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(54) ROLL-BENDING PROCESS APPARATUS AND ROLL-BENDING PROCESS METHOD

(57) A roll-bending process apparatus (100) including a pushing roll (10) having a cylindrical side surface and two receiving rolls (11 and 12) each having a cylindrical side surface is provided. The roll-bending process apparatus (100) bends a work (20) by pushing the pushing roll (10) toward the receiving rolls (11 and 12). The roll-bending process apparatus (100) forms a taper-shaped bending-formed article by adjusting a pushing amount of the pushing roll (10) so that a first pushing amount on one end side (10a) of the pushing roll (10) is different from a second pushing amount on the other end side (10b) of the pushing roll (10).

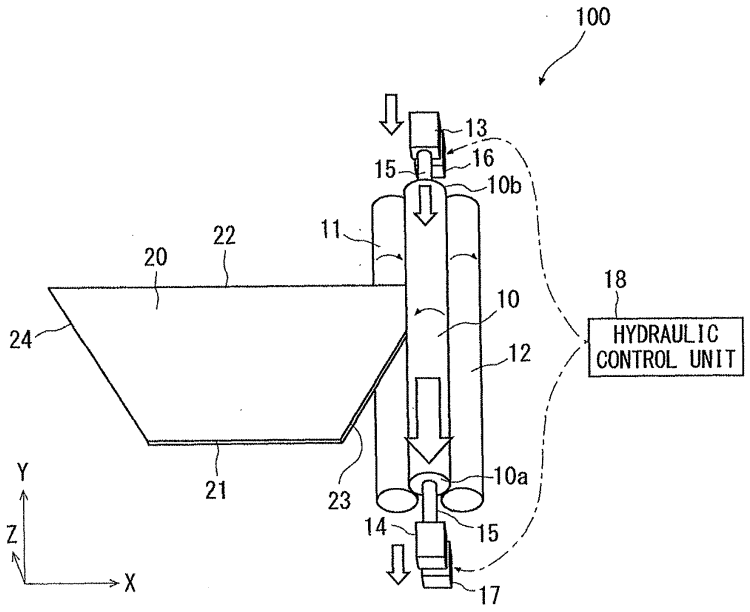

Fig. 1

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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a roll-bending process apparatus and a roll-bending process method. In particular, the present invention relates to a roll-bending process apparatus and a roll-bending process method for forming a bending-formed article having a tapered shape.

2. Description of Related Art

[0002] A bending-formed article having a tapered shape is manufactured by bending a plate material having a trapezoidal shape or a fan-like shape. In the process for bending the plate material, a roll-bending process apparatus, for example, is used.

[0003] For example, Japanese Unexamined Patent Application Publication No. 2012-236207 discloses a roll-bending process apparatus including three truncated-cone shaped rolls. As an example of this apparatus, Fig. 6 shows a roll-bending process apparatus 600. The roll-bending process apparatus 600 forms a conical tubular formed article by making a roughly trapezoidal plate-like work 70 pass between a pushing roll 60 and receiving rolls 61 and 62 while pushing the pushing roll 60 toward the receiving rolls 61 and 62, and thereby bending the plate-like work 70.

[0004] Note that the pushing distance that the pushing roll 60 pushes the work 70 is roughly constant in the longitudinal direction of the pushing roll 60. For example, the pushing distance at one end 60a of the pushing roll 60 is roughly equal to that at the other end 60b of the pushing roll 60. When the work 70 passes between the pushing roll 60 and the receiving rolls 61 and 62, an upper bottom 71 of the work 70 passes between rolls on the side of the one end 60a and a lower bottom 72 of the work 70 passes between these rolls on the side of the other end 60b. As a result, the work 70 is bent so as to conform to the side surface of the pushing roll 60. The pushing roll 60 has a shape tapered in such a manner that the pushing roll 60 becomes narrower from the side of the other end 60b toward the side of the one end 60a. Therefore, the side surface of the pushing roll 60 is inclined. Consequently, the lower bottom 72 is bent at a curvature lower than that of the upper bottom 71, thus making it possible to obtain a conical tubular formed article having a predetermined taper angle.

SUMMARY OF THE INVENTION

[0005] The present inventors have found the following problem. In some cases, it is desired to obtain bending-formed articles having different taper angles. For such cases, the roll-bending process apparatus disclosed in Japanese Unexamined Patent Application Publication No. 2012-236207 can form conical tubular formed articles having different taper angles by changing the rolls to other truncated-cone shaped rolls having different taper angles. However, it is necessary to prepare a plurality of truncated-cone shaped rolls having different taper angles according to the taper angles of the conical tubular formed articles to be formed.

[0006] Further, truncated-cone shaped rolls have a complex structure compared to that of cylindrical rolls. In addition, truncated-cone shaped rolls are not widely used and hence are not general-purpose rolls. Therefore, the preparation of a plurality of types of truncated-cone shaped rolls having different taper angles requires a high facility cost.

[0007] Accordingly, the present invention has been made in view of the above-described circumstances and an object thereof is to provide a roll-bending process apparatus and a roll-bending process method capable of forming bending-formed articles having different taper angles even when the apparatus and the method have a general-purpose structure.

[0008] A first exemplary aspect of the present invention is a roll-bending process apparatus including:

a pushing roll having a cylindrical side surface; and
two receiving rolls each having a cylindrical side surface, in which
the roll-bending process apparatus bends a work by pushing the pushing roll toward the receiving rolls, and
the roll-bending process apparatus forms a taper-shaped bending-formed article by adjusting a pushing amount of the pushing roll so that a first pushing amount on a side of one end of the pushing roll (e.g., a pushing amount on one end 10a side) is different from a second pushing amount on a side of the other end of the pushing roll (e.g., a pushing amount on the other end 10b side).

[0009] The above-described configuration makes it possible to change the pushing amount on the one end side of the pushing roll to one different from that on the other end side of the pushing roll. Therefore, it is possible to form bending-formed articles having different taper angles even though the apparatus has a general-purpose structure including three rolls each having a cylindrical side surface.

[0010] Further, in the taper-shaped bending-formed article, when a part having a large curvature (e.g., upper bottom 21) is disposed on the one end side of the pushing roll and a part having a small curvature (e.g., lower bottom 22) is disposed on the other end side of the pushing roll, the first pushing amount may be larger than the second pushing amount. Further, when bending-formed articles having different taper angels are formed, a combination of the first and second pushing amounts may be changed.

[0011] The above-described configuration makes it

possible to form bending-formed articles having various taper angles even though the apparatus has a general-purpose structure.

[0012] Another exemplary aspect of the present invention is a roll-bending process method using a pushing roll having a cylindrical side surface and two receiving rolls each having a cylindrical side surface, the roll-bending process method being for bending a work by pushing the pushing roll toward the receiving rolls, the roll-bending process method includes:

forming a taper-shaped bending-formed article by adjusting a pushing amount of the pushing roll so that a first pushing amount on a side of one end of the pushing roll is different from a second pushing amount on a side of the other end of the pushing roll.

[0013] The above-described configuration makes it possible to change the pushing amount on the one end side of the pushing roll to one different from that on the other end side of the pushing roll. Therefore, it is possible to form bending-formed articles having different taper angles even though a general-purpose structure including three rolls each having a cylindrical side surface is used.

[0014] Further, in the taper-shaped bending-formed article, when a part having a large curvature is disposed on the one end side of the pushing roll and a part having a small curvature is disposed on the other end side of the pushing roll, the first pushing amount may be larger than the second pushing amount. Further, when bending-formed articles having different taper angels are formed, a combination of the first and second pushing amounts may be changed.

[0015] The above-described configuration makes it possible to form bending-formed articles having various taper angles even when rolls having a general-purpose structure are used.

[0016] Further, the work may be a trapezoidal plate including an upper bottom that forms a part having a large curvature of the bending-formed article, and a lower bottom that forms a part having a small curvature of the bending-formed article, the lower bottom being longer than the upper bottom. Further, the lower bottom may be bent at a predetermined curvature by the pushing on the other end side of the pushing roll, and the upper bottom may be bent at a predetermined curvature larger than that of the lower bottom by the pushing on the one end side of the pushing roll.

[0017] The above-described configuration makes it possible to form conical tubular formed articles having various taper angles even when rolls having a general-purpose structure are used.

[0018] According to the present invention, it is possible to provide a roll-bending process apparatus and a roll-bending process method capable of forming conical tubular formed articles having various taper angles even when the apparatus and the method have a general-purpose structure.

[0019] The above and other objects, features and advantages of the present invention will become more fully understood from the detailed description given hereinbelow and the accompanying drawings which are given by way of illustration only, and thus are not to be considered as limiting the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020]

Fig. 1 is a schematic diagram of one process in a manufacturing method according to a first exemplary embodiment;
Fig. 2 is a schematic diagram of one process in the manufacturing method according to the first exemplary embodiment;
Fig. 3 is a graph showing curvatures with respect to pushing amounts;
Fig. 4 is a schematic diagram of one process in the manufacturing method according to the first exemplary embodiment;
Fig. 5 is a perspective view of a sub-muffler; and
Fig. 6 is a schematic diagram of one process in a manufacturing method in related art.

DESCRIPTION OF THE EXEMPLARY EMBODIMENTS

First exemplary embodiment

[0021] A manufacturing method according to a first exemplary embodiment is explained with reference to Figs. 1 to 4. Figs. 1, 2 and 4 are schematic diagrams of one process in the manufacturing method according to the first exemplary embodiment. Fig. 3 is a graph showing curvatures with respect to pushing amounts. Note that in Fig. 2, illustrations of bearing housings 13 and 14, and hydraulic cylinders 16 and 17 are omitted for clarifying the figure.

[0022] Firstly, a manufacturing apparatus used in a manufacturing method according to the first exemplary embodiment is explained. As shown in Fig. 1, a roll-bending process apparatus 100 includes a pushing roll 10, receiving rolls 11 and 12, bearing housings 13 and 14, and hydraulic cylinders 16 and 17.

[0023] The pushing roll 10 is supported in the bearing housings 13 and 14 through the shaft body 15, and is a cylindrical body that can rotate around the axis. The side-wall surface of the pushing roll 10 (also referred to as "cylindrical side surface") is in parallel with its axis. That is, the pushing roll 10 does not have a tapered shape and its taper angle is substantially 0°. The pushing roll 10 is raised/lowered by the hydraulic cylinders 16 and 17 through the bearing housings 13 and 14 and the shaft body 15. For example, the pushing roll 10 can be lowered toward the receiving rolls 11 and 12.

[0024] The receiving rolls 11 and 12 are supported on a support pedestal (not shown) through respective shaft

bodies (not shown), and are cylindrical bodies that can rotate around the axes. Similarly to the sidewall surface of the pushing roll 10, the sidewall surfaces of the receiving rolls 11 and 12 (also referred to as "cylindrical side surfaces") are in parallel with their axes. That is, the receiving rolls 11 and 12 do not have a tapered shape and their taper angles are substantially 0°. The receiving rolls 11 and 12 are arranged so that they are in parallel with each other with a predetermined gap therebetween. The receiving rolls 11 and 12 are fixed so that their axes are located at predetermined positions.

[0025] The bearing housing 13 is disposed on the side of the other end 10b of the pushing roll 10, and the bearing housing 14 is disposed on the side of the one end 10a of the pushing roll 10. Further, the bearing housings 13 and 14 are supported by the hydraulic cylinders 16 and 17, respectively, so that they can be raised/lowered.

[0026] The hydraulic cylinders 16 and 17 are disposed below the bearing housings 13 and 14, respectively. The hydraulic cylinder 16 adjusts the pushing amount on the other end 10b side of the pushing roll 10 through the bearing housing 13, and the hydraulic cylinder 17 adjusts the pushing amount on the one end 10a side of the pushing roll 10 through the bearing housing 14. The hydraulic cylinders 16 and 17 can adjust their respective pushing amounts so that the pushing distance on the other end 10b side of the pushing roll 10 and that on the one end 10a side of the pushing roll 10 are different from each other. The hydraulic cylinder 17 has a higher output than that of the hydraulic cylinder 16 so that the hydraulic cylinder 17 can achieve a larger pushing amount than that of the hydraulic cylinder 16. The hydraulic cylinders 16 and 17 may adjust the pushing amounts by, for example, controlling their hydraulic flow rates by using a hydraulic control unit 18.

[0027] Next, a manufacturing method according to the first exemplary embodiment is explained. As shown in Figs. 1 and 2, a roll-bending process is performed by making a trapezoidal plate-like work 20 pass between the pushing roll 10 and the receiving rolls 11 and 12 while pushing the pushing roll 10 toward the receiving rolls 11 and 12 (roll-bending process S1). The work 20 is a trapezoidal plate made of a material that can be subjected to a roll-bending process. Examples of the material that can be subjected to a roll-bending process include a metal material such as stainless steel. The work 20 includes an upper bottom 21 corresponding to the upper bottom of a trapezoid, a lower bottom 22 corresponding to the lower bottom of the trapezoid, and leg sections 23 and 24 corresponding to the legs of the trapezoid. In the trapezoid, the lower bottom 22 is a side longer than the upper bottom 21.

[0028] Typically, a roll-bending process is performed so that the upper bottom 21 of the work 20 passes through the gap on the side of the one end 10a and the lower bottom 22 of the work 20 passes through the gap on the side of the other end 10b. When the work 20 passes between the pushing roll 10 and the receiving rolls 11 and 12, the pushing roll 10 is lowered so that the pushing amount on the one end 10a side of the pushing roll 10 (also referred to as "first pushing amount") is larger than that on the other end 10b side of the pushing roll 10 (also referred to as "second pushing amount"). Note that as shown in Fig. 3, though depending on the case, the curvature R of a bending-formed article formed by a roll-bending process apparatus is, for example, in proportion to the pushing amount L of the pushing roller. In such cases, since the upper bottom 21 is pushed into the gap on the one end 10a side where the pushing amount is larger than that on the other end 10b side by the lowering of the pushing roll 10, the upper bottom 21 is pushed with a pushing amount larger than that for the lower bottom 22 that passes though the gap on the other end 10b side. Therefore, the upper bottom 21 is bent at a curvature larger than that of the lower bottom 22. Accordingly, the curvature of the upper bottom 21 is larger than that of the lower bottom 22. The work 20 is continuously bent until the leg sections 23 and 24 are opposed to each other. As a result, as shown in Fig. 4, the work 20 is formed into a conical tubular formed article having a predetermined taper angle (also referred to as "bending-formed article"). The upper bottom 21 becomes one end of the conical tubular formed article and the lower bottom 22 becomes the other end thereof.

[0029] In this roll-bending process S1, it is possible to change the ratio between the curvatures of the upper bottom 21 and the lower bottom 22 in various ways by changing the combination of the pushing amount on the one end 10a side of the pushing roll 10 and that on the other end 10b side of the pushing roll 10. Therefore, it is possible to change the taper angle of the conical tubular formed article formed from the work 20 (Fig. 4). The taper angle of this conical tubular formed article is an angle of the wall body with respect to the axis Y0.

[0030] Note that if necessary, the leg sections 23 and 24 of the work 20 may be welded to each other (welding process S2). By welding the leg sections 23 and 24 to each other, a conical tubular formed article having no tear (or no seam) in the circumference direction can be formed.

[0031] As descried above, according to the manufacturing method in accordance with the first exemplary embodiment, a conical tubular formed article can be formed. In the manufacturing method according to the first exemplary embodiment, a roll-bending process apparatus having a general-purpose structure, i.e., a roll-bending process apparatus including a cylindrical pushing roll and cylindrical receiving rolls is used. Further, it is possible to adjust the pushing amount on the side of one end of the pushing roll and that on the side of the other end thereof by using hydraulic cylinders or the like. This makes it possible to manufacture conical tubular formed articles having different taper angles.

[0032] Incidentally, it is possible to obtain a sub-muffler, for example, by performing a diameter reducing process for shrinking an end(s) of an obtained conical tubular

formed article, disposing a flow path tube serving as a flow path for exhaust, and so on. As an example of such a sub-muffler, Fig. 5 shows a sub-muffler 200. The sub-muffler 200 includes a conical tubular central section 29 having a taper angle, a flow path tube 30 for letting exhaust flow into and out from the central section 29, one end 27 extending from one end of the central section 29 and connected to the flow path tube 30, and the other end 28 extending from the other end of the central section 29 and connected to the flow path tube 30. The one end 27, the other end 28, and the central section 29 are an integrated object, and are obtained by performing a diameter reducing process for the one end (upper bottom 21) and the other end (lower bottom 22) of the conical tubular formed article (see Fig. 4).

[0033] Note that the present invention is not limited to the above-described first exemplary embodiment, and it can be modified as appropriate without departing from the spirit and scope of the present invention. For example, the roll-bending process apparatus according to the first exemplary embodiment may further include another roll opposed to the pushing roll 10 on the side of the receiving rolls 11 and 12. Further, although the roll-bending process apparatus according to the first exemplary embodiment uses the hydraulic cylinders 16 and 17 for pushing the pushing roll, it may use an actuator other than the hydraulic cylinder. Examples of such actuators include a hydraulic motor. Further, although a trapezoidal plate-like work is used in the manufacturing method according to the first exemplary embodiment, a fan-like planar work may be used in other embodiments. Further, although the work 20 passes between the pushing roll 10 and the receiving rolls 11 and 12 only once in the roll-bending process S1, it may pass therebetween a plurality of times.

[0034] From the invention thus described, it will be obvious that the embodiments of the invention may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended for inclusion within the scope of the following claims.

[0035] A roll-bending process apparatus (100) including a pushing roll (10) having a cylindrical side surface and two receiving rolls (11 and 12) each having a cylindrical side surface is provided. The roll-bending process apparatus (100) bends a work (20) by pushing the pushing roll (10) toward the receiving rolls (11 and 12). The roll-bending process apparatus (100) forms a taper-shaped bending-formed article by adjusting a pushing amount of the pushing roll (10) so that a first pushing amount on one end side (10a) of the pushing roll (10) is different from a second pushing amount on the other end side (10b) of the pushing roll (10).

Claims

1. A roll-bending process apparatus comprising:

   a pushing roll having a cylindrical side surface; and
   two receiving rolls each having a cylindrical side surface, wherein
   the roll-bending process apparatus bends a work by pushing the pushing roll toward the receiving rolls, and
   the roll-bending process apparatus forms a taper-shaped bending-formed article by adjusting a pushing amount of the pushing roll so that a first pushing amount on a side of one end of the pushing roll is different from a second pushing amount on a side of the other end of the pushing roll.

2. The roll-bending process apparatus according to Claim 1, wherein in the taper-shaped bending-formed article, when a part having a large curvature is disposed on the one end side of the pushing roll and a part having a small curvature is disposed on the other end side of the pushing roll, the first pushing amount is larger than the second pushing amount.

3. The roll-bending process apparatus according to Claim 1 or 2, wherein when bending-formed articles having different taper angels are formed, a combination of the first and second pushing amounts is changed.

4. A roll-bending process method using a pushing roll having a cylindrical side surface and two receiving rolls each having a cylindrical side surface, the roll-bending process method being for bending a work by pushing the pushing roll toward the receiving rolls, the roll-bending process method comprising:

   forming a taper-shaped bending-formed article by adjusting a pushing amount of the pushing roll so that a first pushing amount on a side of one end of the pushing roll is different from a second pushing amount on a side of the other end of the pushing roll.

5. The roll-bending process method according to Claim 4, wherein in the taper-shaped bending-formed article, when a part having a large curvature is disposed on the one end side of the pushing roll and a part having a small curvature is disposed on the other end side of the pushing roll, the first pushing amount is larger than the second pushing amount.

6. The roll-bending process method according to Claim 4 or 5, wherein when bending-formed articles having different taper angels are formed, a combination of

the first and second pushing amounts is changed.

7. The roll-bending process method according to any one of Claims 4 to 6, wherein
the work is a trapezoidal plate including an upper bottom that forms a part having a large curvature of the bending-formed article, and a lower bottom that forms a part having a small curvature of the bending-formed article, the lower bottom being longer than the upper bottom, and
the lower bottom is bent at a predetermined curvature by the pushing on the other end side of the pushing roll, and
the upper bottom is bent at a predetermined curvature larger than that of the lower bottom by the pushing on the one end side of the pushing roll.

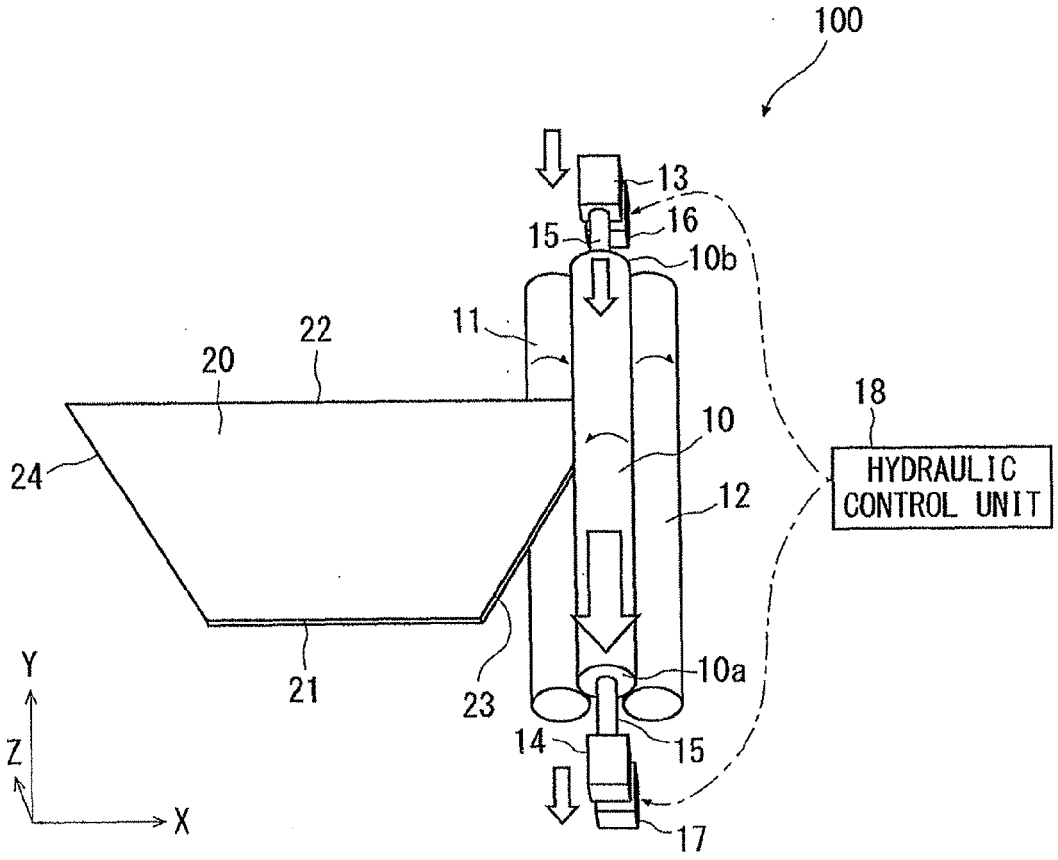
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Fig. 1

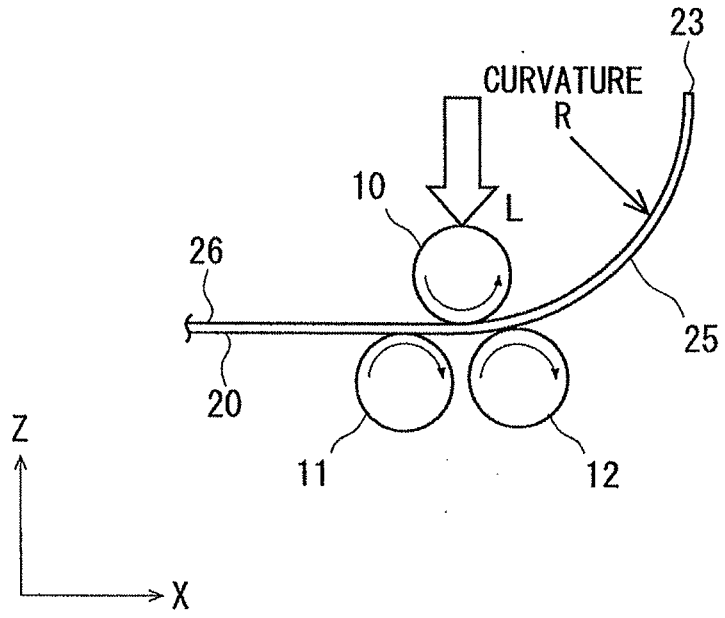

Fig. 2

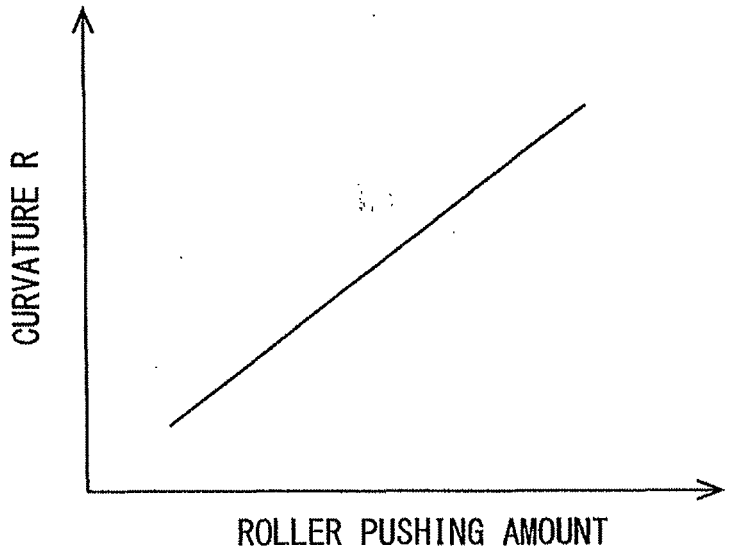

Fig. 3

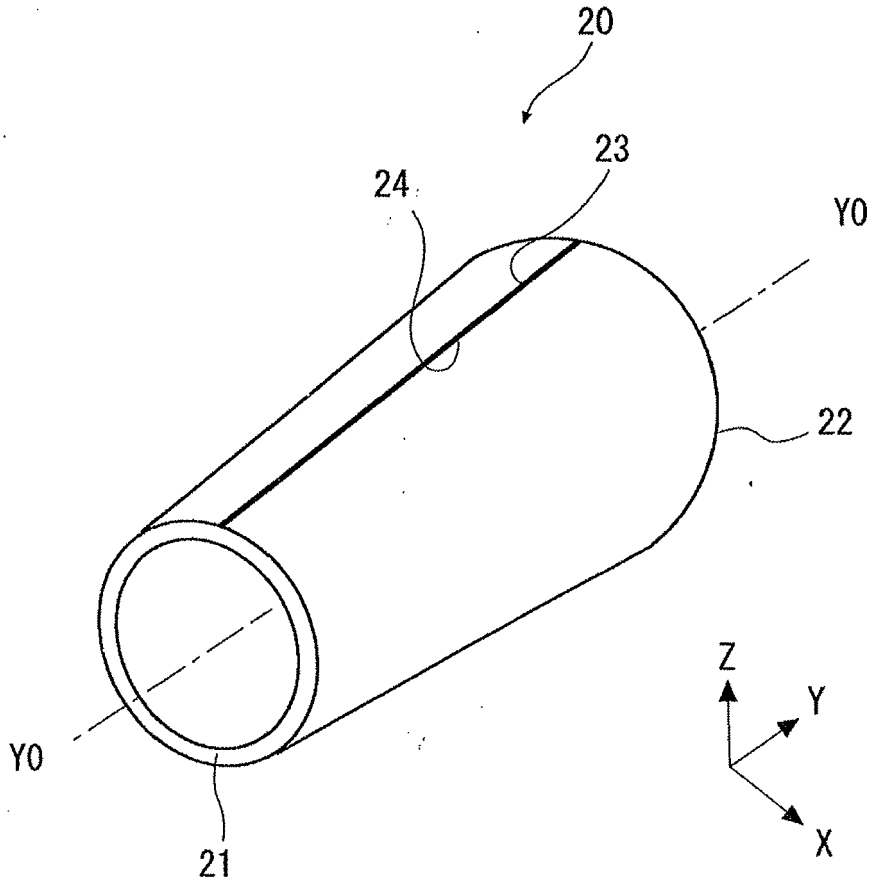

Fig. 4

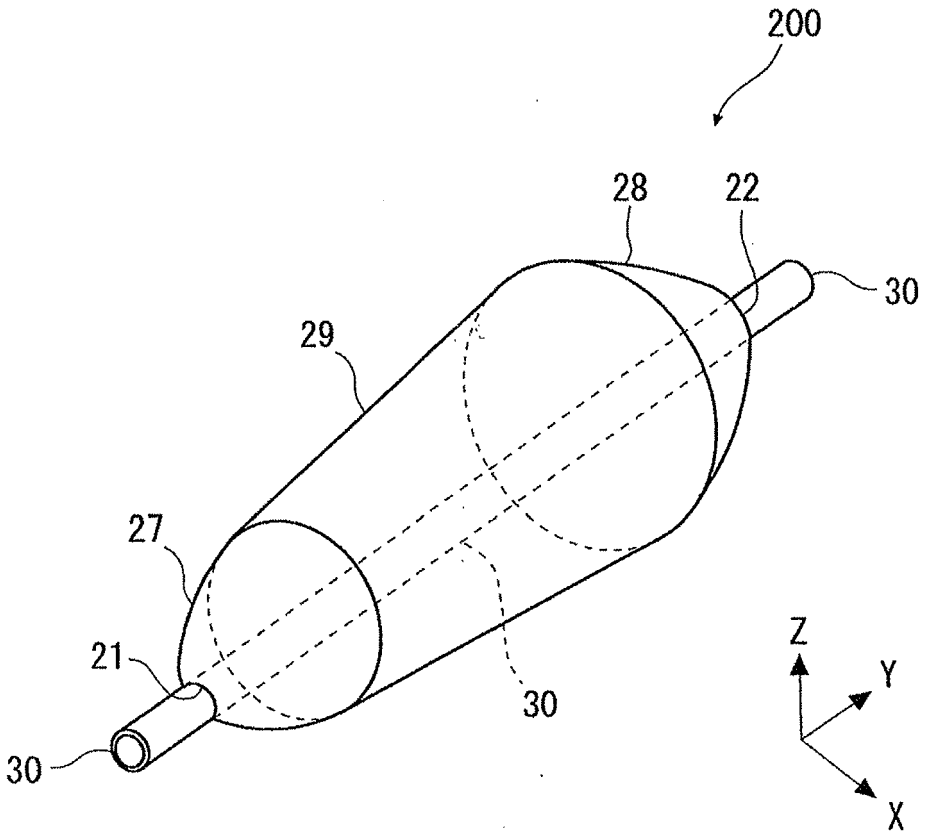

Fig. 5

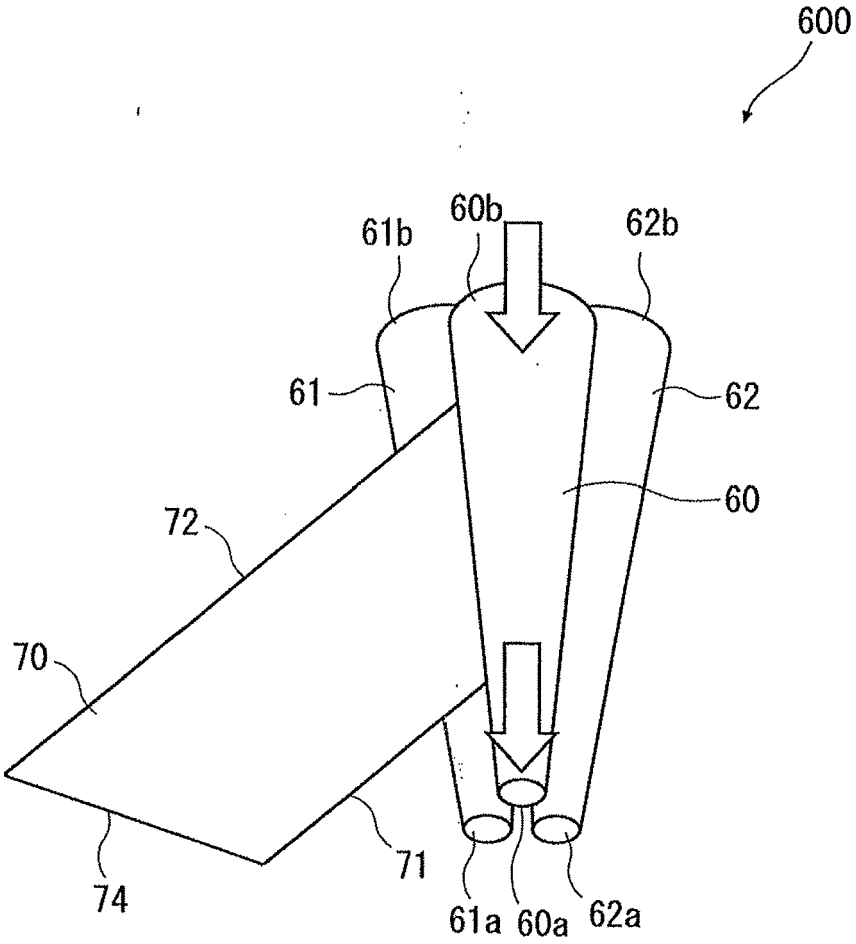

Fig. 6

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EUROPEAN SEARCH REPORT

Application Number
EP 15 16 6702

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	15 September 2015	Cano Palmero, A

CATEGORY OF CITED DOCUMENTS

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