped paper web through the garniture belt against the bottom of the forming groove.

[0023] With respect to the rigidity of the paper web along the transfer direction of the paper web, the rigidity of the paper web formed in a U-shape is higher than the rigidity of the flat paper web. Therefore, the above-described arrangement of the press roller, in which the transfer of the paper web increased in rigidity is assisted by the press roller, is suitable for stabilizing the transfer of the paper web.

[0024] Moreover, the web bending device can further include a preliminary forming guide disposed upstream from the

tube forming section, for forming both side edges of the paper web into an arc shape. Such a preliminary molding guide uniformly imparts a travel resistance to both side edges of the paper web and at the same time pre-bends them. Therefore, both side edges of the paper web can pass through the tube forming section smoothly and the paper web is easily and stably formed into a paper tube.

[0025] On the other hand, the paper bending device is further equipped with a dryer disposed downstream from the tube forming section, for drying the lapped portion of the paper tube. This dryer can include: a heater; a heating rib integrally formed in the heater, for pressing the lapped portion of the paper tube while in sliding contact with the lapped portion; and a pair of regulation guides for pressing both side surfaces of the paper tube through the garniture belt while in sliding contact with both side surfaces during drying of the lapped portion.

[0026] Such a pair of regulation guides prevents the paper tube from expanding in the width direction even when the lapped portion is pressed by the heating rib during drying of the lapped portion. Therefore, both side edges of the paper web are favorably bonded with each other through the adhesive without the overlap of both side edges being separated in the lapped portion.

[0027] The present invention also provides a paper tube manufacturing method and a paper tube manufactured by the manufacturing method. The details of the paper tube manufacturing machine, the manufacturing method, and the paper tube will be revealed by the following description.

Advantageous Effects of the Invention

[0028] Since the paper tube manufacturing machine and the paper tube manufacturing method of the present invention use a paper web which is provided with multiple grooves, it is possible to form a paper web into a paper tube easily and continuously even when the paper material for forming the paper web is thick and highly rigid. In this case, since the paper tube is a single-layered flatwise paper tube, the amount used of the adhesive required for forming the paper tube is small, and since the rigidity of the paper material itself is high, the formed paper tube can have a required rigidity in both the radial direction and the axial direction thereof regardless of with or without the grooves.

Brief Description of the Drawings

[0029]

FIG. 1 is a schematic view showing a paper tube manufacturing machine of one embodiment.
FIG. 2 is a perspective view showing the details of a groove forming device of FIG. 1.
FIG. 3 is a side view of a cutting roller of FIG. 2.
FIG. 4 is an enlarged view showing cut grooves formed in a paper material.
FIG. 5 is a perspective view showing the details of an applicator of FIG. 1.
FIG. 6 is a plan view showing a starting end part of a forming bed.
FIG. 7 is a side view of the forming bed of FIG. 6.
FIG. 8 is a front view showing the starting end part of the forming bed.
FIG. 9 is a plan view of the tube forming section.
FIG. 10 is a side view of the paper tube forming section from its starting end.
FIG. 11 is a view showing a bending process of a paper web in the tube forming section.
FIG. 12 is a front view of a dryer.
FIG. 13 is a graph showing the relation between the depth of the cut groove and the radial strength of a paper tube.
FIG. 14 is a graph showing the relation between the depth of the cut groove and the axial strength of the paper tube.
FIG. 15 is a front view of a test device for obtaining the radial strength of FIG. 13.
FIG. 16 is a side view of the test device of FIG. 15.
FIG. 17 is a front view of a test device for obtaining the axial strength of FIG. 14.
FIG. 18 is a side view of the test device of FIG. 17.
FIG. 19 is a schematic view showing a web manufacturing machine for forming a paper web.

Mode for Carrying out the Invention

[0030] Referring to FIG. 1, there is shown a paper tube manufacturing machine of one embodiment; in the course of the description of the paper tube manufacturing machine, a paper tube manufacturing method will also be revealed. The paper tube manufacturing machine includes a main frame 10, and a web roll WR is rotatably supported through a bobbin holder 12 in a lower part of the main frame 10. In FIG. 1, the bobbin holder 12 is represented only by its hollow shaft at the center thereof.

[0031] The web roll WR can feed a web-like paper material P along a feed path 14, and in this embodiment, the paper

material P has a sufficiently larger thickness and a higher rigidity compared with a cigarette paper used for cigarettes. In particular, the paper material P has a width of approximately 16.7 to 28.1 mm, a basis weight of 100 to 300 g/m^2, a thickness of 150 to 500 μm, and a density of 0.5 g/cm^3 or higher.

[0032] The feed path 14 is defined by a number of guide rollers 16 and connects the web roll WR and a web bending device 18. The web bending device 18 is disposed above the web roll WR and is supported by the main frame 10. Therefore, when viewed in FIG. 1, the feed path 14 extends horizontally from the web roll WR to the right, thereafter extends upward to the reference height of the web bending device 18, and then extends horizontally to the left to reach the web bending device 18.

[0033] The web bending device 18 includes a forming bed 20, and the forming bed 20 extends horizontally at the reference height. Part of an endless garniture belt 22 is disposed on the forming bed 20. Specifically, the garniture belt 22 has an advancing portion extending horizontally on the forming bed 20 and a returning portion located the outside of the forming bed 20.

[0034] The returning portion of the garniture belt 22 is guided by a number of guide rollers 24, and is wound around a drive drum 26 at a predetermined winding angle. The drive drum 26 is connected with the output shaft of an electric motor (not shown), and is rotated at a constant circumferential speed by the drive force of the electric motor. The rotation of such a drive drum 26 causes the advancing portion of the garniture belt 22 to travel at a constant speed from right to left when viewed in FIG. 1.

[0035] Meanwhile, the paper material P is introduced from the above-described feed path 14 onto the advancing portion of the garniture belt 22 and is lapped over the garniture belt 22. Therefore, the paper material P travels along with the advancing portion of the garniture belt 22 due to the frictional force between the garniture belt 22 and the paper material P, and this travel causes the paper material P to be delivered from the web roll WR at a constant speed. The above-mentioned bobbin holder 12 has a built-in brake (not shown), and this brake imparts a predetermined tensile force to the paper material P.

[0036] A groove forming device 28 is disposed on the feed path 14; the details of this groove forming device 28 are shown in FIG. 2 and FIG. 3. The groove forming device 28 includes a cutting roller 30 and a receiving roller 32. These cutting roller 30 and receiving roller 32 are disposed so as to pinch the paper material P on the feed path 14 between them, and are rotatably supported by the main frame 10.

[0037] The cutting roller 30 has multiple circular cutting blades 34 protruding from an outer circumferential surface thereof, and these circular cutting blades 34 are disposed at predetermined intervals in the axial direction of the cutting roller 30. The circular cutting blades 34 have a sharp cutting edge, and the angle of this cutting edge, namely, the cutting edge angle α is, for example, 14 to 30°. By contrast, the receiving roller 32 has a smooth outer circumferential surface.

[0038] When the paper material P passes between the cutting roller 30 and the receiving roller 32, these rollers 30 and 32 rotate in the opposite direction from each other, and as shown in FIG. 4, each of the circular cutting blades 34 forms a V-shaped cut groove G in one surface of the paper material P, and these cut grooves G have an opening angle β corresponding to the cutting edge angle α. Therefore, the paper material P after passing through the groove forming device 28 has become a paper web PW having the multiple cut grooves G.

[0039] Such multiple cut grooves G extend continuously in the feed direction of the paper material P, namely, in the longitudinal direction of the paper material P, and increase the flexibility of the paper web PW. In this embodiment, the cut grooves G are formed in the inner surface of the paper material P which faces upward when the paper web PW is lapped over the garniture belt 22, although these grooves may be formed in the outer surface of the paper material P on the garniture belt 22 side. However, when the cut grooves G are formed in the inner surface of the paper material P, as will be revealed by the following description, the cut grooves G are deformed such that the two opposite inner surfaces of the cut groove G come closer to or into contact with each other when the paper tube is formed from the paper web PW. Thus, such a paper tube can have a higher rigidity compared with a paper tube made of a paper web with the cut grooves G formed in the outer surface of the paper material P.

[0040] In particular, each of the cut grooves G has a depth D_G of 60 to 90% of the thickness T of the paper material P, and the interval S between adjacent cut grooves G is 2 mm or smaller. The interval S is determined by the interval between adjacent circular cutting blades 34, while the depth D_G is determined by the clearance between the cutting edge of the circular cutting blade 34 and the outer circumferential surface of the receiving roller 32. In this embodiment, the clearance is adjustable.

[0041] As described above, the cutting roller 30 and the receiving roller 32 can also form the multiple cut grooves G in the paper material P just by being rotatably supported by the main frame 10. However, from the viewpoint of relieving the load on the paper web PW and securing the stable formation of the cut grooves G, it is preferable that the cutting roller 30 is forcibly rotated along the feed direction of the paper web PW, and that the circumferential speed of the cutting edge in the circular cutting blade 34 is made equal to the feed speed of the paper material P. In addition, for simply facilitating the formation of the cut grooves G, a speed difference may be provided between the circumferential speed of the cutting roller 30 and the feed speed of the paper web PW, or the rotation direction of the cutting roller 30 and the feed direction of the paper web PW may be set to be opposite to each other.

[0042] For this purpose, as shown in FIG. 2, the roller shaft of the cutting roller 30 is connected with a drive source, namely, an electric motor 30_M. On the other hand, this electric motor 30_M is electrically connected with a rotary encoder 38, and this rotary encoder 38 is mounted on the drum shaft of the drive drum 26 described above.

[0043] The rotary encoder 38 sends a rotation signal indicating the circumferential speed of the drive drum 26 to the electric motor 30_M, and on the basis of this signal, the electric motor 30_M rotates the cutting roller 30 so as to make the circumferential speed of the cutting edge in the circular cutting blade 34 equal to the circumferential speed of the drive drum 26, namely, the feed speed of the paper material P.

[0044] As is clear from the above description, the paper material P after passing through the groove forming device 28 has become the paper web PW having the multiple cut grooves G. That is, in this embodiment, the above-described feed path 14 is divided into an upstream portion and a downstream portion at the groove forming device 28, the upstream portion defining a guide path 14_U for guiding the paper material P, while the downstream portion defining the transfer path 14_D for transferring the paper web PW toward the web bending device 18.

[0045] Moreover, as shown in FIG. 1, travel guides 40 are disposed each immediately upstream and immediately downstream from the groove forming device 28. These travel guides 40 guide the travel of the paper material P and the paper web PW, and serve to make the formation of the above-described cut grooves G more stable.

[0046] The web bending device 18 further includes an applicator 42 of an adhesive, the applicator 42 being disposed on the transfer path 14_D; the details of this applicator 42 are shown in FIG. 5. The applicator 42 includes an application nozzle 44, and the application nozzle 44 is disposed immediately above the paper web PW on the transfer path 14_D so as to face downward. In particular, in this embodiment, the application nozzle 44 is disposed immediately above one of both side edges E_1 and E_2 of the paper web PW, that is, the side edges E_1 which is located on the near side when viewed in FIG. 5.

[0047] The application nozzle 44 is connected with an electric pump 46, and the electric pump 46 is connected with an adhesive tank 48. The electric pump 46 suctions the adhesive from the tank 48 while feeding the suctioned adhesive into the application nozzle 44, and thereby the application nozzle 44 discharges the adhesive toward the paper web PW and continuously applies the adhesive to the side edge E_1 of the paper web PW.

[0048] Therefore, the paper web PW having passed the application nozzle 44 has an adhesive layer A extending along the side edge E_1. The width of the adhesive layer A is, for example, approximately 1 to 3 mm. It is preferable that such an adhesive layer A is formed of a constant amount of adhesive per unit length.

[0049] For this purpose, the electric pump 46 is electrically connected with a controller 50 which controls the amount of adhesive discharged from the application nozzle 44. This controller 50 receives a rotation signal sent from the above-mentioned rotary encoder 38 and supplies an application amount signal, which is proportional to the travel speed of the paper web PW, to the electric pump 46. The electric pump 46 is driven in accordance with the application amount signal, and makes the application nozzle 44 discharge the adhesive in a discharge amount corresponding to the travel speed of the paper web PW.

[0050] Moreover, the applicator 42 further includes a support 52 disposed immediately under the transfer path 14_D. This support 52 guides the travel of the paper web PW and maintains a constant aerodynamic force between the side edge E of the paper web PW and the application nozzle 44. In this embodiment, a glue for food-related materials is suitable as the adhesive. For example, the adhesive is selected from the group of CMC-Na, vinyl acetate, EVA, pullulan, and pectin.

[0051] FIG. 6 is a plan view showing a starting end part of the above-mentioned forming bed 20.

[0052] A forming groove 54 is formed in the upper surface of the forming bed 20, and the forming groove 54 extends along the entire length of the forming bed 20 and opens in the shape of a fan in the starting end part of the forming bed 20. Specifically, the forming groove 54 gradually decreases in width from the starting end toward the terminal end of the forming bed 20, and has a constant width in the region except for the starting end part of the forming bed 20.

[0053] The above-described forming groove 54 guides the travel of the garniture belt 22 and the paper web PW. Therefore, when these garniture belt 22 and paper web PW proceed inside the forming groove 54, as is clear from FIG. 7, the garniture belt 22 and the paper web PW are formed by the forming groove 54 into a U-shape in traverse cross-section.

[0054] The web bending device 18 further includes a press roller 56. This press roller 56 is rotatably supported in the starting end part of the forming bed 20. The lower part of the press roller 56 is positioned inside the forming groove 54, and the press roller 56 together with the garniture belt 22 presses the paper web PW, which is in the process of being formed into a U-shape, against the garniture belt 22, namely, the bottom of the forming groove 54.

[0055] Such a press roller 56 serves to increase the frictional force between the paper web PW and the garniture belt 22 and allow the paper web PW to travel along with the garniture belt 22. Therefore, in order to further increase the frictional force, the outer circumferential surface of the press roller 56 is preferably coated with a friction layer 58 as shown in FIG. 8, and for example, the friction layer 58 can be formed from an elastic material such as rubber.

[0056] When the paper web PW and the garniture belt 22 pass through the press roller 56, the press roller 56 rotates by being dragged by the paper web PW. However, to secure a stable travel of the paper web PW, it is preferable that the press roller 56 is forcibly rotated at a circumferential speed equal to the travel speed of the paper web PW. For this

purpose, the roller shaft of the press roller 56 is connected with a drive source, namely, an electric motor 56_M, and this electric motor 56_M rotates the press roller 56 on the basis of the aforementioned rotation signal.

[0057] The above-described press roller 56 can also be disposed so as to cooperate with the guide roller 24 to pinch the paper web PW and the garniture belt 22 between them near the starting end of the forming bed 20. However, when the focus is placed on the rigidity of the paper web PW along the travel direction of the paper web PW, the rigidity of the paper web PW when it is formed in a U-shape is higher than the rigidity of the paper web PW when it is flat. Therefore, the press roller 56 disposed in the forming groove 54 can impart a more powerful feeding force to the paper web PW without causing undesirable deformation of the paper web PW.

[0058] The above-described web bending device 18 further includes a tube forming section 60, and this tube forming section 60 is disposed downstream from the press roller 56, immediately above the forming bed 20. FIG. 9 is a plan view of the tube forming section 60.

[0059] As shown in FIG. 9, the tube forming section 60 includes a first forming guide 62 and a second forming guide 64, and these first and second forming guides 62 and 64 extend along the travel direction of the paper web PW. Specifically, the first forming guide 62 is disposed on the far side in the forming bed 20, namely, on the side edge E_2 side of the paper web PW, while the second forming guide 64 is disposed immediately downstream from the first forming guide 62 in the travel direction of the paper web PW, on the side edge E_1 side of the paper web PW.

[0060] As shown in FIG. 10, the first and second forming guides 62 and 64 have ceiling surfaces 62c and 64c, respectively, facing the forming groove 54, and these ceiling surfaces 62c and 64c have a shape of an arc of approximately a quarter of a circle. These ceiling surfaces 62c and 64c are open wider at the starting end of the corresponding forming guide, and are gradually narrowed into an arc shape from the starting end to the terminal end of the forming guide.

[0061] When the paper web PW having already been bent into a U-shape passes through the tube forming section 60, first, a side surface S_2 of the paper web PW on the side edge E_2 side enters the first forming guide 62 along with the garniture belt 22, and the side surface S_2 is guided to the ceiling surface 62c through the garniture belt 22 and bent into an arc shape. Thereafter, the side surface S_1 of the paper web PW on the side edge E_1 side enters the second forming guide 64 along with the garniture belt 22, and the side surface S_1 is guided through the garniture belt 22 to the ceiling surface 64c and bent into an arc shape.

[0062] The bending process of the side surfaces S_2 and S_1 described above is sequentially performed in the course of traveling of the U-shaped paper web PW; FIG. 11 shows how the side surface S_1 is bent after the side surface S_2.

[0063] When the bending process of the side surface S_1 is completed, the side edge E_1 of the side surface S_1 is lapped over the side edge E_2 of the side surface S_2 which has been bent into an arc shape, and these side edges E_1 and E_2 form a lapped portion L. As described above, since the adhesive layer A (see FIG. 5) has been formed on the side edge E_1, the side edges E_1 and E_2 forming the lapped portion L are bonded with each other through the adhesive layer A.

[0064] At this time, the paper web PW is formed into a hollow tube HT with a diameter of 5 to 8 mm, and this hollow tube HT is continuously sent out from the tube forming section 60. As is clear from the description above, the tube forming section 60 is basically similar in structure to the rod forming section of a manufacturing machine for manufacturing cigarette rods or filter rods.

[0065] On the other hand, as shown in FIG. 9, a preliminary forming guide 66 is disposed immediately upstream from the tube forming section 60, and the preliminary forming guide 66 has a shape of, for example, a halved taper tube, and has a semi-circular ceiling surface 66c facing the forming groove 54. The ceiling surface 66c is open wider at the starting end of the preliminary forming guide 66 and is narrowed into a semi-circular shape toward the terminal end of the preliminary forming guide 66.

[0066] When the paper web PW having been bent into a U-shape is transferred by the garniture belt 22 and passes through the preliminary forming guide 66, both the side surfaces S_1 and S_2 of the paper web PW enter the preliminary forming guide 66 and are concurrently curved into an arc shape by the ceiling surface 66c of the preliminary forming guide 66.

[0067] Thus, the preliminary forming guide 66 preliminarily curves the side surfaces S_1 and S_2 of the paper web PW on the upstream of the tube forming section 60, and imparts a travel resistance through the garniture belt 22 to each of the side surfaces S_1 and S_2. Therefore, even when, at the downstream of the preliminary forming guide 66, the side surface S_2 of the paper web PW enters the first forming guide 62 of the tube forming section 60 and the travel resistance is imparted to one side of the paper web PW through the side surface S_2 thereof, the travel of the paper web PW does not become unstable.

[0068] Further, since the preliminary forming guide 66 pre-bends the side surfaces S_1 and S_2 of the paper web PW, the side surfaces S_1 and S_2 enter the tube forming section 60 more smoothly.

[0069] On the other hand, when the above-described press roller 56 is rotated by the electric motor 56_M, the press roller 56 forcibly feeds the paper web PW toward the tube forming section 60. As a result, the press roller 56 and the preliminary forming guide 66 work together or individually to allow the side surface S_2 of the paper web PW to smoothly enter the first forming guide 62, and the preliminary forming guide 66 serves to stabilize the forming of the above-described hollow tube HT.

[0070] As shown in FIG. 12, a dryer 68 is disposed immediately downstream from the above-described tube forming section 60. The dryer 68 includes an electric heater 70 having a block-like shape. The heater 70 is disposed immediately above the forming groove 54 and extends along the travel direction of the paper web PW. A heating rib 72 integrally protrudes from the lower surface of the heater 70, and the heating rib 72 also extends in the travel direction of the paper web PW.

[0071] The lapped portion L of the hollow tube HT sent out from the tube forming section 60 is pressed by the heating rib 72, and at the same time, comes into sliding contact with the heating rib 72. Therefore, the lapped portion L is subjected to the heat from the heating rib 72 and dried, and thereby the side edges E_1 and E_2 forming the lapped portion L are firmly bonded with each other.

[0072] Further, regulation guides 74 are disposed on both sides of the heater 70, and these regulation guides 74 extend in the travel direction of the paper web PW. The hollow tube HT sent out from the tube forming section 60 is sandwiched from both sides between the regulation guides 74 and comes into sliding contact with these regulation guides 74.

[0073] When the heating rib 72 presses the lapped portion L, the regulation guides 74 prevent the hollow tube HT from expanding in the width direction. Therefore, during the drying treatment of the lapped portion L, the overlap of the side edges E_1 and E_2 forming the lapped portion L is not separated, and these side edges E_1 and E_2 are favorably bonded with each other.

[0074] In particular, when the basis weight, the thickness, and the travel speed of the paper web PW, and the application amount of the adhesive layer A are respectively 200 g/m^2, 250 μm, 2 m/min (33.3 mm/sec.), and 5 to 10 mg/m, the heating temperature of the heater 70 required for the drying treatment of the lapped portion L was approximately 170°C, although it depends on the type of the adhesive.

[0075] The drying state of the adhesive in the lapped portion L is determined by the heating temperature and the heating time of the adhesive. Thus, the heating temperature H_T (°C) is obtained from the following formula, where a constant obtained by experiments is C, the travel speed of the paper web PW is V (mm/sec), and the length of the heater 70 is L_H (mm) :

$$H_T = (C \times V) / L_H$$

In this embodiment, the length of the heater 70 is 70 mm.

[0076] In order to stably perform the drying treatment of the lapped portion L with the difference in the type of paper web PW, namely, the paper material P, and the adhesive taken into consideration, it is desirable that the heating temperature required of the heater 70 be set higher than the heating temperature H_T obtained from the above formula.

[0077] As shown in FIG. 1, a cutting device 76 is disposed downstream from the web bending device 18. The hollow tube HT having passed through the web bending device 18 passes through the cutting device 76 in which the hollow tube HT is cut into predetermined lengths, and the individual paper tubes PT are formed at this time.

[0078] Table 1 below shows the relation between the depth of the cut grooves G of the paper web PW and creases of the paper web PW appearing in the outer circumferential surface of the formed paper tube PT. Here, the paper web PW of the paper tube PT had a basis weight of 200 g/m^2, a thickness of 250 μm, a density of 0.83 g/m^3, and the diameter of the paper tube PT was 7.2 mm.

[Table 1]

CUT GROOVE DEPTH D_G	0%	60%	70%	80%	90%
CREASE	WITH CREASE	WITHOUT CREASE	WITHOUT CREASE	WITHOUT CREASE	WITHOUT CREASE

[0079] As is clear from Table 1, when the cut grooves G are formed in the paper web PW to a depth of 60 to 90% of the thickness, no crease appeared in the outer circumferential surface of the paper tube PT and a paper tube PT having a smooth outer circumferential surface was obtained. The depth D_G of 0% means that the paper web PW has no cut groove G.

[0080] The creases of the paper tube PT is likely to occur in the forming process, especially in the process of the U-shaped paper web PW passing through the tube forming section 60. That is, when the flexibility of the side surfaces S_1 and S_2 in the paper web PW is low, these side surfaces S_2 and S_1 cannot smoothly enter the first forming guides 62 and 64 and are buckled at the inlet of these forming guides 62 and 64.

[0081] FIG. 13 shows the relation between the depth of the cut grooves G and the radial strength of the paper tube

PT, and FIG. 14 shows the relation between the depth of the cut grooves G and the axial strength of the paper tube PT. In FIGS. 13 and 14, the strengths of a cigarette and a cigarette filter are also shown.

[0082] The results of FIG. 13 were obtained with a first test device 78 shown in FIG. 15 and FIG. 16. This first test device 78 includes a rest 80, and the rest 80 has a V-shaped groove 82 on the upper surface thereof. The paper tube PT under test is retained in a horizontal posture inside the V-shaped groove 82. The first test device 78 further includes a pusher 84, and the pusher 84 is disposed above the reste 80 so as to be able to move up and down.

[0083] The pusher 84 is lowered toward the paper tube PT retained on the rest 80, and pushes the outer circumferential surface of the paper tube PT by a predetermined distance in the radial direction of the paper tube PT. At this time, the first test device 78 measured the reaction force, which was received from the paper tube PT through the pusher 84, as the radial strength of the paper tube PT. The radial strengths of the cigarette and the filter were also measured in the same manner as with the paper tube PT.

[0084] The results of FIG. 14 were obtained with an axial test device 86 shown in FIG. 17 and FIG. 18. The test device 86 includes a flat base 88, and the paper tube PT under test was placed on the base 88 in a vertical posture. The test device 86 also further includes a pusher 90, and the pusher 90 can also move up and down.

[0085] The pusher 90 is lowered toward the upper end of the paper tube PT from above the paper tube PT, and pushes the upper end of the paper tube PT by a predetermined distance in the axial direction of the paper tube PT. At this time, the test device 86 measured the reaction force, which was received from the paper tube PT through the pusher 90, as the axial strength of the paper tube PT. The axial strengths of the cigarette and the filter were also measured in the same manner as with the paper tube PT.

[0086] As is clear from FIG. 13, with respect to the radial strength of the paper tube PT, the strength of the paper tube PT having the cut grooves G tends to be lower than the strength of the paper tube PT having no cut grooves G. However, there is little difference between these strengths. In addition, the strength of the paper tube PT having the cut grooves G is sufficiently higher compared with the strength of the cigarette or the filter. This means that the paper tube PT is rigid enough not to be easily crushed by the force with which it is held lightly between the fingers of a user.

[0087] On the other hand, as is clear from FIG. 14, with respect to the axial strength of the paper tube PT, almost no difference occurs in the strength of the paper tube PT regardless of whether it has cut grooves G or not. In addition, the strength of the paper tube PT is sufficiently higher compared with the strength of the cigarette or the filter.

[0088] These results have proven that the paper tube PT having the cut grooves G has sufficient rigidity in both the radial direction and the axial direction, and at the same time, as described above, can be continuously manufactured with the above-described paper tube manufacturing machine without developing creases on the outer circumferential surface thereof. Thus, the paper tube PT of this embodiment is suitable for the pipe member of the above-described flavor inhaler.

[0089] The present invention is not restricted to the paper tube manufacturing machine of the above-described one embodiment or the paper tube manufacturing method implemented with the paper tube manufacturing machine.

[0090] For example, while the above-described paper tube manufacturing machine forms the paper web PW on the feed path 14, the paper web PW may also be formed by a web manufacturing machine separate from the paper tube manufacturing machine; FIG. 19 shows one example of the web manufacturing machine.

[0091] For the description of this web manufacturing machine, components which have the same function as the components of the paper tube manufacturing machine will be denoted by the same reference signs and the description thereof will be omitted.

[0092] As shown in FIG. 19, the web manufacturing machine includes a web roll WR_1 of the paper material P, and the web roll WR_1 is connected with the bobbin holder 12 through a travel path 92. The travel path 92 is defined by many guide rollers 94.

[0093] The bobbin holder 12 is connected with an electric motor 96, and the electric motor 96 rotates the bobbin holder 12 such that the travel of the paper material P (paper web PW) becomes constant. When this bobbin holder 12 is rotated, the paper material P is delivered from the web roll WR_1. The delivered paper material P travels along the travel path 92 and is wound around the bobbin holder 12.

[0094] The groove forming device 28 described above is disposed on the travel path 92. When the paper material P passes through the groove forming device 28, the groove forming device 28 as described above forms the multiple cut grooves G in the paper material P and forms the paper material P into the paper web PW. Therefore, the paper web PW is wound around the bobbin holder 12, and thereby a web roll WR_2 of the paper web PW is formed. Such a web roll WR_2 is mounted on the paper tube manufacturing machine of FIG. 1 and used to manufacture the paper tube PT. In this case, needless to say, the groove forming device 28 has been removed from the paper tube manufacturing machine.

[0095] Finally, the numerical values indicating the specifications of the above-described paper material P and the paper web PW are mere examples, and these values can be appropriately selected according to the diameter of the paper tube to be formed.

Explanation of Reference Signs

[0096]

14	Feed path
14_U	Guide path
14_D	Transfer path
18	Web bending device
20	Forming bed
22	Garniture belt
28	Groove forming device
30	Cutting roller
30_M	Electric motor (drive source)
32	Receiving roller
34	Circular cutting blade
42	Applicator
54	Forming groove
56	Press roller
56_M	Electric motor (drive source)
60	Tube forming section
66	Preliminary forming guide
68	Dryer
70	Heater
72	Heating rib
74	Restriction guide
α	Cutting edge angle
G	Cut groove
L	Lapped portion
P	Paper material
PT	Paper tube
PW	Paper web

Claims

1. A paper tube manufacturing machine comprising:

a transfer path for guiding transfer of a paper web, the paper web having multiple grooves which extend along a transfer direction of the paper web and increase the flexibility of the paper web; and
a web bending device disposed on said transfer path, for bending the paper web, wherein
said web bending device includes:

an endless garniture belt for transferring the paper web along said transfer path;
a tube forming section for forming the paper web continuously into a hollow cylindrical paper tube through the garniture belt while maintaining an inner surface of the paper web in a free state in the course of the transfer of the papar web, the paper tube having a lapped portion where both side edges of the paper web are lapped; and
an applicator for applying an adhesive to one of both side edges of the paper web before the lapped portion is formed, to thereby bond both side edges with each other in the lapped portion.

2. The paper tube manufacturing machine according to claim 1, wherein the grooves are cut grooves.

3. The paper tube manufacturing machine according to claim 1, further comprising:

a guide path disposed upstream from the transfer path, for guiding a web-like paper material to be formed as the paper web onto said transfer path; and
a groove forming device disposed on said guide path, for forming the grooves in at least one of an inner surface and an outer surface of the paper material.

4. The paper tube manufacturing machine according to claim 3, wherein the grooves are cut grooves.

5. The paper tube manufacturing machine according to claim 4, wherein
said groove forming device includes a cutting roller and a receiving roller which cooperate together to pinch the paper material on said guide path therebetween, and
the cutting roller has multiple circular cutting blades arranged in an axial direction thereof, and the circular cutting blades rotate together with the cutting roller to form the cut grooves in the paper material.

6. The paper tube manufacturing machine according to claim 5, wherein the circular cutting blade has a cutting edge angle of 14 to 30°.

7. The paper tube manufacturing machine according to claim 5, wherein said groove forming device further includes a drive source for rotating the cutting roller so as to make a circumferential speed of the circular cutting blade equal to a feeding speed of the paper material.

8. The paper tube manufacturing machine according to claim 1 or 2, wherein said web bending device further includes a press roller disposed upstream from said tube forming section, for pressing the paper web against the garniture belt.

9. The paper tube manufacturing machine according to claim 8, wherein said web bending device further includes a drive source for roatating the press roller so as to make a circumferential speed of the press roller equal to the transfer speed of the paper web.

10. The paper tube manufacturing machine according to claim 8 or 9, wherein
said web bending device further includes:

a forming bed extending along the transfer direction of the paper web; and
a forming groove formed in the forming bed, for guiding the transfer of the paper web and the garniture belt and forming the paper web through the garniture belt into a U-shape before the paper web and the garniture belt pass through said tube forming section, and
the press roller is disposed in the forming groove and presses the U-shaped paper web through the garniture belt against a bottom of the forming groove.

11. The paper tube manufacturing machine according to claim 1 or 2, wherein said web bending device further includes a preliminary forming guide disposed upstream from said tube forming section, for formings preliminarily both side edges of the paper web into an arc shape.

12. The paper tube manufacturing machine according to claim 1 or 2, wherein
said paper bending device further includes a dryer disposed downstream from said tube forming section, for drying the lapped portion of the paper tube, and
the dryer includes: a heater; a heating rib integrally formed in the heater, for pressing the lapped portion of the paper tube while in sliding contact with the lapped portion; and a pair of regulation guides for pressing both side surfaces of the paper tube through the garniture belt while in sliding contact with both side surfaces during drying of the lapped portion.

13. The paper tube manufacturing machine according to claim 1 or 2, wherein
the paper web has a basis weight of 100 to 300 g/m^2, a thickness of 150 to 500 μm, and a density of 0.5 g/cm^3 or higher, and
the paper tube has a diameter of 5 to 8 mm.

14. The paper tube manufacturing machine according to claim 1 or 2, wherein
the cut groove has a depth of 60 to 90% of the thickness of the paper web, and
the interval of adjacent cut grooves is 2 mm or smaller.

15. A paper tube manufacturing method comprising:

preparing a web-like paper material, and a paper web having multiple grooves formed in the paper material to extend in a longitudinal direction of the paper material, the groove increasing flexibility of the paper material;
in the course of transferring the paper web along a transfer path, continuously forming the paper web through

a garniture belt into a hollow cylindrical paper tube having a lapped portion where both side edges of the paper web are lapped, while maintaining an inner surface of the paper web in a free state; and
applying an adhesive to one of both side edges of the paper web before the lapped portion is formed, to thereby bond both side edges forming the lapped portion with each other.

16. The paper tube manufacturing method according to claim 15, wherein the grooves are cut grooves.

17. The paper tube manufacturing method according to claim 16, wherein the cut grooves are formed in the paper material in the course of the paper material being guided toward the transfer path.

18. The paper tube manufacturing method according to any one of claims 15 to 17, wherein the paper web is pressed against the garniture belt before both side edges of the paper web are sequentially bent into an arc shape.

19. A paper tube manufactured by the paper tube manufacturing method according to claim 15.

FIG. 1

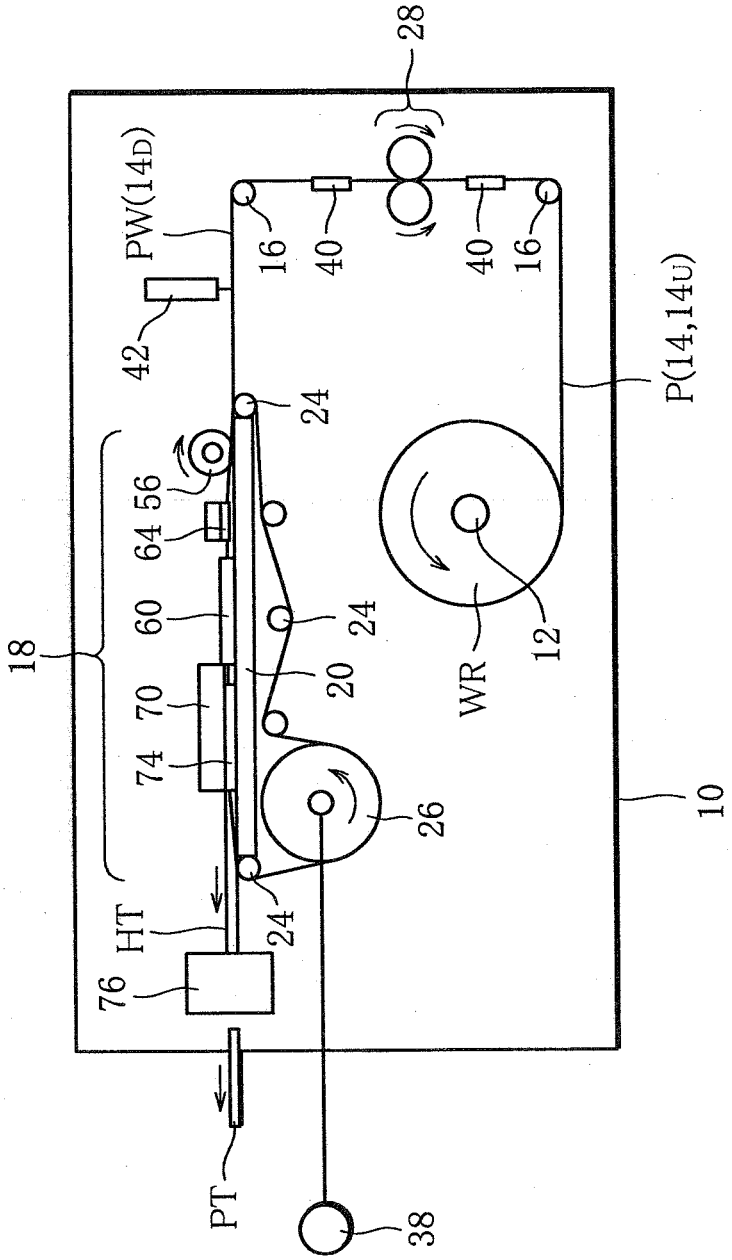

28
PW(14D)
16
40
40
16
42
24
P(14,14U)
64
56
60
24
18
20
WR
12
70
74
26
10
HT
24
76
PT
38

FIG. 2

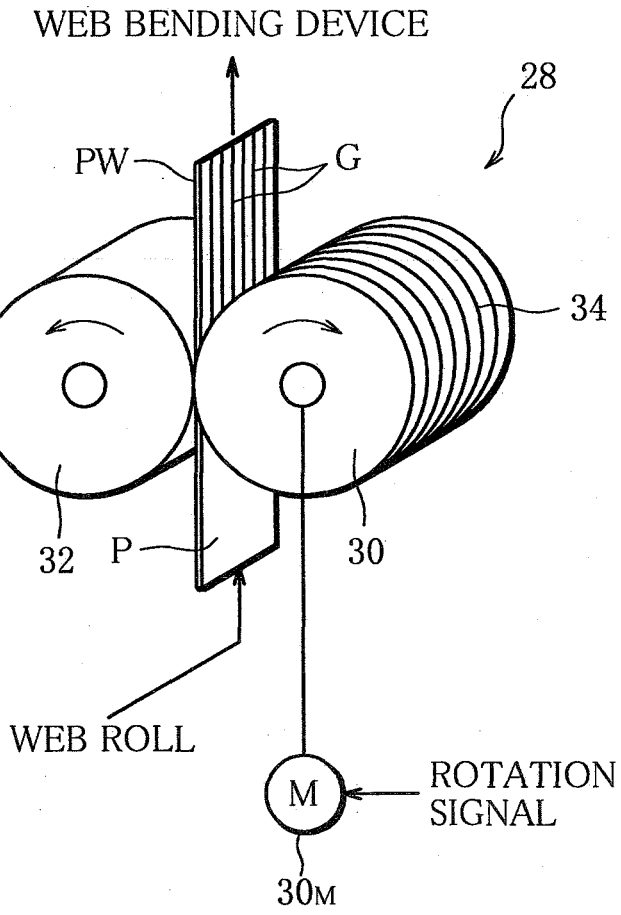

WEB BENDING DEVICE
28
PW
G
34
32
P
30
WEB ROLL
M
ROTATION SIGNAL
30M

FIG. 3

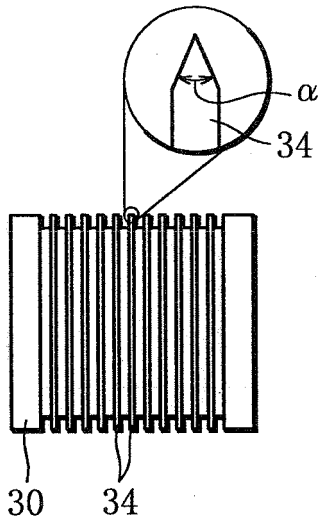


FIG. 4

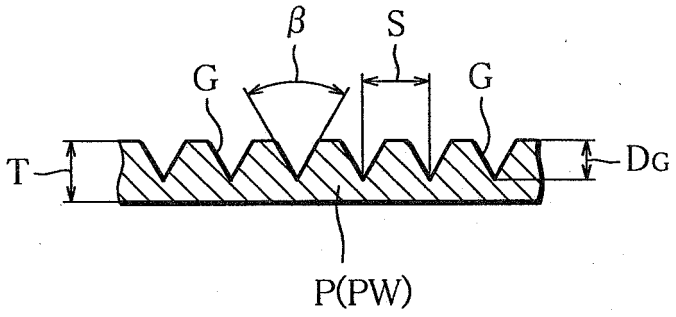


FIG. 5

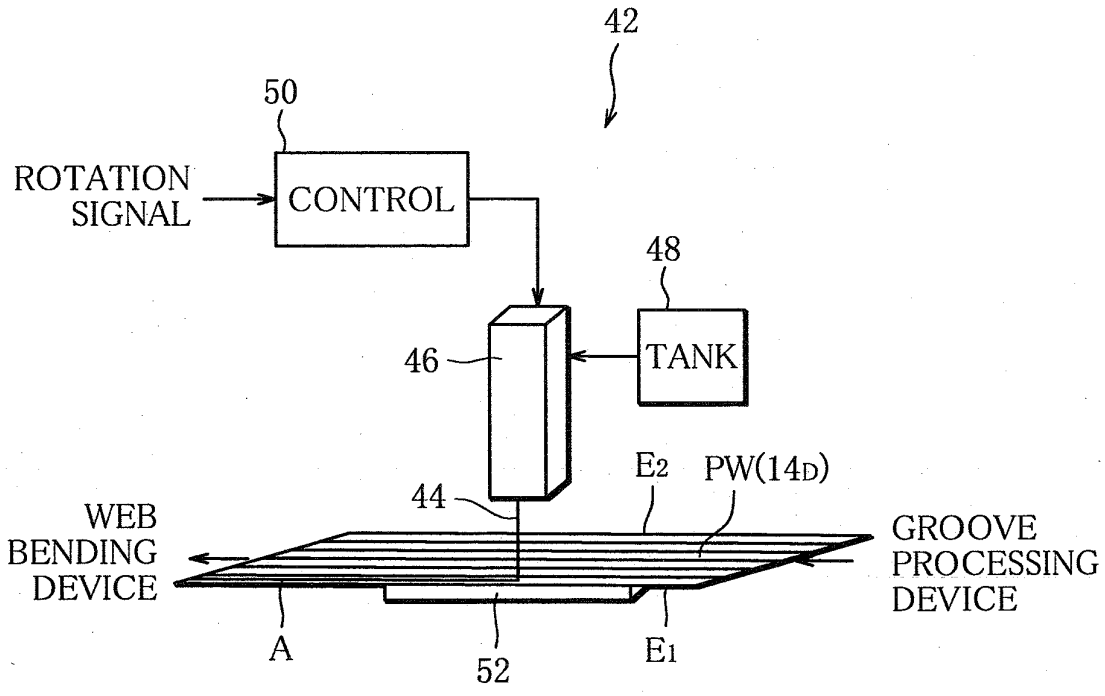

42
50
ROTATION SIGNAL
CONTROL
48
TANK
46
44
E2
PW(14D)
WEB BENDING DEVICE
GROOVE PROCESSING DEVICE
A
52
E1

FIG. 6

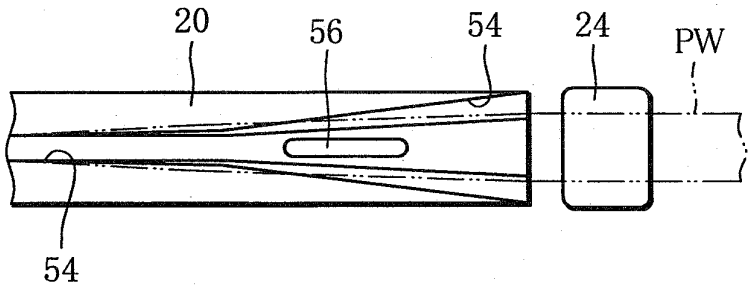

20
56
54
24
PW
54

FIG. 7

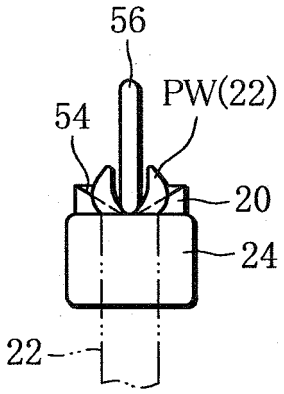

56
PW(22)
54
20
24
22

FIG. 8

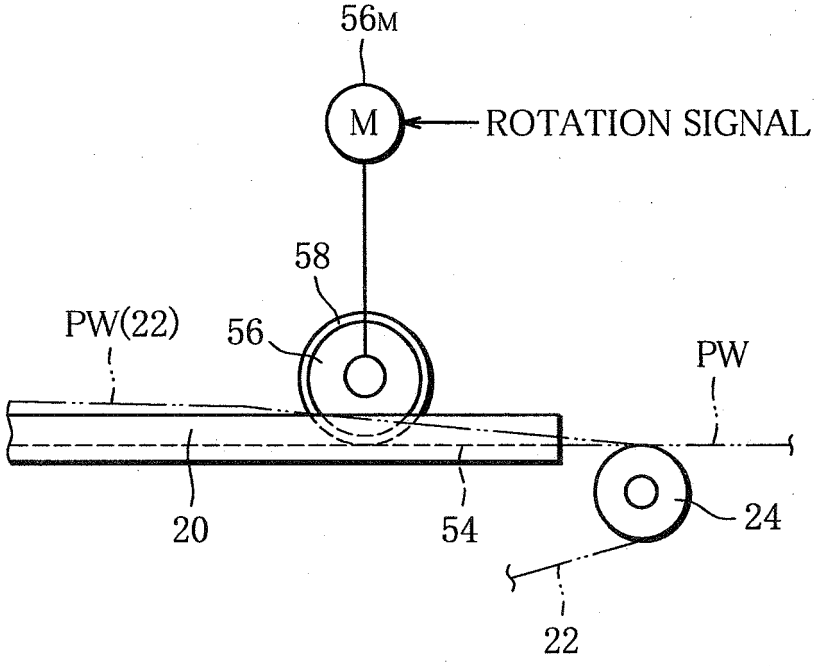

56M
M
ROTATION SIGNAL
58
PW(22)
56
PW
20
54
24
22

FIG. 9

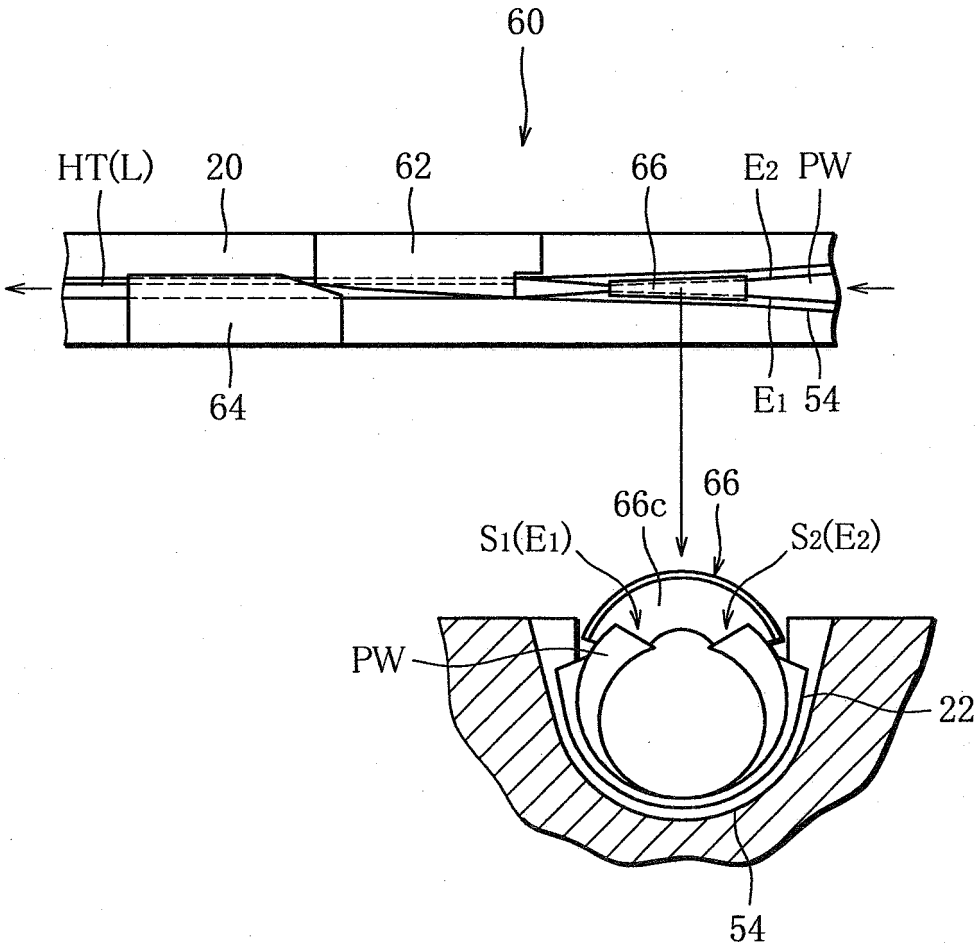


FIG. 10

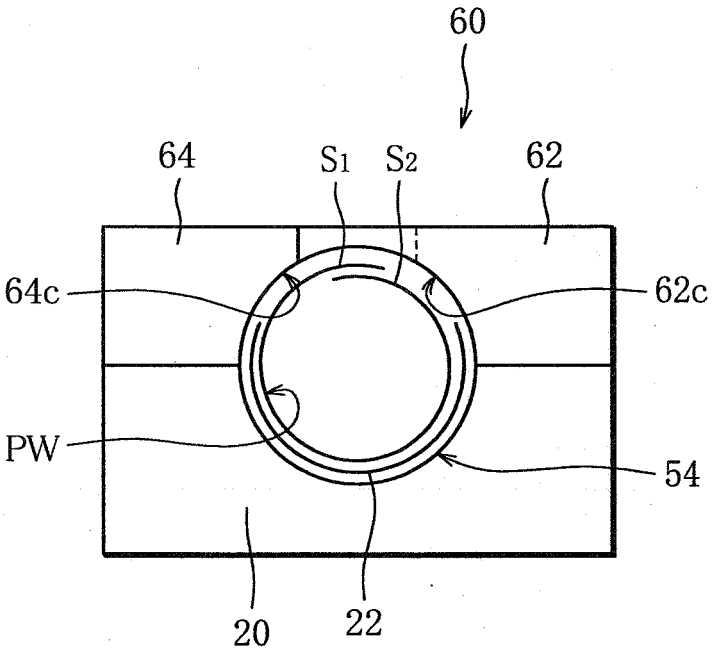


FIG. 11

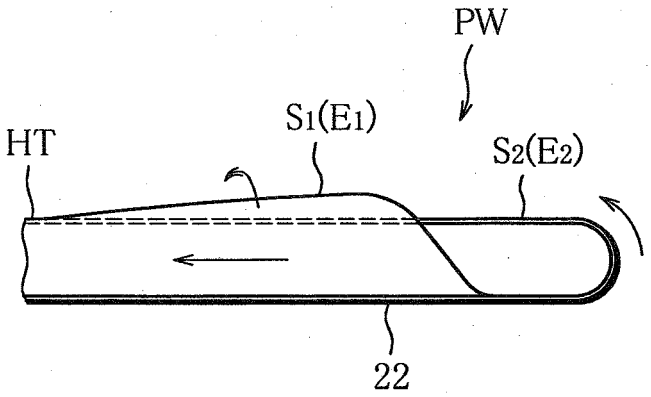


FIG. 12

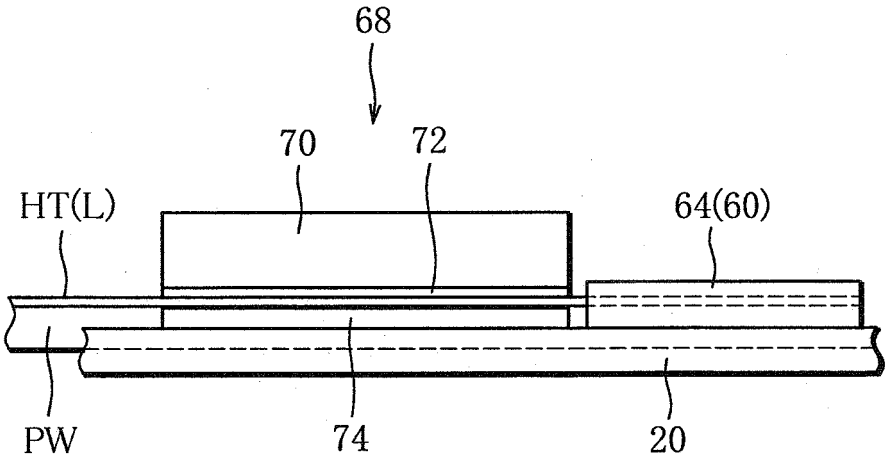

68
70
72
HT(L)
64(60)
PW
74
20

FIG. 13

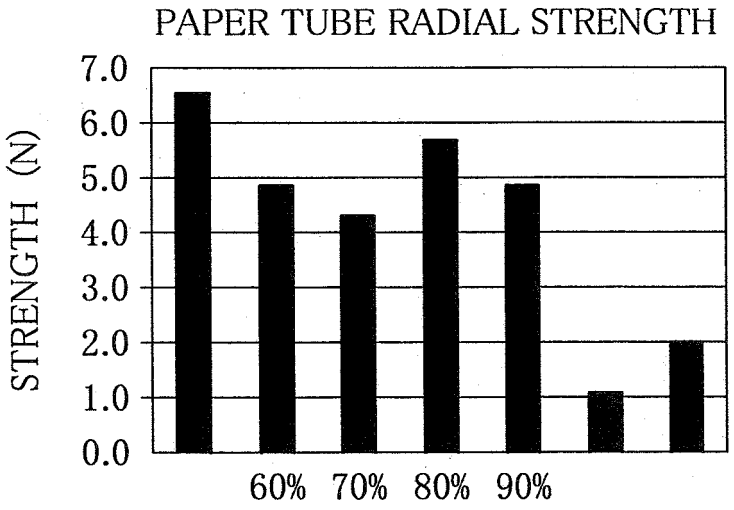

PAPER TUBE RADIAL STRENGTH
STRENGTH (N)
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
60%
70%
80%
90%

FIG. 14

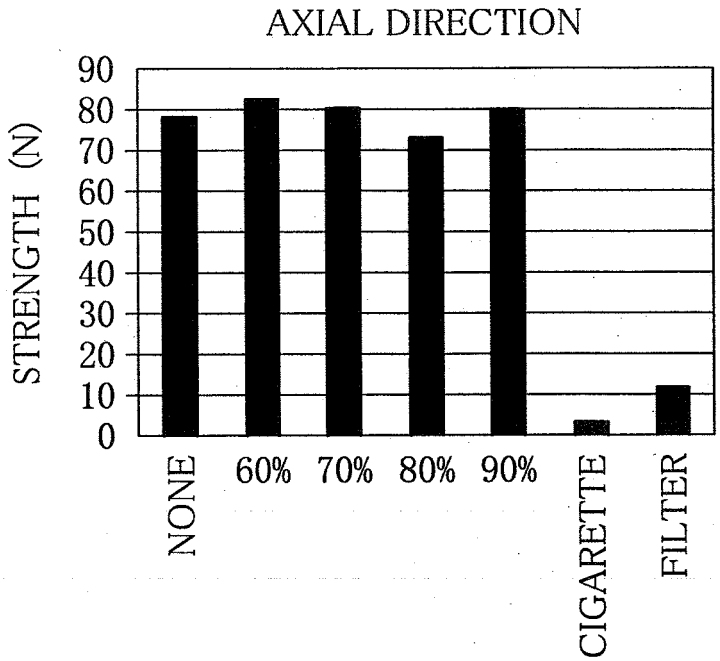

AXIAL DIRECTION
STRENGTH (N)
90
80
70
60
50
40
30
20
10
0
NONE
60%
70%
80%
90%
CIGARETTE
FILTER

FIG. 15

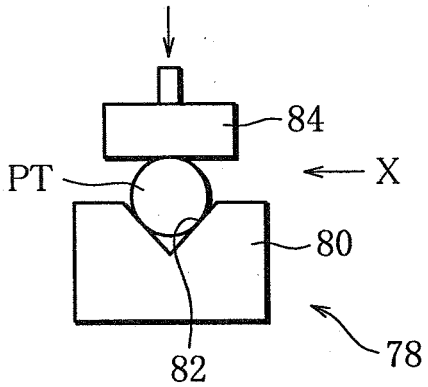

84
PT
X
80
82
78

FIG. 16

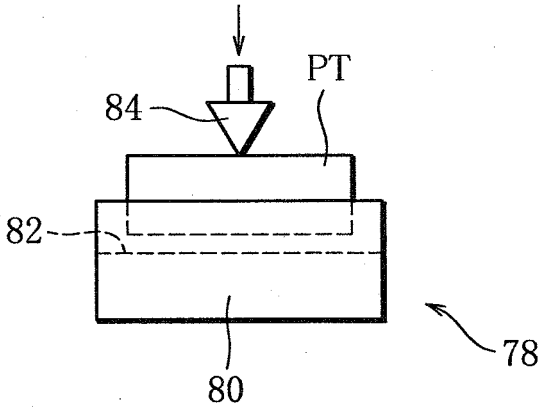


FIG. 17

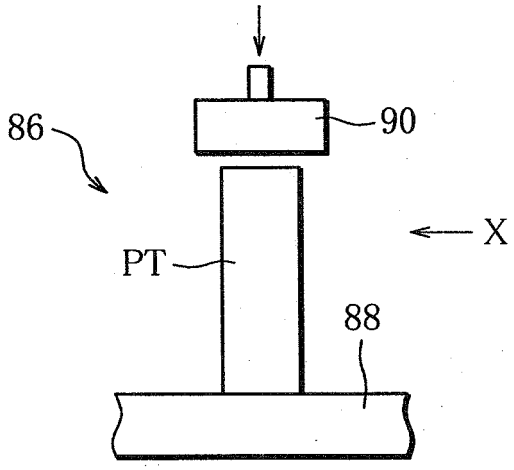


FIG. 18

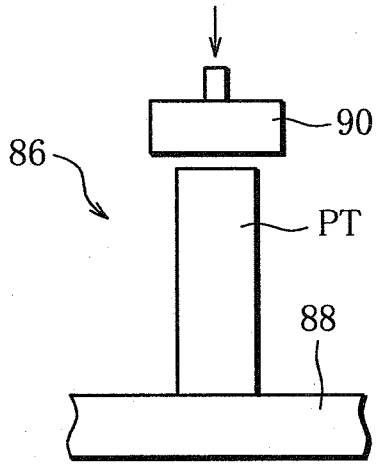
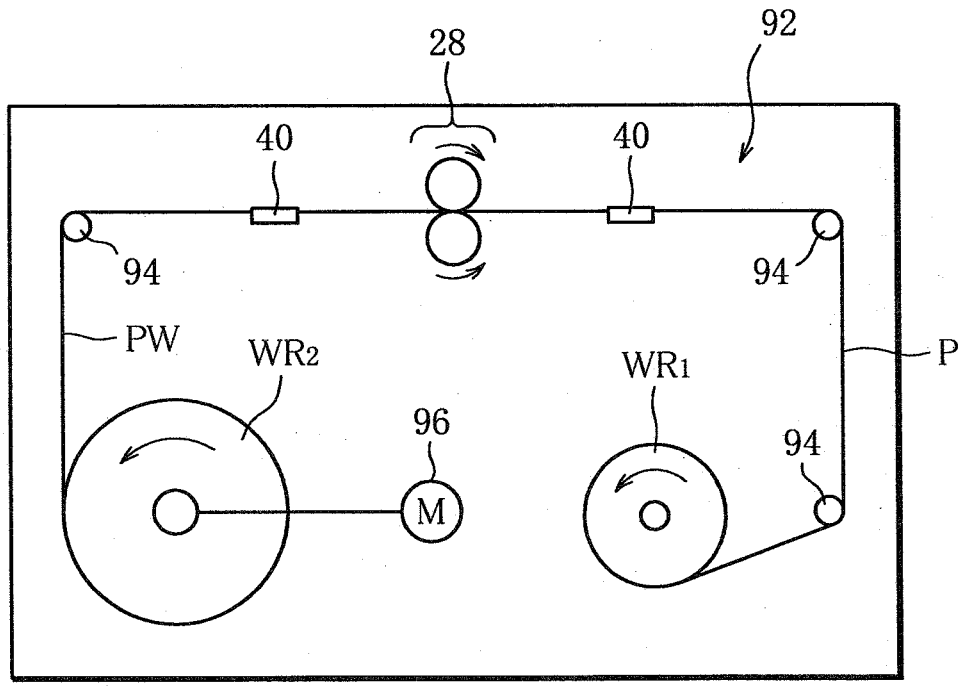


FIG. 19



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/078178

A. CLASSIFICATION OF SUBJECT MATTER
A24F47/00(2006.01)i, *A24C5/14*(2006.01)i, *B31F1/08*(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A24F47/00, A24C5/14, B31F1/08

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2013
Kokai Jitsuyo Shinan Koho 1971-2013 Toroku Jitsuyo Shinan Koho 1994-2013

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 4740506 B2 (Philip Morris Products Inc.), 03 August 2011 (03.08.2011), fig. 7, 8 & JP 2003-527127 A & US 2002/0005207 A1 & US 2004/0020500 A1 & EP 1265504 A & WO 2001/070054 A1 & DE 60139307 D & AU 5294901 A & CA 2403378 A & BR 109685 A & MA 25744 A & ZA 200208402 A & HK 1048235 A & DK 1265504 T & ES 2329546 T & CA 2680291 A	1-19
A	JP 4530371 B2 (Japan Tobacco Inc.), 25 August 2010 (25.08.2010), fig. 1, 2 & WO 2006/064704 A1	1-19

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 January, 2013 (25.01.13)	05 February, 2013 (05.02.13)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/078178

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 3782394 B2 (Japan Tobacco Inc.), 07 June 2006 (07.06.2006), fig. 1 to 5 & WO 2002/019848 A1	1-19
A	JP 06-097982 B2 (Sanjo Machine Works, Ltd.), 07 December 1994 (07.12.1994), fig. 1 to 5 & JP 3-103165 A	1-19
A	JP 2010-535530 A (Philip Morris Products S.A.), 25 November 2010 (25.11.2010), fig. 1, 2 & US 2009/0065011 A1 & EP 2173204 A & WO 2009/022232 A2 & AR 67895 A & CA 2696060 A & KR 10-2010-0054141 A & MX 2010001649 A & EA 201070253 A & CN 101778578 A & ZA 201000098 A & TW 200934399 A & AU 2008288170 B	1-19

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2010535530 A **[0007]**