

(19)



(11)

EP 2 341 025 A2

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
06.07.2011 Bulletin 2011/27

(51) Int Cl.:
B65H 27/00 (2006.01)

(21) Application number: **10197135.6**

(22) Date of filing: **28.12.2010**

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
 GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
 PL PT RO RS SE SI SK SM TR**
 Designated Extension States:
BA ME

- **Kamoshida, Shinichi**
Nagano 392-8502 (JP)
- **Aoyagi, Kenji**
Nagano 392-8502 (JP)
- **Ono, Katsunori**
Nagano 392-8502 (JP)
- **Kiyota, Shungo**
Nagano 392-8502 (JP)
- **Uesugi, Ryoji**
Nagano 392-8502 (JP)
- **Matsuyama, Kenji**
Nagano 392-8502 (JP)
- **Ogawa, Hideyuki**
Nagano 392-8502 (JP)
- **Okuyama, Shinji**
Yamagato 998-0194 (JP)
- **Shintate, Toru**
Nagano 392-8502 (JP)

(30) Priority: **29.12.2009 JP 2009299054**
23.04.2010 JP 2010100135

(71) Applicant: **Seiko Epson Corporation**
Shinjuku-ku
Tokyo (JP)

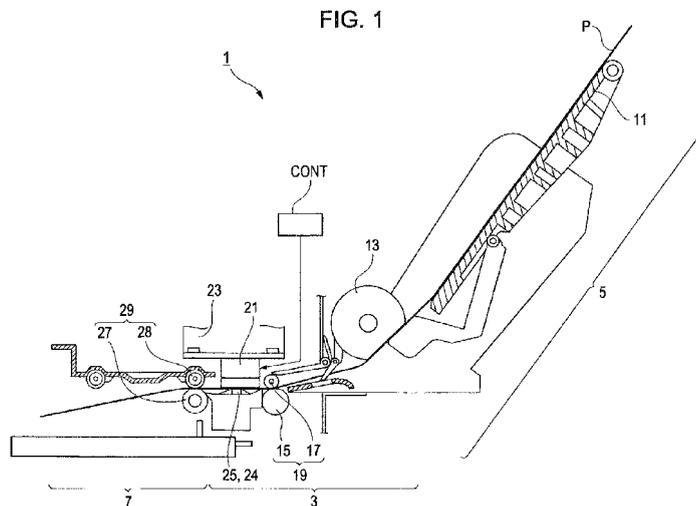
- (72) Inventors:
- **Takashima, Nagamitsu**
Nagano 392-8502 (JP)
 - **Saito, Koichi**
Nagano 392-8502 (JP)
 - **Ozawa, Kenji**
Nagano 392-8502 (JP)
 - **Todoriki, Akio**
Nagano 392-8502 (JP)

(74) Representative: **HOFFMANN EITL**
Patent- und Rechtsanwälte
Arabellastraße 4
81925 München (DE)

(54) Printing apparatus

(57) A printing apparatus includes a transport roller which is formed in a cylindrical shape in which a pair of ends of a metal plate faces each other and has a high

friction layer transporting a transport medium on an outer circumferential surface thereof; and a printing unit performing printing on the transport medium transported by the transport roller.



EP 2 341 025 A2

Description

1. Technical Field

[0001] The present invention relates to a printing apparatus.

2. Related Art

[0002] In general, a printing apparatus is used to print information on a sheet-shaped print medium. The printing apparatus is provided with a transport unit that transports the print medium. It is necessary for the transport unit to have a configuration for realizing high transport accuracy, since the transport unit has an influence on the print accuracy of the printing apparatus. The transport unit includes a transport roller that transports the print medium in a rotation manner. In general, a solid bar-shaped member is used in the transport roller (for example, see Japanese Patent No. 3271048).

[0003] However, a problem may arise in that the solid transport roller has a heavy weight.

SUMMARY

[0004] An advantage of some aspects of the invention is that it provides a printing apparatus including a light-weight transport roller.

[0005] According to an aspect of the invention, there is provided a printing apparatus including: a transport roller which is formed in a cylindrical shape in which a pair of ends of a metal plate facing each other approach each other or come into contact with each other and in which a high friction layer transporting a transport medium is formed on an outer circumferential surface; and a printing unit performing printing on the transport medium transported by the transport roller.

[0006] With such a configuration, the transport roller is formed in a cylindrical shape, thereby achieving lightness of the transport roller compared to a case where a solid transport roller is used. Accordingly, a light-weight printing apparatus can be provided. By forming the transport roller in a cylindrical shape, the transport roller can be provided at low cost. Moreover, since the high friction layer transporting the transport medium is formed on the outer circumferential surface, high transport accuracy can be ensured and thus high print accuracy can be ensured.

[0007] In the printing apparatus, the transport roller has a joint joining the pair of ends.

[0008] With such a configuration, positional displacement of the pair of ends can be prevented by the joint. Accordingly, since the transport roller can be prevented from being deformed, the high transport accuracy can be ensured.

[0009] In the above printing apparatus, the joint has a straight line portion parallel to the direction of the central axis of the transport roller.

[0010] With such a configuration, since the joint has the straight line portion parallel to the direction of the central axis of the transport roller, positional displacement of the pair of ends in the straight line portion can be prevented.

[0011] In the above printing apparatus, the joint has an intersection portion formed in a direction intersecting the direction of the central axis of the transport roller.

[0012] With such a configuration, since the joint has the intersection portion formed in the direction intersecting the direction of the central axis of the transport roller, positional displacement of the pair of ends in the intersection portion can be prevented.

[0013] In the above printing apparatus, the joint has a tilted portion formed in a tilted direction with respect to the direction of the central axis of the transport roller.

[0014] With such a configuration, since the joint has the tilted portion formed in a tilted direction with respect to the direction of the central axis of the transport roller, positional displacement of the pair of ends in the tilted portion can be prevented.

[0015] In the above printing apparatus, the joint has a curved portion formed to be curved.

[0016] With such a configuration, since the joint has the curved portion formed to be curved, positional displacement of the positions of the pair of ends in the curved portion can be prevented.

[0017] In the above printing apparatus, the joint has the pair of ends disposed so that the pair of ends comes into contact with each other on the outer circumferential surface of the transport roller and the pair of ends are separated from each other on the inner circumferential surface of the transport roller.

[0018] With such a configuration, since the pair of ends is disposed so that the pair of ends come into contact with each other on the outer circumferential surface of the transport roller and the pair of ends are separated from each other on the inner circumferential surface of the transport roller, the smoothness is improved in the joint on the side of the outer circumferential surface. Therefore, even when the transport roller is rotated, the circumferential surface of the transport roller can reliably come into contact with the transport medium. Therefore, the transport medium can be transported with high accuracy.

[0019] In the above printing apparatus, the joint is formed over the high friction layer and an opening formed through the inside and outside of the transport roller is formed at a position deviated from the high friction layer in the joint.

[0020] With such a configuration, since the joint is formed over the high friction layer and the opening formed through the inside and outside of the transport roller is formed at the position deviated from the high friction layer in the joint, for example, a foreign substance moving from the ends of the transport roller via the joint can be prevented from reaching the high friction layer. Accordingly, the transport accuracy of the high friction layer can be

prevented from deteriorating.

[0021] In the above printing apparatus, a thickness of the transport roller in the joint is smaller than a thickness in other portions.

[0022] With such a configuration, since the thickness of the transport roller in the joint is smaller than the thickness in the other portions, inner stress of the transport roller in the joint can be adjusted. Accordingly, the transport roller can be prevented from being curved over time.

[0023] In the above printing apparatus, the high friction layer includes at least one of an inorganic particle and an organic particle and an average grain diameter of the particle is greater than a distance between the pair of ends in the joint.

[0024] With such a configuration, since the high friction layer includes at least one of an inorganic particle and an organic particle and the average grain diameter of the particle is greater than a distance between the pair of ends in the joint, the high friction layer can be formed inside the joint.

[0025] In the above printing apparatus, the joint includes a plurality of intersection portions extending in a direction intersecting the direction of the rotation axis of the transport roller, a first straight line portion formed between the ends of one of a pair of adjacent intersection portions, and a second straight line portion formed between the ends of the other of the pair of adjacent intersection portions and shorter than the first straight line portion. The distance between the pair of ends in the first straight line portion is shorter than the distance between the pair of ends in the second straight line portion.

[0026] With such a configuration, the joint formed between the pair of ends is formed in a straight line shape substantially parallel to the direction of the rotation axis in the middle portion of the transport roller in the direction of the rotation axis. In addition, the bent portions are formed only both sides of the middle straight line portion formed in the straight line shape. Therefore, the middle straight line portion of the joint does not fit due to unevenness. Therefore, deformation or distortion rarely occurs in the transport roller, compared to a case where a fitting portion is formed due to unevenness along the entire length of the joint. Accordingly, satisfactory accuracy can easily be achieved in the shape or size such as circularity or declination. Moreover, the distance between the pair of ends in the middle portion is shorter than the distance between the pair of ends in the second straight line portion, and the high accuracy of the shape or size of the transport roller can be achieved.

[0027] One end forming the second straight line portion in the bent portion serves as a convex piece forming the outer shape of the second straight line portion formed between the pair of adjacent intersection portions and the one end. Accordingly, when the convex piece closely approaches or comes into contact with the facing end by pressing, the front end of the convex piece is not sufficiently bent on the circumferential surface and floats outward with respect to the facing end. Therefore, a stepped

difference occurs in the second straight line portion. Then, the obtained transport roller is easily deformed due to the stepped difference, and thus the satisfactory accuracy of the shape or size of the transport roller is rarely achieved. Accordingly, by making the distance between the ends in the second straight line portion longer than that in the middle straight line portion to reduce the floating of the front end of the convex piece, the stepped difference can be prevented from occurring in the second straight line portion. That is, by preventing the stepped difference from occurring in the second straight line portion, the transport roller can be prevented from being deformed due to the stepped difference and thus the accuracy of the shape or size can be improved. Since the first straight line portion is longer than the second straight line portion, the pair of ends facing each other along the entire length of the joint can closely approach or come into contact with each other with relatively satisfactory accuracy in the pressing.

[0028] In the above printing apparatus, the joint is formed in the middle portion of the transport roller in the direction of the rotation axis. The joint includes a middle straight line portion formed in a straight line shape substantially parallel to the direction of the rotation axis, a plurality of intersection portions formed in both sides of the middle portion and extending in a direction intersecting the direction of the rotation axis, a first straight line portion formed between ends of one of the pair of adjacent intersection portions, and a second straight line portion formed between ends of the other of the pair of adjacent intersection portions and shorter than the first straight line portion. The distance between the pair of ends in the middle portion is shorter than the distance between the pair of ends in the second straight line portion.

[0029] With such a configuration, the joint formed between the pair of ends is formed in the straight line shape substantially parallel to the direction of the rotation axis in the middle portion in the direction of the rotation axis of the transport roller. Moreover, the bent portions are formed only at the both sides of the middle straight line portion formed in the straight line shape. Therefore, the middle straight line portion of the joint does not fit by unevenness. Accordingly, deformation or distortion rarely occurs in the transport roller, compared to a case where the fitting portion is formed due to unevenness along the entire length of the joint. Accordingly, satisfactory accuracy can easily be achieved in the shape or size such as circularity or declination. Moreover, the distance between the pair of ends in the middle portion is shorter than the distance between the pair of ends in the second straight line portion, the high accuracy of the shape or size of the transport roller can be achieved.

[0030] One end forming the second straight line portion in the bent portion serves as a convex piece forming the outer shape of the second straight line portion formed between the pair of adjacent intersection portions and the one end. Accordingly, when the convex piece closely

approaches or comes into contact with the facing end by pressing, the front end of the convex piece is not sufficiently bent on the circumferential surface and floats outward with respect to the facing end. Therefore, a stepped difference occurs in the second straight line portion. Then, the obtained transport roller is easily deformed due to the stepped difference, and thus the satisfactory accuracy of the shape or size of the transport roller is rarely achieved. Accordingly, by making the distance between the ends in the second straight line portion longer than that in the middle straight line portion to reduce the floating of the front end of the convex piece, the stepped difference can be prevented from occurring in the second straight line portion. That is, by preventing the stepped difference from occurring in the second straight line portion, the transport roller can be prevented from being deformed due to the stepped difference and thus the accuracy of the shape or size can be improved. Since the first straight line portion is longer than the second straight line portion, the pair of ends facing each other along the entire length of the joint can closely approach or come into contact with each other with relatively satisfactory accuracy in the pressing.

[0031] In the above printing apparatus, the transport roller has a connection portion connected to a driving unit rotating the transport roller.

[0032] With such a configuration, since the transport roller has the connection portion connected to the driving unit rotating the transport roller, the transport roller can be smoothly rotated. Thus, high transport accuracy can be maintained.

[0033] In the above printing apparatus, the connection portion is disposed on the end of the transport roller.

[0034] With such a configuration, since the connection portion is disposed on the end of the transport roller, the end of the transport roller can be connected to the driving unit.

[0035] In the above printing apparatus, the connection portion includes a notched portion of which a part in the circumferential direction of the transport roller is notched.

[0036] With such a configuration, since the connection portion includes the notched portion of which the part in the circumferential direction of the transport roller is notched, a part of the driving unit can be connected to the notched portion in an engagement manner. Thus, idling of the driving unit can be prevented.

[0037] In the above printing apparatus, the transport roller includes a joint joining the pair of ends and the notched portion is formed in a portion deviated from the joint in the circumferential direction of the transport roller.

[0038] With such a configuration, the transport roller includes the joint joining the pair of ends and the notched portion is formed in the portion deviated from the joint in the circumferential direction of the transport roller. Therefore, even when a biasing force of the periphery of the central axis is added to the notched portion, the biasing force does not operate to the degree that the pair of ends are separated from each other in the joint. Thus, it is

possible to prevent the pair of ends from being separated from each other.

[0039] In the above printing apparatus, the transport roller includes a connection portion in which a pair of ends of the metal plate are connected to each other and a second notched portion formed on the outer circumferential surface and formed at the position where the connection portion is not formed.

[0040] With such a configuration, the connection portion and the second notched portion of the transport roller are separated from each other. Therefore, even when a biasing force in the periphery of the shaft is applied to the second notched portion, the biasing force does not operate to the degree that the pair of ends are separated from each other in the connection portion. Thus, the pair of ends are not separated from each other.

[0041] In the above printing apparatus, the transport roller includes a transport area for transporting the transport medium and further includes a first driving member which is disposed closer to one end of the transport roller than the transport area and delivers a rotation driving force to the transport roller and a second driving member which delivers the delivered rotation driving force to an apparatus performing a process associated with printing.

[0042] With such a configuration, since at least one of the first driving member and the second driving member adding torque to the transport roller are disposed closer to the one end than the transport area, large torque is not added to the transport area of the transport roller. Therefore, it is possible to prevent the transport accuracy and the print accuracy from deteriorating due to deviation in the joint of the transport area of the transport roller.

BRIEF DESCRIPTION OF THE DRAWINGS

[0043] The invention will be described with reference to the accompanying drawings, wherein like numbers reference like elements.

[0044] Fig. 1 is a side sectional view illustrating an ink jet printer according to an embodiment of the invention.

[0045] Fig. 2A is a plan view illustrating a transport unit.

[0046] Fig. 2B is a side view illustrating a driving system.

[0047] Figs. 3A and 3B are schematic diagrams illustrating the configuration of a transport roller mechanism.

[0048] Fig. 4 is a schematic diagram illustrating the configuration of a manufacturing apparatus for a transport roller according to the embodiment.

[0049] Figs. 5A and 5B are sectional views illustrating an extracting step according to this embodiment.

[0050] Fig. 6 is a plan view of a metal plate subjected to extracting.

[0051] Figs. 7A to 7C are diagrams illustrating a bending step according to this embodiment.

[0052] Figs. 8A to 8C are diagrams illustrating the bending step according to this embodiment.

[0053] Fig. 9 is a plan view illustrating a metal plate in which flat plate parts are formed in a cylindrical shape.

[0054] Fig. 10 is a diagram illustrating grinding members which grind a roller body.

[0055] Fig. 11A is a perspective view illustrating the roller body.

[0056] Fig. 11B is a side sectional view illustrating a joint.

[0057] Figs. 12A to 12C are diagrams illustrating a step of forming a high friction layer in the roller body.

[0058] Fig. 13 is a schematic diagram illustrating the configuration of a coating booth forming the high friction layer.

[0059] Fig. 14 is an expanded view illustrating a joint and the main portions near the joint of the roller body.

[0060] Figs. 15A to 15D are schematic diagrams illustrating the configuration of the roller body.

[0061] Figs. 16A to 16C are schematic diagrams illustrating the configuration of the roller body.

[0062] Figs. 17A and 17B are schematic diagrams illustrating the configuration of the roller body.

[0063] Fig. 18 is a perspective view illustrating the main portions of the roller body.

[0064] Fig. 19 is a side view illustrating the roller body.

[0065] Figs. 20A, 20C, and 20E are plan views illustrating the main portions of the roller body and Figs. 20B, 20D, and 20F are perspective views illustrating the main portions of the roller body.

[0066] Figs. 21A to 21D are plan views illustrating development engagement portions as the main portions of a metal plate.

[0067] Figs. 22A to 22C are plan views illustrating development engagement portions as the main portions of a metal plate.

[0068] Figs. 23A and 23C are diagrams illustrating a joint.

[0069] Fig. 23B is a plan view illustrating a metal plate.

[0070] Fig. 24A is a diagram illustrating a joint of the roller body.

[0071] Fig. 24B is a plan view illustrating a metal plate.

[0072] Fig. 25A is a diagram illustrating a joint of the roller body.

[0073] Fig. 25B is a plan view illustrating a metal plate.

[0074] Fig. 26 is a perspective view illustrating a relation between a transport roller and a sheet when the sheet is transported.

[0075] Figs. 27A to 27C are diagrams illustrating the shape of a joint.

[0076] Fig. 28A is a diagram illustrating the shape of a joint.

[0077] Fig. 28B is a diagram illustrating an operation.

[0078] Fig. 29 is a diagram illustrating the shape of the joint.

[0079] Figs. 30A to 30C are diagrams illustrating the shape of a joint.

[0080] Figs. 31A and 31B are schematic diagrams illustrating the configuration of the roller body.

[0081] Fig. 32 is a diagram illustrating the joint of the roller body.

[0082] Figs. 33A and 33B are diagrams illustrating a

spot welding step.

[0083] Fig. 34 is a diagram illustrating a roller body according to a modified example.

[0084] Figs. 35A to 35C are diagrams illustrating a manufacturing procedure of the roller body.

[0085] Figs. 36A to 36C are diagrams illustrating the manufacturing procedure of the roller body.

[0086] Figs. 37A to 37C are diagrams illustrating the manufacturing procedure of the roller body.

[0087] Figs. 38A to 38C are diagrams illustrating the manufacturing procedure of the roller body.

[0088] Fig. 39 is a diagram illustrating a roller body according to a modified example.

[0089] Fig. 40 is a diagram illustrating a roller body according to a modified example.

[0090] Figs. 41A to 41D are diagrams illustrating a manufacturing procedure of the roller body.

[0091] Fig. 42 is a flowchart illustrating a step of manufacturing the transport roller.

[0092] Fig. 43 is a plan view illustrating a part of the transport unit.

[0093] Fig. 44 is a perspective view illustrating the main portions of the roller body.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0094] Hereinafter, embodiments of the invention will be described with reference to the drawings.

[0095] Elements are expressed in different scales so as to allow the elements to be visible in the drawings used for the following description.

[0096] Fig. 1 is a side sectional view illustrating an ink jet printer according to an embodiment of the invention.

[0097] Fig. 2A is a plan view illustrating a transport unit of the ink jet printer. Fig. 2B is a side view illustrating a driving system of the transport unit.

[0098] As shown in Fig. 1, an ink jet printer (printing apparatus) 1 includes a printer main body 3, a feeding unit 5 disposed in the rear upper portion of the printer main body 3, and a discharge unit 7 disposed in the front of the printer main body 3.

[0099] A feeding tray 11 is disposed in the feeding unit 5. A plurality of sheets (media, print media, or transport media) P is stacked in the feeding tray 11. Here, examples of the sheet P include a plain sheet, a coat sheet, a sheet for an OHP (overhead projector), a glossy sheet, and a gloss film. Hereinafter, the side of the feeding tray 11 and the side of the discharge unit 7 along a transport path of the sheet P are referred to as an upstream side and a downstream side, respectively. A feeding roller 13 is disposed on the downstream side of the feeding tray 11.

[0100] The feeding roller 13 is configured to pinch the sheet P located in the uppermost portion of the feeding tray 11 between separation pads (not shown) facing each other, and to deliver the sheet P to the downstream side. A transport roller mechanism 19 is disposed on the downstream side of the feeding roller 13.

[0101] The transport roller mechanism 19 includes a transport roller 15 disposed on the lower side thereof and a driven roller 17 disposed on the upper side thereof.

[0102] The transport roller 15 pinches the sheet P with the driven roller 17 and is disposed to be rotatably driven by a driving unit 30 shown in Fig. 2. Accordingly, the transport roller 15 is configured to transport the sheet P toward a print head (print unit) 21 disposed on the downstream side by a transport (sheet feeding) processing with accuracy so as to perform transport and print processing.

[0103] The print head 21 is held in a carriage 23. The carriage 23 reciprocates in a direction perpendicular to a feeding direction (transport direction of the sheet P). Print processing by the print head 21 is controlled by a control unit CONT. A platen 24 is disposed at the position at which the platen 24 faces the print head 21.

[0104] The platen 24 includes a plurality of diamond ribs 25 disposed at intervals along a movement direction of the carriage 23.

[0105] The diamond rib 25 supports the sheet P from the lower side when the print head 21 prints the sheet P. The top surface of the diamond rib 25 functions as a support surface. The distance between the diamond rib 25 and the print head 21 is adjustable depending on the thickness of the sheet P. Accordingly, the sheet P can smoothly pass through on the top surface of the diamond rib 25. A discharge roller mechanism 29 is disposed on the downstream side of the diamond rib 25 and the print head 21.

[0106] The discharge roller mechanism 29 includes a discharge roller 27 disposed on the lower side thereof and a discharge jag roller 28 disposed on the upper side thereof. The sheet P is extracted by rotation driving of the discharge roller 27 to be discharged.

[0107] Hereinafter, the driving unit 30 of the transport roller mechanism 19 and the discharge roller mechanism 29 will be described, and a driving speed relation between the transport roller 15 and the discharge roller 27 will be described.

[0108] The printer main body 3 is provided with a transport motor 32 driven under the control of the control unit CONT, as shown in Figs. 2A and 2B. A pinion 33 is disposed in the driving shaft of the transport motor 32, a transport driving gear 35 is meshed with the pinion 33, and the transport roller 15 is internally inserted and connected to the transport driving gear 35.

[0109] With such a configuration, the transport motor 32 and the like serve as the driving unit 30 rotatably driving the transport roller 15.

[0110] The transport roller 15 is provided with an inner gear 39 on the same shaft as that of the transport driving gear 35, an intermediate gear 41 is meshed with the inner gear 39, and a discharge driving gear 43 is meshed with the intermediate gear 41. The rotational shaft of the discharge driving gear 43 is a shaft body 45 of the discharge roller 27, as shown in Fig. 2A.

[0111] With such a configuration, the transport roller

15 of the transport roller mechanism 19 and the discharge roller 27 of the discharge roller mechanism 29 are driven by a rotational drive force from the transport motor 32 which is the same driving source of the transport roller and the discharge roller 27.

[0112] The rotation speed of the discharge roller 27 is set to be faster than the rotation speed of the transport roller 15 by adjusting a gear ratio between the respective gears thereof. Accordingly, the discharge speed of the discharge roller mechanism 29 is faster than the transport speed of the transport roller mechanism 19 by a speed increase rate.

[0113] The holding force (pressing force) of the transport roller mechanism 19 for the sheet P is set to be larger than the holding force (pressing force) of the discharge roller mechanism 29. Therefore, when both the transport roller mechanism 19 and the discharge roller mechanism 29 hold the sheet P, the sheet transport speed is regulated by the transport speed of the transport roller mechanism 19, irrespective of the discharge speed of the discharge roller mechanism 29.

[0114] Next, the transport roller 15 and the transport roller mechanism 19 having the transport roller 15 will be described.

[0115] Fig. 3A is a schematic diagram illustrating the configuration of the transport roller mechanism 19. Fig. 3B is a schematic diagram illustrating the configuration of a bearing.

[0116] The transport roller 15 includes a hollow cylindrical roller body 16 and a high friction layer (medium support region) 50 formed in a part of the surface of the roller body 16 in a longitudinal direction (shaft direction).

[0117] The roller body 16 is formed of a steel plate coil, as a base material, in which a metal sheet such as a zinc-coated steel plate or a stainless steel plate is wound. The roller body 16 is a cylindrical shaft which is subjected to bending so that a pair of end surfaces of a coiled metal plate face each other, and the inner circumferential surface of the coil serves as the inner circumferential surface of the roller body 16. That is, the metal plate for forming the roller body 16 is curved in the cylindrical shape in the state where curling remains in the inner circumferential surface of the cylinder of the coil.

[0118] The roller body 16 includes a joint 80 formed by bending and butting a pair of end surfaces 61a and 61b of the metal plate, as shown in Figs. 8A and 8B. In the roller body 16 according to this embodiment, a circumferential direction (bending direction) and a curling direction (rolled direction of the metal plate) of a coil are considered to be the same as each other, and thus the joint 80 is formed substantially parallel to the shaft direction of the roller body 16.

[0119] As shown in Fig. 3A, the high friction layer 50 is selectively formed in the middle portion of the roller body 16 except for both the end portions thereof. Sharply pointed portions of inorganic particles are fixed on the surface of the high friction layer 50 in an exposed state, so that the high friction layer has high friction.

[0120] The high friction layer 50 is formed by forming a resin film through selective application of resin particles to a formation region of the high friction layer on the surface of the roller body 16 so that a uniform film thickness from about 10 μm to about 30 μm , for example, uniformly disperses inorganic particles or organic particles (for example, resin particles) onto the resin film, and then performs a burning process. As the resin particles, fine particles made of, for example, epoxy-based resin or polyester-based resin and having a diameter from about 10 μm to about 20 μm are preferably used. As the inorganic particles, ceramics particles such as aluminum oxide (alumina: A1203), silicon carbide (SiC), or silicon dioxide (SiO₂) adjusted so as to have a predetermined grain diameter distribution by a crushing process are preferably used.

[0121] As shown in Fig. 3A, both the end portions of the transport roller 15 are rotatably held by the bearing 26 integrally formed into the platen 24 (see Fig. 1). As shown in Fig. 3B, the bearing 26 is formed in a U form having an opened upper portion. The transport roller 15 is inserted into the portion of the U shape form so that the transport roller 15 is rotatably supported in three front, rear, and lower directions. A lubricant oil (lubricant liquid) such as grease is supplied (applied) to the contact surface (the surface of the transport roller 15) between the bearing 26 and the transport roller 15. An engagement portion (not shown) is formed in one end or both ends of the transport roller 15 to engage and connect the inner gear 39 and the transport driving gear 35 to each other so as not to be rotatable. The transport roller 15 has engagement portions with various forms to connect various connection components to each other.

[0122] The driven roller 17 has a plurality (for example, six) of rollers 17a arranged in the same shaft and is disposed at the position facing and coming into contact with the high friction layer 50 of the transport roller 15. An urging spring (not shown) is mounted on the driven roller 17 including the rollers 17a, so that the driven roller 17 is urged toward the transport roller 15.

[0123] Thus, the driven roller 17 comes into contact with the high friction layer 50 of the transport roller 15 by a predetermined pressing force (the holding force for the sheet P) and is driven by the rotation of the transport roller 15 so as to be rotated. The force holding the sheet P between the transport roller 15 and the driven roller 17 is increased, thereby reliably transporting the sheet P.

[0124] In order to suppress the damage of the respective rollers 17a of the driven roller 17 due to sliding contact with the high friction layer 50, the surfaces of the rollers 17a are subjected to a low abrasion process such as fluororesin coating.

[0125] The transport unit (transport device) 20 of the ink jet printer 1 includes the transport roller 15, the bearing 26, the driving unit 30, and the driven roller 17 described above.

[0126] Next, the operation of the ink jet printer 1 will be described with reference to Fig. 1 and Figs. 2A and

2B. In the ink jet printer 1, the uppermost sheet P stacked in the feeding tray 11 is pinched by the feeding roller 13 and is discharged to the downstream side. The discharged sheet P reaches the transport roller mechanism 19. In the transport roller mechanism 19, the sheet P is pinched between the transport roller 15 and the driven roller 17, and then is transported to the section below the print head 21 at a constant speed by the sheet transport process by the rotational driving of the transport roller 15. The sheet P transported to the section below the print head 21 is subjected to printing with high quality by the print head 21, while smoothly passing through on the top surface of the diamond rib 25. The sheets P subjected to the printing by the print head 21 are sequentially discharged by the discharge roller 27 of the discharge unit 7.

[0127] Since the transport speed of the discharge roller mechanism 29 is set to be faster than the transport speed of the transport roller mechanism 19, the sheet P is transported in the state where back tension is applied to the sheet P. Here, when both the transport roller mechanism 19 and the discharge roller mechanism 29 holds the sheet P, the transport speed of the sheet P is regulated by the transport speed of the transport roller mechanism 19. Therefore, even when the discharge roller mechanism 29 and the transport roller mechanism 19 simultaneously discharge and transport the sheet P, the transport speed of the sheet P is also regulated by the transport speed of the transport roller mechanism 19. Therefore, the sheet can stably be fed (transported) without transport irregularity with accuracy.

[0128] Here, when the sheet P is supported and is transported on the high friction layer 50 of the transport roller 15, torque is applied to the roller body 16. Then, a stress is applied in a direction in which the joint 80 (see Figs. 8A to 8C) of the pair of end surfaces 61a and 61b of the metal plate forming the roller body 16 is opened. When the joint 80 of the roller body 16 is opened, the transport roller 15 does not uniformly come into contact with the sheet P, thereby causing transport irregularity.

[0129] In this embodiment, however, the roller body 16 of the transport roller 15 is formed from the metal plate in which the curling of the steel plate coil remains, and is formed in a cylindrical shape with the inner circumferential surface which is the inner circumferential surface of the coil. The curling of the metal plate of the steel plate coil is in the curled state where the inner circumferential surface of the steel plate coil becomes a concave surface. That is, the curling remains in the metal plate forming the roller body 16, so that the metal plate is curled toward the inner circumferential surface of the roller body 16.

[0130] Thus, at least the curling is not applied in the direction in which the joint of the roller body 16 is opened. Compared to a case where curling remains just as the roller body 16 is curled toward the outer circumferential surface, it is difficult to open the joint of the roller body 16. That is, according to this embodiment, even when a stress is applied in the direction in which the joint of the roller body 16 is opened, it is possible to prevent the joint

from being opened. Accordingly, the transport roller 15 capable of realizing high transport accuracy can be provided.

[0131] The circumferential direction (bending direction) of the roller body 16 and the curling direction (rolled direction of the metal plate) of the steel plate coil are the same as each other. Therefore, the bending direction of the metal plate of the roller body 16 and the direction of the curling in the curled state can be made to agree with each other. Thus, the curling of the metal plate forming the roller body 16 is applied in a direction in which the joint of the roller body 16 is closed. Accordingly, it is possible to more reliably prevent the joint of the roller body 16 from being opened.

[0132] Since the roller body 16 has the hollow cylindrical shaft, the weight can be considerably reduced compared to a case where a solid shaft is used. Moreover, machinability of a material is less asked compared to a case where the solid shaft is used in the roller body 16. Accordingly, since a material having no harmful material such as lead can be used as the material of the roller body 16, thereby reducing environmental burden.

[0133] Since the high friction layer 50 is formed in the transport roller 15, the driven roller 17 is disposed at the position coming into contact with the high friction layer 50. Thus, since the force holding the sheet P between the transport roller 15 and the driven roller 17 increases, the sheet P can be transported more reliably.

[0134] The transport unit 20 according to this embodiment includes the transport roller 15 and the bearing 26 supporting the transport roller 15. Accordingly, as described above, the transport roller 15 capable of realizing high transport accuracy is rotatably supported by the bearing 26, thereby supporting and transporting the sheet P with high accuracy by the high friction layer 50. By using the hollow roller body 16 in the transport roller 15, the weight of the transport unit 20 can be considerably reduced compared to the case where the solid shaft is used, thereby reducing the environmental burden.

[0135] In the ink jet printer 1 according to this embodiment, since the transport unit 20 can transport the sheet P with high accuracy, the printing can be performed on the sheet P with high accuracy. Moreover, by using the hollow roller body 16 in the transport roller 15, the weight of the entire printer can be considerably reduced compared to the case where the solid shaft is used, thereby reducing the environmental burden.

[0136] Next, a manufacturing apparatus for the transport roller 15 will be described.

[0137] Fig. 4 is a schematic diagram illustrating the manufacturing apparatus for the transport roller 15 according to this embodiment.

[0138] As shown in Fig. 4, a manufacturing apparatus 100 includes an uncoiler 110, a leveler 120, a first press machine 130, and a second press machine 140 arranged in one direction. The manufacturing apparatus 100 includes a transport unit (not shown) transporting a metal plate M unwound from a coil C in one direction and a

cutting unit (not shown) cutting a processed cylindrical shaft from the metal plate M.

[0139] The uncoiler 110 rotatably supports the cylindrical coil (steel plate coil) C in which the metal plate M is wound in the rolled direction and unwinds the coil C.

[0140] The leveler 120 includes a plurality of work rolls 121 disposed vertically in an alternate manner and flattens the metal plate M by passing the metal plate M between the upper and lower work rolls 121. The leveler 120 according to this embodiment does not completely eliminate the curling (rolling) of the metal plate M by the coil C. The curling is adjusted to the degree that the first press machine 130 processes the metal plate.

[0141] The first press machine 130 includes a male die (punch) 131 and a female die (die) 132 and is configured to perform extracting on the metal plate M into a predetermined shape.

[0142] The second press machine 140 includes a plurality of female die (bending die) 141 and 143 and male die (bending punch) 142 and 144, an upper mold 145, and a lower mold 146 which are disposed in one direction, and is configured to perform bending (progressive pressing) on the metal plate M by pressing. By sequentially performing the bending by other molds, while the metal plate M is intermittently sent in one direction by the transport unit (not shown), the metal plate M is gradually formed into a cylindrical shape.

[0143] Next, a method of manufacturing the transport roller 15 will be described.

[0144] First, the coil C is prepared in which the metal plate M such as a cold rolled steel plate or an electrogalvanized steel plate with, for example, a plate thickness from about 0.8 mm to about 1.2 mm is wound in the rolled direction. Then, the metal plate M is unwound by axially rotating the coil C while supporting the coil C by the uncoiler 110 of the manufacturing apparatus 100. The metal plate M unwound from the coil C is in an arc curling state, when an inner circumferential concave surface C1 and an outer circumferential convex surface C2 of the coil C are viewed from the side. The unwound metal plate M is transported in one direction (rolled direction) by the transport unit (not shown) and reaches the leveler 120.

[0145] The metal plate M reaching the leveler 120 is flattened by the plurality of work rolls 121 vertically arranged so that the curling is adjusted. Thus, the metal plate M is flattened to the degree that the first press machine 130 processes the metal plate M, but the curling remains to some extent in the inner circumferential concave surface C1 of the coil C. The metal plate M flattened by the leveler 120 is transported in one direction by the transport unit (not shown) and reaches the first press machine 130.

[0146] The metal plate M reaching the first press machine 130 is subjected to an extracting using the male die 131 and the female die 132 by the press machine. In the extracting, for example, as shown in Figs. 5A and 5B, the metal plate M extracted from the die by the extracting is formed as a base material. That is, the metal plate M

which is the base material of the roller body 16 is subjected to bending so that the upper surface C2 facing the male die 131 shown in Fig. 5A becomes an outer circumferential surface to form a cylindrical shape.

[0147] In this case, as shown in Fig. 5B, even when sag portions sd, shear planes sp, broken-out planes bs, and burrs (not shown) occur in the metal plate M extracted from the die in the extracting step, it is desirable that the upper surface C2 on which the relatively smooth sag portions sd are formed is the outer circumference of the roller body 16. In other words, it is desirable that the lower surface C1 of the metal plate M in which the burrs and the broken-out surfaces bs are continuously formed is an inner circumference of the roller body 16.

[0148] Thus, whenever the roller body 16 having the joint 80 (see Fig. 8C and the like) formed by butting a pair of end surfaces 61a and 61b of the metal plate M is formed, the unevenness such as the burrs or the broken-out surfaces bs function as preventing the joint 80 from being opened.

[0149] Accordingly, it is possible to improve the accuracy of the joint 80 of the roller body 16 and thus provide the transport roller 15 with high transport accuracy. Moreover, since the burrs are present in the inner circumferential surface of the roller body 16 and can be prevented from protruding from the outer circumferential surface of the roller body 16, a burring step can be omitted, thereby improving productivity. Of course, the invention is not limited to the above-described configuration, but another configuration may be used.

[0150] Fig. 6 is a plan view of the metal plate M subjected to the extracting by the first press machine 130.

[0151] As shown in Fig. 6, in the metal plate M, rim sections 66 continuous in the transport direction (rolled direction), strip-shaped flat plate sections 60 extending in a direction intersecting the transport direction, and connection sections 67 connecting the rim sections 66 to the flat plate sections 60 are formed by the extracting. In this embodiment, the extraction process is performed so that the flat plate section 60 has a substantially rectangular form, and short sides 60a are parallel to the rolled direction, and long sides 60b are perpendicular to the rolled direction. By repeating the pressing while the metal plate M is intermittently sent by a transport unit (not shown), the plurality of flat plate sections 60 and connection sections 67 are formed at equal intervals in the transport direction of the metal plate M.

[0152] The metal plate M subjected to the extracting by the first press machine 130 is transported by the transport unit (not shown) and reaches the second press machine 140 shown in Fig. 4.

[0153] Figs. 7A to 7C and Figs. 8A to 8C are side views illustrating a bending step by the second press machine 140.

[0154] The flat plate section 60 of the metal plate M reaching the second press machine 140 is subjected to the bending in a direction (rolled direction) parallel to the short side 60a shown in Fig. 6 by this press machine.

That is, the bending is performed so that a pair of end surfaces along the long sides 60b on the both sides of the flat plate section 60 becomes close. As shown in Figs. 7A to 7C and Figs. 8A to 8C, a cylindrical shape is formed by facing and butting the pair of end surfaces against each other.

[0155] Specifically, the flat plate section 60 of the metal plate M is pressed by the female die (bending die) 141 and the male die (bending punch) 142 shown in Fig. 7A so that both side portions 62a and 62b of the flat plate section 60 are bent in an arc form (preferably, about 1/4 arc). In Fig. 7A, in order to facilitate understanding of the respective members, the respective gaps between the flat plate section 60, the female die 141, and the male die 142 are opened and the respective members are illustrated. In effect, however, there are no gaps, and the contacted portions of the flat plate section 60, the female die 141, and the male die 142 are substantially attached to each other. The same is applied to Figs. 7B and 7C and Figs. 8A to 8C described below.

[0156] The male die 142 is disposed so as to face the inner circumferential surface C1 (the lower surface of the flat plate section 60 in Figs. 7A to 7C) of the coil C shown in Fig. 4. The female die 141 is disposed so as to face the outer circumferential surface C2 (the upper surface of the flat plate section 60 in Figs. 7A to 7C) of the coil C shown in Fig. 4. Thus, both the side portions 62a and 62b of the flat plate section 60 are bent toward the inner circumferential surface C1 of the coil C.

[0157] Next, the metal plate M is sent in the one direction, and the middle portion of the flat plate section 60 in the short side direction (bending direction) is pressed by the second female die (bending die) 143 and the second male die (bending punch) 144 shown in Fig. 7B. Then, the flat plate section 60 is bent in an arc form (preferably, about 1/4 arc) toward the inner circumferential surface C1 of the coil C shown in Fig. 4.

[0158] Next, after the metal plate M is sent in the one direction, as shown in Fig. 7C, a core die 147 is disposed on the inward side of the flat plate section 60. As shown in Figs. 8A to 8C, the end surfaces 61a and 61b of the both side portions 62a and 62b of the flat plate section 60, respectively, are made to be closer using the upper die 145 and the lower die 146 shown in Fig. 7C.

[0159] The outer diameter of the core die 147 shown in Fig. 7C and Figs. 8A to 8C is the same as the inner diameter of the hollow cylindrical roller body 16 to be formed. As shown in Fig. 7C, the radius of the press surface 146c of the lower die 146 and the radius of the press surface 145a of the upper die 145 are the same as the outer diameter of the roller body 16 in consideration of a grinding margin.

As shown in Figs. 8A to 8C, the lower die 146 has a pair of right and left separate dies. The separate dies 146a and 146b are configured to be movable upward and downward individually.

[0160] From the state shown in Fig. 7C, as shown in Fig. 8A, the left separate die 146a comes close to the

upper die 145, one side of the flat plate section 60 is subjected to pressing, and the flat plate section is bent in a substantially semi-circular form. Like the lower die 146, the upper die 145 also has a pair of right and left separate dies (see a separate surface 145b). In the step shown in Fig. 8A, the upper die on the same side may come close to the separate die 146a.

[0161] Next, as shown in Fig. 8B, by making the other separate die 146b close to the upper die 145 while moving the core die 147 toward the upper die 145 to some degree (to the degree that one end surface 61a and the other end surface 61b come close to each other), the other side of the flat plate section 60 is subjected to pressing to be bent in a substantially semi-circular form.

[0162] Thereafter, as shown in Fig. 8C, the cylindrical roller body (hollow pipe) 16 is formed by making all of the core die 147 and the pair of separate dies 146a and 146b close to the upper die 145. In this state, the right and left end surfaces 61a and 61b face and are butted to each other. That is, in the cylindrical roller body 16, the both end surfaces 61a and 61b of the flat plate section 60 of the metal plate M which is the base material come close to each other to form the joint between these end surfaces 61a and 61b. Here, the inner circumferential surface C1 of the coil C shown in Fig. 4 turns into the inner circumferential surface of the roller body 16 and the outer circumferential surface C2 of the coil C turns into the outer circumferential surface of the roller body 16. Thus, the roller body 16 is formed by winding the flat plate section 60 about the core die 147.

[0163] Fig. 9 is a plan view illustrating the metal plate M in which the flat plate sections 60 are formed in the cylindrical shape gradually by the steps shown in Figs. 7A to 7C and Figs. 8A to 8C.

[0164] The metal plate M extracted from the die as in Fig. 6 reaches the second press machine 140 shown in Fig. 4. Then, the flat plate sections 60 are sequentially bent through the steps shown in Figs. 7A to 7C and by this press machine in the steps shown in Figs. 8A to 8C, while intermittently sending the metal plate M in the one direction (progressive pressing step). Therefore, as shown in Fig. 9, the flat plate section 60 reaching the second press machine 140 gradually turns into the circular cylinder frontward the transport direction of the metal plate M. After the flat plate section 60 is formed in the cylindrical shape, the connection sections 67 are cut by a cutting unit (not shown) so as to become the hollow cylindrical roller body 16.

[0165] Next, in this embodiment, in order to improve the circularity of the formed roller body 16 and reduce the displacement, a centerless grinding step is performed. In this grinding step, for example, as shown in Fig. 10, the outer circumferential surface 16a of the roller body 16 is ground using grinding members GD with a columnar form (or a cylindrical shape).

[0166] The roller body 16 comes into contact with the outer circumferential parts of the two grinding members GD by disposing the roller body 16 between the two grind-

ing members GD arranged with a gap so that the gap is smaller than the outer diameter of the roller body 16. Thereafter, the two grinding members GD are rotated, for example, in the same direction. By the rotation of the two grinding members GD, a frictional force is generated between the grinding members GD and the roller body 16.

[0167] It is desirable that the sizes of the two grinding members GD in the longitudinal direction (in a height direction of the column) are larger than the roller body 16 so that the entire roller body 16 is ground at once in the longitudinal direction. When the grinding members GD are rotated, it is desirable that the roller body 16 is disposed, for example, in the middle portion of the grinding members GD in the longitudinal direction, for example, so that the entire roller body 16 in the longitudinal direction comes into contact with the two grinding members GD in order to ensure the margin in the longitudinal direction of the roller body 16.

[0168] The outer circumferential surface 16a of the roller body 16 is ground by the frictional force generated due to the rotation of the grinding members GD, while the roller body 16 is rotated in a direction opposite to the rotational direction of the grinding members GD. Thus, substantially the entire surface of the outer circumferential surface 16a of the roller body 16 is ground evenly. Therefore, the circularity of the roller body 16 is improved compared to the case where the grinding step is not performed.

[0169] In the pressing or the grinding, it is desirable that there is no gap between the both end surfaces 61a and 61b of the flat plate section 60, that is, the both end surfaces 61a and 61b come into contact with each other. In effect, however, it is difficult to form no gap, while reliably maintaining the circularity or the deviation of the obtained roller body 16. Accordingly, the gap is maintained to some extent.

[0170] The joint 80 has the outer circumferential surface and the inner circumferential surface of the flat plate section 60 of the same size (width), so that the distance between the pair of end surfaces 61a and 61b is relatively larger on the side of the outer circumferential surface 16a of the roller body 16 and is relatively smaller on the side of the inner circumferential surface 16b of the roller body 16, as shown in Fig. 11B.

[0171] Next, the roller body 16 is subjected to a plating process (plating step). By the plating, a plated layer is formed in the inner and outer circumferential surfaces and the end surfaces 61a and 61b of the roller body 61. Although the steel plate with a previously formed plated layer such as SECC is used, it is necessary to sufficiently form the plated layer on the end surfaces 61a and 61b in the plating step due to the fact that the base material of the steel plate of the end surfaces 61a and 61b may be exposed by punching and extracting and thus may easily corrode. When the roller body 16 serving as the cylindrical shaft according to the invention is formed in this way, the high friction layer 50 shown in Figs. 3A and

3B are formed on the surface of the roller body 16.

[0172] As a method of forming the high friction layer 50, a dry method and a wet method (or a method of combining both these methods) can be used. In this embodiment, the dry method is preferably used. Specifically, resin particles and inorganic particles are first prepared as a material for forming the high friction layer 50. As the resin particles, fine particles with a diameter of about 10 μm made of epoxy-based resin or polyester-based resin are preferably used.

[0173] As the inorganic particles, ceramics particles such as aluminum oxide (alumina: A1203), silicon carbide (SiC), or silicon dioxide (SiO₂) are preferably used. Among them, alumina is preferably used, since alumina has relatively high hardness and a function of increasing friction resistance, and alumina is relatively cheap and thus is not necessary to decrease the cost. Therefore, in this embodiment, alumina particles are used as the inorganic particles.

[0174] The alumina particles adjusted so as to have a predetermined grain diameter distribution by a crushing process are used. By producing the alumina particles by the crushing process, the end portions of the alumina particles are relatively sharp and thus high frictional force is generated by the sharp end portions of the alumina particles.

[0175] In this embodiment, the alumina particles are adjusted so that the grain diameter is equal to or larger than 15 μm and is equal to or smaller than 90 μm and the grain diameter (average particle diameter) of the weighted average of the central diameters is 45 μm .

[0176] That is, in this embodiment, the alumina particle (inorganic particle) with the average grain diameter (central diameter) larger than a distance d1 (30 μm) of the above-described joint 80 on the side of the outer circumferential surface is used. In particular, as for the grain diameter distribution (particle size range), it is desirable that the grain diameter of the particle is smaller than the distance d1 on the outer circumferential surface of the joint 80 and is larger than a distance d2 (10 μm) on the inner circumferential surface thereof. Moreover, it is desirable that the minimum grain diameter in the grain diameter distribution is larger than the shortest distance between a pair of end surfaces 61a and 61b in the joint 80, for example, the distance d2 on the side of the inner circumferential surface.

[0177] When the resin particles and the inorganic particles are prepared, the above-described resin particles are first applied to the roller body 16. That is, the roller body 16 is disposed inside a coating booth (not shown), and the roller body 16 is maintained with a (negative) potential, for example, in a single body state.

[0178] The sprayed particles (resin particles) are charged with a + (positive) high potential, while spraying resin particles (ejected) toward the roller body 16 using a tribo gun of an electrostatic coating apparatus (not shown). Then, the charged resin particles are absorbed on the outer circumferential surface of the roller body 16

to form a resin film.

[0179] The resin film produced by spraying the resin particles are formed in the region where the high friction layer 50 shown in Figs. 3A and 3B is formed. That is, the resin film is formed only in the middle portion of the roller body 16 without being formed in the entire length of the roller body 16, as shown in Fig. 12A, for example, by masking the both ends of the roller body 16 with a tape or the like. That is, a resin film 51 is formed selectively only in the region, which comes into contact with the transported sheet (medium) P, corresponding to the middle portion of the transport roller 15 formed by the roller body 16. The joint 80 is not illustrated in Fig. 12A and Figs. 12B and 12C described below.

[0180] A weak static electrical charge of about +0.5 KV remains in the resin film 51, after the spray coating process. When the spray coating process is performed, the resin film 51 is formed on the entire circumference of the roller body 16 so as to have a substantially uniform thickness, by axially rotating the roller body 16. The resin film 51 is formed so as to have a film thickness from about 10 μm to about 30 μm , for example, in consideration of the particle diameter of the above-described alumina particle. The film thickness can be appropriately adjusted depending on the amount of resin particles to be ejected, ejection time, and the like.

[0181] Next, the roller body 16 on which the resin film 51 is formed is taken out from the above-described coating booth 90 and is moved into another coating booth shown in Fig. 13 by a handling robot (not shown). A pair of rotation driving members 91 is installed in the lower portion of the coating booth 90. Chucks 92 are installed in the pair of rotation driving members 91, respectively, to support the roller body 16 substantially horizontally.

[0182] Both the ends of the roller body 16 are held and fixed to the chucks 92 and the rotation driving members 91 rotate the chucks 92. Thus, the roller body 16 is axially rotated to be rotatably driven slowly at a low speed from about 100 rpm to about 500 rpm, for example. Of course, the roller body 16 may be supported so as to be slightly tilted.

[0183] A corona gun 93 is installed in the upper portion of the coating booth 90. The corona gun 93 is configured to be movable right and left on a shaft 94 in Fig. 13. A discharge mechanism 90a is installed in the bottom portion of the coating booth 90. Accordingly, an air stream slowly flowing downward is formed in the coating booth 90. A suction air volume of the discharge mechanism 90a is set to be appropriate.

[0184] With such a configuration, the above-described alumina particles 95 are electrostatically adsorbed selectively on the resin film 51 formed on the roller body 16 by spraying and blowing the alumina particles 95 from the corona gun 93 while axially rotating the roller body 16. In order to electrostatically adsorb the alumina particles selectively on the resin film 51, the both ends of the roller body 16 are masked with a tape or the like, just as the resin film 51 is formed.

[0185] In the electrostatic coating process, the surface potential of the chucks 92 and the rotation driving members 91 are substantially the same as the potential of the roller body 16, and thus the inner surface potential of the coating booth 90 is set to be about the zero potential electrically neutrally. This is because the alumina particles 95 from the corona gun 93 are not adsorbed in the portions other than the roller body 16. In order to maintain the inner surface potential of the coating booth 90 electrically neutrally, it is preferable that the coating booth 90 is manufactured using a steel plate with, for example, about electric resistance of 1011 Ω .

[0186] The potential of the corona gun 93 is set to be the zero V and the air pressure supplied to the corona gun 93 is set to be a low pressure of about 0.2 Mpa. Next, the alumina particles 95 with the about zero potential are blown from the upper side, while moving the corona gun 93 right and left in Fig. 13, and thus the alumina particles 95 vertically fall naturally under the own weight.

[0187] As described above, the weak electrostatic charge (about +0.5 KV) generated in the electrostatic coating process remains in the resin film 51 of the roller body 16. Therefore, the alumina particles 95 are electrostatically adsorbed substantially uniformly on the entire circumference of the resin film 51 by this electrostatic charge. Thus, the alumina particles are attached on the outer circumferential surface of the roller body 16 using the resin film 51 as a binder, in the state where the electrostatically adsorbed alumina particles 95 come into contact with and partially enter the surface of the resin film 51.

[0188] In this embodiment, since the inner surface potential of the coating booth 90 becomes the about zero potential electrically neutrally and the air stream in the coating booth 90 slowly flows downward, the alumina particles 95 vertically fall freely downward under the own weight. Since the horizontally supported roller body 16 is axially rotated slowly downward in the falling direction, the alumina particles 95 are spread substantially uniformly on the outer circumferential surface of the roller body 16.

[0189] Accordingly, the alumina particles 95 are uniformly attached, in particular, on the surface of the resin film 51 which is not masked. Thus, as shown in Fig. 12B, the alumina particles (inorganic particles) 95 are dispersed and exposed on the resin film 51 in the middle portion of the roller body 16. That is, when the alumina particles 95 come into contact with the resin film 51 by the electrostatic adsorption force, some of the alumina particles 95 enter the resin film 51 and the remaining alumina particles 95 protrude from the surface of the resin film 51. At this time, since the alumina particles 95 are easily erected vertically to the surface of the roller body 16, the alumina particles 95 are evenly spread and most of the alumina particles are attached outward on the sharply pointed end parts (top parts).

[0190] Accordingly, the alumina particles 95 have a high frictional force by the end parts protruding from the

surface of the resin film 51. Here, in order for the alumina particles 95 to have the frictional force necessary and sufficient for the sheet P, it is preferable that the ratio of the area of the alumina particles 95 to the area of the resin film 51 is in the range from 20% to 80%.

[0191] When the alumina particles 95 are slowly sprayed vertically downward in the application (spreading) of the alumina particles 95, the alumina particles 95 may be applied not only according to the electrostatic coating method but also an application (spreading) method of using, for example, a spray gun.

[0192] When the alumina particles 95 are spread and attached to the resin film 51, the roller body 16 is heated and hardened at the temperature of about 180°C to about 300°C for about 20 minutes to about 30 minutes, and the resin film 51 is baked and hardened. Accordingly, the alumina particles 95 are adhered to the roller body 16. Thus, as shown in Fig. 12C, the high friction layer 50 in which the alumina particles (inorganic particles) 95 on the resin film 51 are dispersed and exposed is formed, and thus the transport roller 15 according to the invention is obtained.

[0193] In this embodiment, the application (spray) of the resin particles and the application (spray) of the alumina particles (inorganic particles) are performed in the different coating booths, but may, of course, be performed in the same coating booth.

[0194] When the high friction layer 50 is formed in this manner, the gap between the end surfaces 61a and 61b are buried mainly with the alumina particles 95 particularly in the joint 80 without forming a groove formed in the gap between the end surfaces 61a and 61b of the flat plate section 60.

[0195] That is, the average grain diameter of the alumina particles 95 is larger than the distance d1 of the joint 80 on the side of the outer circumferential surface, most of the alumina particles 95 do not enter the joint 80 and are attached on the outer circumferential surface of the roller body 16 via the resin film 51, as shown in Fig. 14. Accordingly, although the gap is formed between the end surfaces 61a and 61b of the flat plate section 60 in the joint 80, the gap is covered with the alumina particles 95 and thus effectively no groove is formed in the gap.

[0196] Moreover, since the alumina particles 95 have the grain diameter distribution (particle size range) in which a particle 95a is smaller than the distance d1 (30 μm) on the side of the outer circumferential surface of the joint 80 and is larger than the distance d2 (10 μm) on the side of the inner circumferential surface thereof, the particles 95a are inserted and stay in the gap formed in the joint 80, thereby reliably forming no groove in the joint 80.

[0197] Even when a force is applied to the roller body 16 (the transport roller 15) in a direction in which the gap is narrowed at the use time or the like, the alumina particles 95a entering the gap resist the force, thereby preventing the roller body 16 (the transport roller 15) from being deformed. Accordingly, the transport irregularity

caused due to the deformation of the transport roller 15 is prevented in the transport roller mechanism 19 including the transport roller 15.

[0198] The alumina particles 95 have the grain diameter distribution in which the minimum grain diameter is larger than the shortest distance between the pair of end surfaces 61a and 61b in the joint 80, that is, the distance d_2 on the side of the inner circumferential surface. Therefore, when the high friction layer 50 is formed by attaching the alumina particles 95 to the surface of the roller body 16, the alumina particles 95 do not pass through from the gap formed in the joint 80 and do not enter the roller body 16. Accordingly, productivity can be improved since it is not necessary to perform a cleaning process on the inside of the roller body 16.

[0199] As shown in Fig. 3A, the transport roller 15 can be obtained by forming the high friction layer 50 produced through the dispersion and exposure of the alumina particles in the resin film is produced through the above-described steps.

[0200] According to this embodiment, since the transport roller 15 is formed in the cylindrical shape, the weight of the transport roller 15 can be reduced compared to the case where the solid transport roller is used. Thus, the light-weight ink jet printer 1 can be provided. By forming the transport roller in the cylindrical shape, the transport roller 15 can be manufactured at low cost. Moreover, the high friction layer 50 transporting the print sheet P which is the transport medium is disposed on the outer circumferential surface of the transport roller 15 (the roller body 16), the high transport accuracy can be ensured, thereby achieving the high print accuracy.

[0201] The technical scope of the invention is not limited to the above-described embodiment, but the invention may be modified appropriately within the scope of the invention without departing from the gist of the invention.

[0202] In the above-described embodiment, for example, the steel plate coil wound with the metal plate such as a galvanized steel plate or a stainless steel plate is used as the base material of the roller body 16, but the invention is not limited thereto. For example, the roller body 16 may be formed by using, for example, a flat metal plate as the base material, forming the metal plate with substantially the same size as that of the flat plate section 60 from the flat metal plate, and processing the metal plate. Accordingly, the above description or the following description may be applied even when the flat plate section 60 may be replaced with the metal plate.

[0203] For example, openings 170 may be formed in parts of the joint 80 formed in the roller body 16, as shown in Fig. 15A.

[0204] In the joint 80 formed in the roller body 16, as shown in Fig. 15B, the pair of end surfaces 61a and 61b are attached closely to each other on the side of the inner circumference and are separated from each other on the side of the outer circumference, so that a groove is formed on the side of the outer circumference. Alternatively,

the pair of end surfaces 61a and 61b do not come into contact with each other in the joint 80, and the end surfaces 61a and 61b are slightly separated from each other so that a gap is formed. The joint 80 is formed along the entire length of the transport roller 15. Therefore, when grease L supplied to the bearing 26 is attached to the surface of the transport roller 15, the grease L transmits and flows in the joint 80 by capillarity. In particular, since the strength of the transport roller 15 is improved, the capillarity of the grease L becomes stronger with a decrease in the joint 80 (the maximum distance d_1 between the end surfaces 61a and 61b). Therefore, the grease L easily flows along the joint 80.

[0205] As shown in Fig. 15C, the openings 170 are formed in parts of the joint 80 formed in the roller body 16. As shown in Fig. 15C, the opening 170 is formed by notched portions 176 and 177 respectively formed in the pair of end surfaces 61a and 61b forming the joint 80. The maximum distance d_2 between the notched portions 176 and 177 is set to be equal to or larger than, for example, about 1 mm when the end surfaces 61a and 61b are butted with each other, so that the opening 170 is formed.

[0206] The opening 170 is formed in the regions of the joint 80 formed along the entire length of the transport roller 15 (the roller body 16), except for the region where the high friction layer 50 is formed and the region supported by the bearing 26. That is, since the high friction layer 50 is formed in substantially the middle portion of the transport roller 15 and the both end sides of the transport roller 15 are supported by the bearing 26, at least two openings 170 are formed in the transport roller 15.

[0207] The openings 170 are formed in order to prevent the grease L (lubricant oil) supplied (applied) to the bearing 26 from reaching the high friction layer 50 along the joint 80 (the gap between the end surfaces 61a and 61b). That is, the capillarity of the grease L stops by providing the openings 170 in the parts of the joint 80. Specifically, the grease L is prevented from reaching the high friction layer 50 by providing the openings 170 between the regions of the joint 80 supported by the bearing 26 and the region thereof where the high friction layer 50 is formed. Moreover, the capillarity of the grease L can reliably stop by adjusting the size (the maximum distance d_2 between the pair of notched portions 176 and 177) of the opening 170.

[0208] The invention is not limited to the case where the notched portions 176 and 177 for forming the openings 170 are respectively formed in the pair of end surfaces 61a and 61b forming the joint 80. That is, as shown in Fig. 15D, a notched portion 178 may be formed only in one (for example, the end surface 61a) of the pair of end surfaces 61a and 61b forming the joint 80 and the opening 170 may be formed by the notched portion 178 and the end surface 61b. Moreover, the shape of the opening 170 is not limited to a rectangle, and may be a circle.

[0209] The joint 80 formed in the roller body 16 may

be formed in the shape shown in Fig. 16A. That is, in the joint 80, a first end surface 274 and a second end surface 275 come into contact with each other on the side of an outer circumferential surface 271a of a roller body 271. The gap between the first end surface 274 and the second end surface 275 gets gradually wider from the outside to the inside in a diameter direction. The shapes of the first end surface 274 and the second end surface 275 are the same as each other along the entire length of the roller body 271 except for a bent portion 85.

[0210] Both a first angle α formed between the first end surface 274 and the outer circumferential surface 271a and a second angle β formed between the second end surface 275 and the outer circumferential surface 271a are smaller than 90° .

[0211] Since the first end surface 274 and the second end surface 275 of the joint 80 come into contact with each other on the side of the outer circumferential surface 271a, smoothness of a contact portion 276 on the side of the outer circumferential surface 271a is improved. Therefore, even when the transport roller 15 is rotated, the outer circumferential surface can stably come into contact with the print sheet P. Accordingly, it is possible to transport the print sheet P with high accuracy.

[0212] As shown in Fig. 16B, the shape of the joint 80 may be formed so that the first angle α formed between the first end surface 274 and the outer circumferential surface 271a of the joint 80 may be smaller than 90° and the second angle β formed between the second end surface 275 and the outer circumferential surface 271a may be equal to or larger than 90° . That is, the shapes of the first end surface 274 and the second end surface 275 in the contact portion 276 may be tilted in a predetermined direction with respect to the circumferential direction.

[0213] The shape of the joint 80 is formed through the following steps. That is, after a metal plate 270 is formed by punching in progressive pressing, end-face adjustment processing is performed on the first end surface 274 and the second end surface 275 of the metal plate 270 to adjust the slopes of the first end surface 274 and the second end surface 275 with respect to the outer circumferential surface 271a.

[0214] As shown in Fig. 16C, the slopes of the first end surface 274 and the second end surface 275 with respect to the outer circumferential surface 271a are adjusted by pressing. By this adjustment process, both the first angle α formed between the first end surface 274 and the outer circumferential surface 271a and the second angle β formed between the second end surface 275 and the outer circumferential surface 271a are smaller than 90° .

[0215] Accordingly, when the roller body 271 with the cylindrical shape is formed by bending the metal plate 270, the first end surface 274 and the second end surface 275 come into contact with each other on the side of the outer circumferential surface 271a.

[0216] In the configuration shown in Figs. 16A and 16B, for example, a part of the first end surface 274 and a part of the second end surface 275 may come into

surface contact with each other. For example, the configuration corresponding to Fig. 16A will be described. As shown in Fig. 17A, a first end-face outer edge 274a, which is the part of the first end surface 274, and a second end-face outer edge 275a, which is the part of the second end surface 275, may come into face contact with each other. That is, there is no gap, a concave portion, or the like opened in a joint 80 on the side of the outer circumferential surface 271a. Therefore, it is possible to constantly maintain the contact between the outer circumferential surface 271a and the print sheet P when the transport roller 15 is rotated. Since the first end-face outer edge 274a and the second end-face outer edge 275a come into face contact with each other, the strength of the roller body 16, particularly, the strength near the joint 80 is improved. Even when a force is applied to the bending or distortion of the roller body 16, it is possible to prevent the first end surface 274 and the second end surface 275 from being separated from each other.

[0217] A gap 277 is formed between a first end-face inner edge 274b and a second end-face inner edge 275b. The width of the gap 277 gradually becomes larger toward the inner circumferential surface 271b. Both a first angle α_1 formed between the first end-face inner edge 274b and the inner circumferential surface 271b and a second angle α_2 formed between the second end-face inner edge 275b and the inner circumferential surface 271b are larger than 90° .

[0218] The configuration corresponding to Fig. 16B will be described. As shown in Fig. 17B, a second gap (gap) 277A is formed between the first end-face inner edge 274b and the second end surface 275. The width of the second gap 277A gradually becomes larger toward the inner circumferential surface 271b. The first angle α_1 formed between the first end-face inner edge 274b and the inner circumferential surface 271b is larger than 90° and a third angle α_3 formed between the second end surface 275 and the inner circumferential surface 271b is equal to or smaller than 90° . That is, the first end surface 274 (and the second end surface 275) in the joint 80 has a shape tilted in a predetermined direction with respect to the circumferential direction. When the print sheet p is transported by rotating the transport roller 15 in the tilted direction, the first end surface 274 and the second end surface 275 are rarely separated from each other although a biasing force caused by the transport is applied to the joint 80. Accordingly, it is possible to suppress the deformation, the distortion, or the like of the transport roller 15 which is likely to be caused by the transport.

[0219] As described above, the engagement portions connecting various connection components such as the transport driving gear 35 and the inner gear 39 shown in Figs. 2A and 2B are formed in one or both of the ends of the roller body 16 (the transport roller 15). For example, as shown in Figs. 18 and 19, through holes 71a are formed at the positions facing the roller body 16 formed of a cylindrical pipe (hollow pipe), that is, at the surface

in which two points defining the diameter of the roller body 16 are formed. Therefore, engagement holes (engagement portions) 71 including a pair of through holes 71a can be formed. Through the engagement holes 71, a connection part 72 such as a toothed wheel can be fixed by a shaft, a pin, or the like (not shown).

[0220] As shown in Figs. 20A and 20B, an engagement portion 73 with a D-cut shape can also be formed in the end of the roller body 16. By forming the engagement portion 73 in the end of the hollow cylindrical pipe (the roller body 16), the engagement portion 73 has an opening 73a notched in a rectangular shape in a plan view in a part thereof, as shown in Fig. 20A. Accordingly, as shown in Fig. 20B, the outer appearance of the side face of the end is apparently formed in a D shape.

[0221] By engaging the connection component (not shown) such as a toothed wheel with the engagement portion 73 apparently formed in the D shape, the connection component can be mounted on the roller body 16 (the transport roller 15) without idling. By forming the groove-shaped opening 73a communicating with the inner hole of the hollow pipe (the roller body 16) in the engagement portion 73, the connection component can be mounted on the roller body 16 without idling using the opening 73a. Specifically, by forming a convex portion in the connection component and fitting the convex portion into the opening 73a, the idling can be prevented.

[0222] As shown in Fig. 20C and 20D, an engagement portion 74 having a groove 74a and a D-cut portion 74b can be formed in the end of the roller body 16. In the engagement portion 74, the D-cut portion 74b is formed in the outward end of the roller body 16 and the groove 74a is formed in the portion more inner than the D-cut portion 74b. As shown in Fig. 20C, the groove 74a is formed by notching about the half of the roller body 16 in the circumferential direction. The D-cut portion 74b has an opening 74c extending in a direction perpendicular to the groove 74a on the outward side of the groove 74a. A pair of bent pieces 74d is formed at both sides of the opening 74c. That is, as shown in Fig. 20D, the pair of bent pieces 74d is bent toward the central axis of the roller body 16. Therefore, the portions corresponding to the bent pieces 74d are concaved from the circular outer circumferential surface of the roller body 16.

[0223] By engaging the connection component (not shown) such as a toothed wheel with the groove 74a or the D-cut portion 74b, the connection component can be mounted on the roller body 16 (the transport roller 15) without idling. By using the opening 74c formed between the bent pieces 74d in the engagement portion 74, the connection component can be mounted on the roller body 16 without idling. Specifically, by forming a convex portion in the connection component and fitting the convex portion into the opening 74c, the idling can be prevented.

[0224] As shown in Figs. 20E and 20F, engagement portions 75 including a groove 75a and an opening 75b can also be formed in the end of the roller body 16. In the engagement portion 75, the opening 75b is formed

in the outward end of the roller body 16 and the groove 75a is formed in the portion more inner than the opening 75b. As shown in Fig. 20E, the groove 75a is formed by notching about half of the roller body 16 in the circumferential direction. The opening 75b is formed by notching a part of the roller body 16 in a rectangular shape on the outside of the groove 75a in a plan view. Accordingly, as shown in Fig. 20F, the outer appearance of the end surface of the opening 75b is apparently formed in a D shape.

[0225] By engaging the connection component (not shown) such as a toothed wheel with the groove 75a or engaging the connection component with the portion formed apparently in the D shape by the opening 75b, the connection component can be mounted on the roller body 16 (the transport roller 15) without idling. Like the engagement portions 73 shown in Figs. 20A and 20B, the connection component can be mounted on the roller body 16 without idling by using the opening 75b in the engagement portions 75.

[0226] The engagement hole 71 or the engagement portions 73, 74, and 75 can be formed by further performing cutting on the roller body 16 obtained through the pressing for the flat plate section 60. In this case, however, since a separate processing step is further performed on the roller body 16 to form only the engagement portions, efficiency of cost or time may deteriorate. In the manufacturing method according to the invention, however, development engagement portions, which are to become the engagement portions by the pressing of a first press step, is formed in the flat plate section 60 before the roller body 16 is subjected to the pressing in a second press step, and then the engagement portions are simultaneously formed together when the flat plate section 60 is formed into the roller body 16 by the pressing in the second press step.

[0227] Specifically, when the metal plate M wound in a coiled shape is punch-processed to form the flat plate section 60 with a slender rectangular plate shape, the small-sized flat plate section 60 is formed from the large-sized metal plate M and the development engagement portion with a notch shape, a protrusion shape, a hole shape, a groove shape, or the like is simultaneously formed in the end of the flat plate section 60.

[0228] For example, as shown in Fig. 21A, a pair of through holes 71a is processed at predetermined positions of the end of the flat plate section 60, and the processed through holes are set as development engagement portions 76a. Then, the engagement hole 71 shown in Figs. 18 and 19 can be formed by facing the pair of through holes 71a through the pressing of the flat plate section 60.

[0229] As shown in Fig. 21B, the end of the flat plate section 60 is notched in a predetermined shape to form a pair of notched portions 73b as development engagement portions 73c. Then, the engagement portion 73 shown in Figs. 20A and 20B can be formed through the pressing on the flat plate section 60.

[0230] As shown in Fig. 21C, the end of the flat plate

section 60 is notched in a predetermined shape to form development engagement portions 76b. Then, the engagement portions 74 shown in Figs. 20C and 20D can be formed through the pressing on the flat plate section 60. That is, the engagement portions 74 can be formed by forming a pair of notched portions (concave portions) 74e and the pair of protrusions 74f as the development engagement portions 76b. In this example, however, since it is necessary to form the bent pieces 74d by subjecting the flat plate section 60 to the pressing and then inwardly bending the pair of protrusions 74f, the efficiency of cost or time may not be sufficiently achieved in the pressing step.

[0231] As shown in Fig. 21D, the end of the flat plate section 60 is notched in a predetermined shape to form development engagement portions 76c. Then, the engagement portions 75 shown in Figs. 20E and 20F can be formed through the pressing on the flat plate section 60. That is, the engagement portions 75 can be formed by forming the pair of notched portions (concave portions) 75c and the pair of protrusions 75d as the development engagement portions 76c. In this example, the opening 75b shown in Fig. 20E can be formed between the pair of protrusions 75d by bending the pair of protrusions 75d in an arc shape when the flat plate section 60 is subjected to the pressing. Accordingly, it is not necessary to further process the roller body 16 formed by the pressing and the efficiency of cost or time can be sufficiently achieved in the processing step.

[0232] In the examples shown in Figs. 21B to 21D, the development engagement portions 73c, 76b, or 76c are formed at the both ends of the flat plate section 60 so that the engagements portions 73, 74, or 75 shown in Figs. 20A to 20F are formed with the joint 80 interposed therebetween. Thus, by forming the development engagements 73c, 76b, or 76c in the both ends of the flat plate section 60, the joint 80 of the roller body 16 can be shorter than the length of the roller body 16. Therefore, it is possible to prevent the roller body 16 from being deformed due to partial contact and interference of the end surfaces 61a and 61b when the joint 80 is formed.

[0233] However, the invention is not limited thereto. As shown in Figs. 22A to 22C, the development engagement portions are not formed at the both ends of the flat plate section 60, and can instead be formed near the central line in the width direction (bending direction). That is, as shown in Fig. 22A, the engagement portion 73 shown in Fig. 18 can be formed by forming a development engagement portion 76d obtained from a slender rectangular notch in the end of the flat plate section 60. The engagement portion 74 shown in Figs. 20C and 20D can be formed by forming a development engagement portion 76e obtained from a T-shaped notch shown in Fig. 22B. Moreover, the engagement portion 75 shown in Figs. 20E and 20F can be formed by forming a development engagement portion 76f obtained from a substantially T-shaped notch shown in Fig. 22C.

[0234] Thus, when the development engagement por-

tions 76d to 76f are formed near the central line in the bending direction, the engagement portions 73 to 75 obtained from the development engagement portions 76d to 76f can be formed with more accuracy.

[0235] As described above, in the method of manufacturing the transport roller 15 according to this embodiment, the development engagement portions are simultaneously formed when the small-sized metal plate (first metal plate) 60 is formed from the large-sized metal plate (second metal plate) M by the pressing. Moreover, the engagement portions 71, 73, 74, or 75 are formed from the development engagement portions, when the metal plate (first metal plate) 60 is subjected to the pressing. Therefore, it is not necessary to further execute a separate processing step of forming only the engagement portions after the roller body 16 is formed. Accordingly, since cost or time necessary for the additional processing step can be reduced, productivity can be improved in that the cost for the transport roller 15 can be sufficiently reduced. In particular, the development engagement portions can be formed collectively when the large-sized metal plate is processed into the small-sized metal plate. Therefore, the step can further be simplified.

[0236] As shown in Fig. 11A, in the transport roller 15 (the roller body 16) according to this embodiment, the joint 80 is formed to be parallel to the central line of the roller body 16 formed from the hollow cylindrical pipe. However, the invention is not limited thereto. For example, the joint formed between the pair of ends of the flat plate section 60 which is the base material may overlap with one or a plurality of points of a straight line parallel to the central axis of the cylindrical pipe on the outer circumferential surface of the cylindrical pipe (roller body) without overlapping with a line segment of the straight line.

[0237] Specifically, as shown in Fig. 23A, a joint 81 may extend from one end of the roller body 16 to the other end thereof while extending toward the outer circumferential surface of the roller body 16 in the circumferential direction so as to intersect a central axis 16c of the roller body 16 without being parallel to the central axis 16c. In order to form the joint 81, the flat plate section 60 with the slender rectangular shape is not formed as the metal plate which is the base material, but a flat plate section 60a with a slender parallelogram shape shown in Fig. 23B is formed and subjected to pressing so that a straight line indicated by Reference Numeral 16d serves as a central axis. Thus, since the roller body 16 shown in Fig. 23A can be obtained, the joint 81 is not parallel to the central axis 16c.

[0238] In the roller body 16 shown in Fig. 23A, the joint 81 is formed from one end of the roller body 16 to the other end thereof so as to circle on the circumferential surface less than once. This is because the pressing on the flat plate section 60a is easily performed. However, as shown in Fig. 23C, a joint 82 may be formed from one end of the roller body 16 to the other end thereof so as to circle on the circumferential surface on more than

once, that is, circle in a spiral shape. In this case, an angle θ may be a more acute angle in the flat plate section 60a, which is formed from the metal plate which is the base material, with the slender parallelogram shape shown in Fig. 23B.

[0239] As shown in Fig. 24A, a joint 83 may be formed in a wave line shape of a curve such as a sine curve. In order to form the joint 83, as shown in Fig. 24B, the flat plate section 60b, which is formed from the metal plate which is the base material, with a substantially slender rectangular shape and both wave-line-shaped long sides is subjected to pressing so that a straight line indicated by Reference Numeral 16d serves as the central axis. A pair of long sides formed in the wave line shape closely approaches each other by the pressing. Therefore, when one long side becomes a ridge portion of course between the portions corresponding to each other, the other long side becomes a valley portion. On the contrary, when one long side becomes a valley portion, the other long side becomes a ridge portion. In this example, the central line of the joint 83 is formed to be parallel to the central axis of the roller body 16, but the central line of the joint 83 may also be formed not to be parallel to the central axis of the roller body 16. In this case, the slender parallelogram metal plate shown in Fig. 23B having both long sides with a wave line shape may be used as the metal plate, which is the base material.

[0240] As shown in Fig. 25A, a joint 84 may be formed in a wave line shape bent like a hook. In order to form the joint 84, the flat plate section 60c in the wave line shape, which is formed from the metal plate which is the base material and has the slender rectangular shape and the both long sides bent like a hook, as shown in Fig. 23B, is subjected to pressing so that a straight line indicated by Reference Numeral 16d serves as a central axis. The flat plate section 60c has a pair of long sides formed in the wave line shape. When one long side becomes a ridge portion, the other long side becomes a valley portion in the portions corresponding to each other. On the contrary, when one long side becomes a valley portion, the other long side becomes a ridge portion. In this example, the central line of the joint 84 is formed to be parallel to the central axis of the roller body 16, but the central line of the joint 84 may also be formed so as not to be parallel to the central axis of the roller body 16, as in the joint 83.

[0241] The joint is not limited to the examples shown in Figs. 23A to 25B, but may be modified so as to have various shape. For example, the curved wave line shape shown in Fig. 24A and the bent wave line shape shown in Fig. 25A may be combined. Moreover, the tilted line shown in Figs. 23A and 23B, the curved wave line, and the bent wave line may be combined.

[0242] In this way, the joints 81 to 84 overlap with one or a plurality of points of the straight line parallel to the central axis of the cylindrical pipe (the roller body 16) without overlapping with a line segment of the straight line. When the transport roller 15 including the roller body

16 transports the sheet P together with the driven roller 17, that is, transports a sheet, the transport speed of the sheet P is uniform, thereby preventing transport irregularity more reliably.

[0243] That is, as shown in Fig. 26, the portion of the transport roller 15 coming into contact with the sheet P when the transport roller 15 transport a sheet is basically a straight line L on the circumferential surface, that is, a straight line L parallel to the central axis 16c. Therefore, the joint 80 of the transport roller 15 (the roller body 16) is parallel to the central axis 16c of the roller body 16, as shown in Fig. 7B, the entire joint 80 of the transport roller 15 temporarily (instantaneously) comes into contact with the sheet P. Then, since the groove is not formed by the joint 80 in the transport roller 15 according to this embodiment, as described above, no problem arise. However, when a groove is formed by the joint 80, the groove temporarily and simultaneously comes into contact with the sheet P and thus the entire width of the sheet P temporarily comes into contact with the groove formed by the joint 80.

As a consequence, since the groove is recessed compared to the other circumferential surface of the transport roller 15, the contact resistance with the sheet P is reduced and thus the transport speed of the sheet P is temporarily is slowed, thereby causing transport irregularity.

[0244] When the joints 81 to 84 are formed, as shown in Figs. 23A, 23C, 24A, and 25B, the portion of the groove simultaneously coming into contact with the sheet P when the sheet is transported is one or a plurality of points although the groove is formed by these joints. Therefore, the contact resistance is rarely changed compared to a case where another surface (line) of the transport roller 15 comes into contact with the sheet, and thus the transport speed of the sheet P is uniform. Accordingly, the transport irregularity is prevented.

[0245] Instead of the joint of the transport roller 15 (the roller body 16) formed from the hollow cylindrical pipe described above, as in Fig. 27A, a joint may be formed so as to have bent portions 85 with a rectangular wave shape formed by a straight line portion 85a parallel to the central axis of the roller body 16 and a straight line portion 85b perpendicular to the straight line portion 85a. When a groove is formed by the joint with the bent portions 85, the groove does not simultaneously come into contact with the entire width of the sheet P when the sheet is transported. Therefore, since the transport speed of the sheet P is substantially uniform, the transport irregularity is prevented.

[0246] The bent portions 85 may be formed along the entire length of the roller body 16, as shown in Fig. 27B. Alternatively, the bent portions 85 may be formed selectively in both ends other than the middle of the roller body 16, as shown in Fig. 27C. When the bent portions 85 are formed only in the both ends of the roller body 16, as shown in Fig. 27C, a middle straight line portion 86 parallel to the central axis of the roller body 16 is formed

between the bent portions 85. Although not illustrated, the middle straight line portion between the bent portions 85 may be formed as a tilted line which is not parallel to the central axis 16c, as shown in Fig. 23A.

[0247] When the bent portions 85 are formed only in the both end portions and the middle straight line portion 86 is formed in the middle portion between the end portions, it is desirable that the formed region of the high friction layer 50 shown in Fig. 12C corresponds to the middle straight line portion 86.

[0248] When the bent portions 85 are formed in the joint and a fitting portion is formed due to unevenness of the bent portions 85, it is difficult to approach (butt) the front ends of the convex portions closely to the concave portions corresponding to the front ends of the convex portions without a gap by fitting the bent portions 85 (the fitting portion), as designed. Therefore, when the bent portions 85 are formed along the entire length of the roller body 16, deformation, distortion, or the like may easily be formed in the roller body 16. When the bent portions 85 are formed only in the both end portions, as shown in Fig. 27C, the deformation, the distortion, or the like can be prevented from occurring. In particular, by setting the middle portion corresponding to the high friction layer 50, which is formed at the region coming into direct contact with the sheet P, as the middle straight line portion 86 without forming the bent portion 85, the deformation, the distortion, or the like can be reliably prevented from occurring in the region coming into direct contact with the sheet P.

[0249] When the bent portions 85 are formed along the entire length of the roller body 16, as shown in Fig. 27B, a joint 87 formed by the bent portions 85 may include a plurality of intersection portions 87a formed from a straight line portion 85b, first straight line portions 87b binding one ends of the intersection portions 87a, and second straight line portions 87c binding the other ends of the intersection portions 87a, as shown in Fig. 28A. Here, the first straight line portions 87b and the second straight line portions 87c are substantially parallel to the central axis of the roller body 16. The intersection portions 87a are perpendicular to the first straight line portions 87b and the second straight line portions 87c, that is, are perpendicular to the central axis of the roller body 16. The second straight line portions 87c are shorter than the first straight line portions 87b.

[0250] When the joint 87 having the above configuration is formed, in particular, it is desirable that a distance d3 between a pair of ends facing each other with reference to the second straight line portion 87c is longer than a distance d4 between a pair of ends facing each other with respect to the first straight line portion 87b. Both of the distances d3 and d4 between the pairs of ends are set to be distances between the ends of the gap formed on the outer circumferential surface of the roller body 16.

[0251] Thus, since the roller body 16 as the hollow cylindrical pipe can be formed to have the shape or size with more accuracy, the transport irregularity caused due

to the deformation or the like of the roller body 16 can be prevented. That is, in the metal plate which is the base material for forming this roller body 16, one ends forming only the second straight line portions 87c are convex pieces 87d which is an outline of a pair of adjacent intersection portions 87a and the second straight line portion 87c binding the ends of the intersections 87a. Accordingly, in a case where the metal plate is subjected to pressing to approach the convex pieces 87d closely to the facing end, the convex piece 87d may float above the facing end by a size t1, as indicated by a two-dot chain line in Fig. 28B, the front end of the convex piece 87d is not sufficiently bent toward the circumferential surface. As a consequence, a stepped difference may occur with respect to the second straight line portion 87c. In this case, the roller body 16 may easily be deformed due to the stepped difference, and thus satisfactory accuracy may not be achieved in terms of shape or size.

[0252] Here, the distance d3 between the ends with respect to the second straight line portion 87c is made to be longer than the distance d4 between the ends with respect to the first straight line portion 87b longer than the second straight line portion 87c. Then, as indicated a solid line in Fig. 28B, a size t2 by which the front end of the convex piece 87d floats is smaller than the above-described size t1. Accordingly, the stepped difference can be suppressed with respect to the second straight line portion 87c.

[0253] In Fig. 28B, the large size t2 is illustrated to facilitate understanding, but in effect, the size t2 is substantially close to zero. Therefore, there is actually no stepped difference. That is, by suppressing the stepped difference in the second straight line portion 87c, the roller body 16 can be prevented from being deformed due to the stepped difference. Accordingly, the accuracy of the shape or the size can be improved.

[0254] When the bent portions 85 are formed only at the both ends of the roller body 16, as shown in Fig. 27C, it is desirable that a distance d5 between a pair of ends facing each other with respect to the intersection portion 87a (straight line portion 85b) in the bent portion 85 is shorter than a distance d6 between a pair of ends facing each other with respect to the middle straight line portion 86, as shown in Fig. 29.

[0255] Thus, the distance d5 becomes relatively shorter and the gap between the ends with respect to the intersection portion 87a. Therefore, when the metal plate which is the base material used to form the roller body 16 is subjected to the pressing, a difference between one end and the other end in the length direction (axial direction) is regulated by a pair of ends facing each other and forming the intersection portion 87a is considerably narrowed. Therefore, since deformation, distortion, or the like rarely occurs in the obtained roller body 16 (the transport roller 15), the transport irregularity caused due to the deformation, the distortion, or the like is prevented.

[0256] When the bent portions 85 are formed only at the both ends of the roller body 16, as shown in Fig. 27C,

a distance d_7 between a pair of ends facing each other with respect to the second straight line portion 87c forming the convex piece 87d of the bent portion 85 may be shorter or longer than a distance d_6 between a pair of ends facing each other with respect to the middle straight line portion 86, as shown in Fig. 29.

[0257] In the case where the distance d_7 is shorter than the distance d_6 , when the entire length of the joint is viewed, the gap between a pair of ends facing each other can easily become uniform, thereby improving the accuracy of the shape or size of the obtained roller body 16. That is, since the length of the middle straight line portion 86 is longer than the length of the second straight line portion 87c in the bent portion 85, the pair of ends with respect to the middle straight line portion 86 can approach each other with high accuracy compared to the second straight line portion 87c. Therefore, even when the distance between the pair of ends with respect to the middle straight line portion 86, in which the accuracy between the ends can be made to be relatively good, is longer compared to the second straight line portion 87c and the gap becomes larger, the gap can be sufficiently uniform. Accordingly, the transport irregularity caused due to the deformation, the distortion, or the like of the roller body 16 is prevented.

[0258] On the other hand, when the distance d_7 is longer than the distance d_6 , as shown in Fig. 28B, the size t_2 by which the front end of the convex piece 87d floats is reduced. Therefore, the stepped difference is suppressed from occurring in the second straight line portion 87c. Accordingly, since the stepped difference is suppressed from occurring in the second straight line portion 87c and thus the deformation or the like of the roller body 16 caused due to the stepped difference is prevented, the accuracy of the shape or size is improved, thereby preventing the transport irregularity.

[0259] In the joint of the transport roller 15 (the roller body 16) formed from the hollow cylindrical pipe described above, as shown in Fig. 30A, an intersection portion 88a of a bent portion 88 may not be parallel to the central axis of the roller body 16 and an angle α of the front end of a convex piece 88b of the bent portion 88 may be an obtuse angle (less than 180°). Thus, when a pair of end surfaces approach each other in the pressing on the metal plate, the front end of the convex piece 88b easily fits into a concave portion. Accordingly, the deformation, the distortion, or the like of the roller body 16 can be prevented from occurring.

[0260] In the configuration in which the bent portions 85 are formed only at the both ends shown Fig. 27C, the bent portions 85 may be replaced by a wave line 89a formed of a curve line shown in Fig. 24A, as shown in Fig. 30B or may be replaced by a bent wave line 89b shown in Fig. 25A, as shown in Fig. 30C.

[0261] The bent portion 85 with a rectangular wave shape shown in Fig. 27A and the wave line 89a formed of the curve line shown in Fig. 30B may be combined to form the joint. Alternatively, the bent portion 85 with the

rectangular wave shape and the bent wave line 89b shown in Fig. 30C may be combined to form the joint.

[0262] in the roller body 16 according to the above-described embodiment, for example, as shown in Fig. 31A, a spot-welded portion SP may be formed in the joint 80. For example, the spot-welded portion SP is formed by melting a part of the roller body 16 (metal plate) with an irradiated laser beam. Of course, the spot-welded portion SP may be formed according to other methods other than the irradiation of the laser beam.

[0263] The spot-welded portion SP is different from the entirely welded joint 80 and is a welded portion formed in a part of the joint 80. The example in which the spot-welded portion is formed in a substantially circular shape is illustrated in Fig. 31A, but the invention is not limited thereto. For example, the spot-welded portion may be formed in a shape (for example, an elliptical shape) slightly expanded in the direction in which the joint 80 is formed.

[0264] For example, a plurality of the spot-welded portions SP is formed in the joint 80. For example, as shown in Fig. 31A, the spot-welded portions SP are formed in the roller body 16 at the positions on the more end side than the position supported by the bearing 26 in the direction of the rotation axis of the roller body 16. The spot-welded portion SP is also formed at the position between the position supported by the bearing 26 and the high friction layer 50.

[0265] In Fig. 31A, one of the both ends of the roller body 16 is illustrated, but the spot-welded portion SP is also formed in the other of the both ends. The spot-welded portion SP may be formed near the portion of the roller body 16 connected to the transport driving gear 35 and the inner gear 39. When the spot-welded portion SP is formed in the portion closer to the side of the high friction layer 50 than the bearing 26, for example, it is desirable that the spot-welded portion is formed in a portion deviated from the portion pressed by the driven roller 17.

[0266] The step (spot welding step) of forming the spot-welded portion SP can be performed, for example, after the progressive pressing step and before the centerless grinding step. In this case, the spot welding is performed on the joint 80 of the roller body 16 formed in the progressive pressing step. The welding step of forming the spot-welded portions SP in the joint 80 is performed to improve the strength of the joint 80 in the spot-welded portion SP. In this configuration, for example, as shown in Fig. 31B, a laser emission apparatus LA emits a laser beam L to a spot formation region SA to melt the spot formation region SA.

[0267] In the spot formation region SA, a part of the melted metal plate M is solidified in a state where the part is connected to the ends 61a and 61b of the metal plate M, and then the spot-welded portion SP is formed. In this embodiment, the example where the part of the metal plate M irradiated with the laser beam L is melted has been described, but the invention is, of course, not limited thereto. For example, the metal plate M may be melted according to other methods (for example, a meth-

od of applying heat).

[0268] After the spot welding step, for example, a rough centerless step may be performed on the roller body 16. For example, the rough centerless step is a grinding step more simply performed than the centerless grinding step according to the above-described embodiment. In the rough centerless step, for example, processing time is shorter than that of the centerless grinding step. A grinding member used in the rough centerless grinding step may not have a grinding capability of the grinding member GD used in the centerless grinding step.

[0269] Hereinafter, examples of the spot-welded portion SP will be described.

[0270] In the above-described embodiment, the example where the spot-welded portions SP are formed in the roller body 16 having the joint 80 with the straight line shape has been described, but the invention is, of course, not limited thereto. For example, the spot-welded portions SP may be appropriately formed in the joint 80 with the above-described shapes other than the joint 80 with the straight line shape.

[0271] For example, as shown in Fig. 32, in the roller body 16 of the transport roller 15 formed in the end in which a joint 73D connected to the rotation driving unit, it is desirable that the spot-welded portions SP are formed near the joint 73D (for example, between the joint 73D and the bearing 26) .

[0272] For example, even when an uneven portion 110 is formed in the joint 80, the invention is applicable. As shown in Fig. 32, the unevenness 110 is formed so as to have a rectangular shape fitting one end 61a of the metal plate M into the other end 61b of the metal plate M. For example, the uneven portion 110 includes a first side 110a formed in the direction of the rotation axis of the roller body 16 and a pair of second sides 110b formed in the circumferential direction of the roller body 16.

[0273] In this case, it is desirable that the spot-welded portions SP are formed in at least one of the first side 110a and the second sides 110b. For example, by forming the spot-welded portion SP in the first side 110a, the strength of the unevenness 110 is increased against, for example, a force in the circumferential direction of the roller body 16. Therefore, for example, the uneven portion 110 can be prevented from being opened in the circumferential direction or from being recessed therein.

[0274] When the spot-welded portions SP are formed in the second sides 110b, the formed positions of the spot-welded portions SP are easily matched with each other. Therefore, the spot-welded portions can be easily formed. Even when the spot-welded portions SP are formed in the second sides 110b, the strength of the roller body 16 can, of course, be improved against the force in the circumferential direction. The spot-welded portions SP may be formed in all of the first side 110a and the second sides 110b.

[0275] The spot-welded portions SP may be formed in boundaries 110c between a straight line portion 80a and

the uneven portion 110 of the joint 80. For example, the force from the unevenness 110 is configured to be easily added in the boundaries 110c. Therefore, by providing the spot-welded portions SP to improve the strength of the boundaries 110c, the deformation in the unevenness 110 can be more reliably prevented.

[0276] The example where the uneven portion 110 is formed between the joint 73D and the bearing 26 has been described in Fig. 32, but the invention is, of course, not limited thereto. For example, even when the unevenness 110 is formed to be closer to the high friction layer 50 than the bearing 26, the spot-welded portions SP can be appropriately formed in the uneven portion 110.

[0277] When the metal plate M is subjected to the pressing so as to be formed in the cylindrical shape, as shown in Fig. 33A, the metal plate M may be formed so that one end 61a and the other end 61b of the metal plate M come into contact with each other on the side of the outer surface 16a of the roller body 16. In this case, as shown in Fig. 33B, the spot-welded portion SP is formed by applying the energy of a laser beam or the like from the outer surface 16a of the roller body 16. Therefore, when the ends 61a and 61b of the metal plate come into contact with each other on the side of the outer side 16a, the spot-welded portion SP can be finished well.

[0278] The example where the joint formed in the roller body 16 is formed in association with the joint 80 has been described above, but the invention is not limited thereto. For example, as shown in Fig. 34, a notched portion 73 which is a joint may be formed at a position (non-arrangement position) deviated from the joint 80. In Fig. 34, the notched portion 73 is formed at the position facing the joint 80, that is, the position opposite to the joint 80 with respect to the central axis of the roller body 16.

[0279] When the transport roller 15 is rotated, a biasing force from a third driving gear driven in a direction reverse to the rotation direction of the transport roller 15 is applied to the transport roller 15. With such a configuration, the biasing force is not applied to separate the first end 61a from the second end 61b. Accordingly, the advantage of preventing the deformation in the roller body 16 can be obtained.

[0280] The example where the core die 147 disposed inside the flat plate section 60 in the bending of the progressive pressing step has the circular shape in a cross-sectional view has been described above, but the invention is not limited thereto.

[0281] Figs. 35A to 35C and Figs. 36A to 36C are diagrams illustrating the bending step according to other examples.

As shown in Figs. 35A to 35C, the flat plate section 60 formed in a substantially C shape in a cross-sectional view is disposed among a first upper die (die) 205, a second upper die (die) 206, and a lower die 207. A columnar cored die (core member) 208 is disposed inside the flat plate section 60.

[0282] The cored die 208 is a substantially round bar-

shaped member. The cored die 208 has a notched portion 208b, which notches the portions corresponding to a first end 61a and a second end 61b (see Figs. 36C) of the flat plate section 60 formed in a cylindrical shape, on an outer circumferential surface 208a. The notched portion 208b extends parallel in the axial direction of the cored die 208 and is formed in the entire length of the cored die 208.

The notched portion 208b has a flat surface 208c facing outward in a radial direction of the cored die 208. Since the flat surface 208c can be formed easily by cutting, the notched portion 208b of the cored die 208 can be easily formed at low cost. A notched depth t in the radial direction of the notched portion 208b is substantially the same as the entire length of the cored die 208. The notched depth t is set depending on the push-in amount necessary for the first end 61a and the second end 61b of the flat plate section 60.

[0283] The first upper die 205, the second upper die 206, and the lower die 207 have press surfaces 205a, 206a, and 207a coming into contact with the flat plate section 60 in the pressing, respectively. Flat surface portions 205b and 206b with a flat surface shape corresponding to the notched portion 208b of the cored die 208 are formed in the press surfaces 205a and 206a, respectively. The flat surface portions 205a and 206a face the flat surface 208c of the notched portion 208b so as to be substantially parallel to the flat surface 208c. The first upper die 205 and the second upper die 206 are movable independently.

[0284] As shown in Fig. 36A, the first upper die 205 is moved toward the lower die 207 in a state where the cored die 208 stops, to press the first end 61a of the flat plate section 60 and curve the first end 61a in a substantially semi-circular shape. On the other hand, like the first upper die 205 and the second upper die 206, the lower die 207 may be separated into a pair of separate dies. In the step shown in Fig. 36A, the lower die located at the same position as that of the first upper die 205 may be moved toward the first upper die 205.

[0285] Next, as shown in Fig. 36B, moving the cored die 208 is slightly moved toward the lower die 207 and the second upper die 206 is simultaneously moved toward the lower die 207 to press the second end 61b of the flat plate section 60 and curve the second end 61b in a substantially semi-circular shape.

[0286] Next, as shown in Fig. 36C, the first upper die 205, the second upper die 206, and the cored die 208 are moved together toward the lower die 207 to press the flat plate section 60. At this time, the first upper die 205 and the second upper die 206 come into contact with the lower die 207. By this pressing, the flat plate section 60 is formed in a substantially cylindrical shape and thus the roller body 16 is formed from the flat plate section 60.

[0287] Here, the notched portion 208b is formed in the cored die 208. The flat surface portions 205b and 206b are formed in the first upper die 205 and the second upper die 206, respectively. Therefore, the flat surface portions

205b and 206b can push the end surfaces 61a and 61b of the flat plate section 60 and the peripheral portion of the end surfaces 61a and 61b inward in the radial direction. Therefore, when the flat plate section 60 is formed in the cylindrical shape, the end surfaces 61a and 61b and the peripheral portions of the end surfaces 61a and 61b can be prevented from being swollen outward. Accordingly, when the bending ends, the circularity of the roller body 16 can be improved.

[0288] The end surfaces 61a and 61b and the peripheral portions of the end surfaces 61a and 61b are pushed inward more than other portions. However, since the flat plate section 60 has elasticity, a return (spring back) occurs when the bending ends. Since the notched depth t of the notched portion 208b is set as a depth determined in consideration of the return, the end surfaces 61a and 61b and the peripheral portions of the end surfaces 61a and 61b are not excessively pushed inward and the circularity of the roller body 16 does not adversely deteriorate when the bending ends.

[0289] In this step, the end surfaces 61a and 61b on the side of the outer circumferential surface 31a come into contact with each other without a gap. By pushing the end surfaces 61a and 61b inward, the end surfaces 61a and 61b on the side of the outer circumferential surface 31a can come into contact with each other more easily. In this embodiment, the end-face adjustment processing is performed so that the angles formed between the end surfaces 61a and 61b and the inner circumferential surface 31b are larger than 90°. However, the end-face adjustment processing may not be performed, when the end surfaces 61a and 61b on the side of the outer circumferential surface 31a can come into contact with each other without a gap by pushing the end surfaces 61a and 61b and the peripheral portions of the end surfaces 61a and 61b inward. Moreover, the end-face adjustment processing can be reduced to some degree compared to a case where the pushing is not performed. On the other hand, a gap 277 is formed between the end surfaces 61a and 61b on the side of the inner circumferential surface 31b.

[0290] In this embodiment, the flat surface portions 205b and 206b are formed in the first upper die 205 and the second upper die 206, respectively. However, when the end surfaces 61a and 61b and the peripheral portions of the end surfaces 61a and 61b are sufficiently biased inward only by the notched portion 208b, the flat surface portions 205b and 206b may not be formed. Even in this case, when the end surfaces 61a and 61b and the peripheral portions of the end surfaces 61a and 61b are not supported from the cored die 208 and are pushed inward.

[0291] Since the roller body 16 (the transport roller 15) is formed using the large-sized metal plate 60 having the curling due to the steel plate coil, it is desirable that the roller body 16 is formed so that the inner circumferential surface of the coil is the inner circumferential surface of the roller body 16. That is, the curling of the large-sized metal plate 60 due to the steel plate coil is in a curved

state where the inner circumferential surface of the steel plate coil is a concave surface. That is, the large-sized metal plate 60 for forming the roller body 16 has the curling in which the metal plate is curled toward the inner circumferential surface of the roller body 16.

[0292] Therefore, the curling does not operate at least in the direction in which the joint 80 of the roller body 16 is opened. Accordingly, the joint 80 of the roller body 16 is rarely opened, compared to the case where the curling remains so that the metal plate is curled toward the outer circumferential surface of the roller body 16. Thus, even when a stress is applied in the direction in which the joint 80 of the roller body 16 is opened, it is possible to prevent the joint 80 from being opened. Accordingly, the transport roller 15 with the high transport accuracy can be obtained.

[0293] Instead of the above-described cored die 208, a second cored die (core member) 208A or a third cored die (core member) 208B may be used according to modified examples. The second cored die 208A which is a first modified example of the cored die 208 will be described with reference to Figs. 37A to 37C. The third cored die 208B which is a second modified example of the cored die 208 will be described with reference to Figs. 38A to 38C. Figs. 37A to 37C are schematic diagrams illustrating the first embodiment example of the cored die. Fig. 37A is a side view, Fig. 37B is a sectional view taken along the line XXXVIIIB-XXXVIIIB, and Fig. 37C is a sectional view taken along the line XXXVIIC-XXXVIIC. Figs. 38A to 38C are schematic diagrams illustrating the second embodiment example of the cored die. Fig. 38A is a side view, Fig. 38B is a sectional view taken along the line XXXVIIIB-XXXVIIIB, and Fig. 38C is a sectional view taken along the line XXXVIIC-XXXVIIC.

[0294] First, the second cored die 208A will be described. In Fig. 37A, the transport roller 15 and the second cored die 208A are arranged in parallel for description. The second cored die 208A has a notched portion 208d in which a portion on the outer circumferential surface 208a corresponding to a holding region F of the transport roller 15. The notched portion 208d is substantially parallel to the axial direction of the second cored die 208A is formed in the range slightly longer than the holding region F in the both ends of the transport roller 15. This is because a bending effect or an influence of a stress or the like is made to be uniform in the holding region F which is a region where the print sheet P is held.

[0295] As shown in Fig. 37B, the cross-sectional shape is substantially circular in the portions of the second cored die 208A corresponding to the both ends of the transport roller 15. As shown in Fig. 37C, the notched portion 208d has a flat surface 208e facing outward in the radial direction. A notched depth t of the notched portion 208d is set in consideration of the end surfaces 34 and 35 of the flat plate section 60 and the return of the circumferential.

[0296] When the flat plate section 60 is curved and the cylindrical roller body 16 is formed, the circularity tends to be not good in the middle portion of the roller body 16 in the axial direction, that is, the portion of the holding

region F holding the transported object than in the both ends of the roller body 16. In this modified example, since the notch portion 208d is formed in the portion corresponding to the holding region F, the end surfaces 61a and 61b and the peripheral portions of the end surfaces 61a and 61b are positively biased inward in the radial direction for the holding region F. Therefore, the circularity of the roller body 16 can be effectively improved when the bending step ends.

[0297] Next, the third cored die 2083 will be described. In Fig. 38A, the transport roller 15 and the third cored die 208B are arranged in parallel for description. The third cored die 208B has a notched portion 208f in which a portion on the outer circumferential surface 208a corresponding to a holding region F of the transport roller 15.

[0298] As shown in Figs. 38B and 38C, in the notched portion 208f, a first notched depth t1 of the portion corresponding to the middle portion of the transport roller 15 is larger than a second notched depth t2 of the portions corresponding to the both ends of the transport roller 15. The first notched depth t1 gets gradually smaller toward the both ends of the transport roller 15 becomes the second notched depth t2. The notched depth may vary step by step.

[0299] Since the first notched depth t1 of the portion of the third cored die 208B corresponding to the middle portion of the transport roller 15 is larger than the second notched depth t2 of the portions corresponding to the both ends of the transport roller 15, the end surfaces 61a and 61b and the peripheral portions of the end surfaces 61a and 61b are positively biased inward in the radial direction in the portion corresponding to the middle portion. Therefore, the circularity of the roller body 16 can be effectively improved when the bending step ends.

[0300] In the above description, the example where the thickness of the roller body 16 is uniform has been described, but the invention is not limited thereto. Instead, the thickness may vary according to the portions of the roller body 16. Fig. 39 is a diagram illustrating an axis O1 and the cross-sectional shape of the roller body 16.

[0301] In the roller body 16 having the cross-sectional shape shown in Fig. 39, thicknesses Th1 of first axis facing portions 160 facing each other along a first straight line CL1 passing through the joint 80 and the axis O1 are a thicknesses Th2 of second axis facing portions 161 facing each other along a second straight line CL2 perpendicular to the first straight line CL1 with respect to the axis O1. That is, a relation of $Th1 < Th2$ is satisfied.

[0302] The first axis facing portions 160 refer to specific portions of the roller body 16 facing each other in predetermined regions along the first straight line CL1 passing through the joint 80 and the axis O1. The second axis facing portions 161 refer to specific portions of the roller body 16 facing each other in predetermined regions along the second straight line CL2 perpendicular to the first straight line CL1 with respect to the axis O1.

[0303] In the cross-sectional shape, the thickness of

the roller body 16 between each first axis facing portion 160 and each second axis facing portion 161 gradually varies from each first axis facing portion 160 to each second axis face portion 161. That is, when it is assumed that the position at which the joint 80 is formed is 0 o'clock, the thickness of the roller body 16 continuously increases from the thickness Th1 to the thickness Th2 from 0 o'clock to 3 o'clock or 9 o'clock. The thickness of the roller body 16 continuously decreases from the thickness Th2 to the thickness Th1 from 3 o'clock or 9 o'clock to 6 o'clock.

[0304] In this embodiment, in a view of the cross-sectional shape shown in Fig. 39, the outer diameter shape (shape of the outer circumferential surface 16a) of the roller body 16 is a circularity shape where the axis O1 is the center. In a view of the cross-sectional shape shown in Fig. 39, the inner diameter shape (shape of the inner circumferential surface 16b) of the roller body 16 is an elliptical shape where the axis O1 is the center. More specifically, the inner diameter shape of the roller body 16 has a longer diameter along the first straight line CL1 and a shorter diameter along the second straight line CL2 on the assumption that the axis O1 is the center.

[0305] The roller body 16 according to this embodiment has a line symmetric shape with respect to the first straight line CL1 and a line symmetric shape with respect to the second straight line CL2 in a view of the cross-sectional shape shown in Fig. 39.

[0306] A thickness difference between the thickness Th1 of the first axis facing portion 160 and the thickness Th2 of the second axis facing portion 161 is set to be equal to or larger than 10% and equal to or smaller than 50% when the thickness Th2 is assumed to be 100%. When the thickness Th2 of the second axis facing portion 161 is 1.00 mm, a difference between the thickness Th1 and the thickness Th2 is equal to or larger than 0.10 mm and equal to or smaller than 0.50 mm.

[0307] Specifically, in the example of this embodiment, the difference between the thickness Th1 and the thickness Th2 is set to be 0.15 mm which is the thickness difference of 15%. That is, the thickness Th2 is set to be 1.00 mm and the thickness Th1 is set to be 0.85 mm.

[0308] When the roller body 16 is formed, for example, as shown in Fig. 40, the cross-sectional shape of the roller body 16 becomes an elliptical shape so that the longer diameter is arranged on the first straight line CL1 and the shorter diameter is arranged on the second straight line CL2 in the pressing step (bending step). In this case, for example, the core member with an elliptical shape in a cross-sectional view is used.

[0309] In the cross-sectional shape shown in Fig. 40, the first axis facing portions 160 are disposed at the positions corresponding to the longer diameter with the elliptical shape. The second axis facing portions 161 are disposed at the positions corresponding to the short diameter with the elliptical shape. The thickness of the roller body 16 is substantially uniform. That is, the thickness Th1 of the first axis facing portion 160 is substantially the same as the thickness Th2 of the second axis facing por-

tion 161.

[0310] Next, the roller body 16 is subjected to the centerless grinding using the grinding members GD according to this embodiment. In the grinding step, according to the thickness difference between the thickness Th1 of the first axis facing portions 160 and the thickness Th2 of the second axis facing portion 161 shown in Fig. 39, the portions corresponding to the first axis facing portions 160 are first ground, and then scraping is performed.

[0311] In the centerless grinding, the outer circumferential surface 16a of the roller body 16 is ground by the frictional force generated by the rotation of the grinding members GD, while the roller body 16 is rotated in a direction opposite to the rotation direction of the grinding members GD. Therefore, substantially the entire outer circumferential surface 16a of the roller body 16 is uniformly ground. Therefore, the circularity of the roller body 16 is improved compared to the case where the centerless grinding step is not performed, and thus the deviation decreases.

[0312] In the centerless grinding, the protruding portions (the first axis facing portions 160 protruding outward more than the virtual circularity shape indicating by a two-dot chain line in Fig. 40) of the roller body 16 are ground by the rotation of the grinding members GD. Therefore, when the roller body 16 with the elliptical outer diameter shape is subjected to the centerless grinding, the outer diameter shape is processed gently. The first axis facing portions 160 protruding more than the circularity shape is ground more than the second axis facing portions 161. Thus, as shown in Fig. 39, the thickness Th1 of the first axis facing portions 160 can be made to be smaller than the thickness Th2 of the second axis facing portions 161 in a view of the cross-sectional shape. On the other hand, the thickness from the first axis facing portions 160 to the second axis facing portions 161 can gradually vary gently.

[0313] In the above-described embodiment, a step (stress adjustment step) of adjusting the stress remaining in the roller body 16 formed in the pressing step (bending step) may be performed. In the stress adjustment step, a pressing force is added to a predetermined portion in which the high friction layer 50 is formed on the outer circumferential surface 16a of the roller body 16. In this embodiment, a case will be described in which the pressing force is added to the substantially entire surface of the outer circumferential surface 16a of the roller body 16. In the stress adjustment step, the pressing force can be added to the roller body 16 using at least one of, for example, the following three steps.

(1) Roller Leveler Step

[0314] In a roller leveler step, a plurality of pressing rollers is used. Here, for example, as shown in Fig. 41A, a case in which two pressing rollers R1 and R2 are used will be described. In the pressing roller R1, for example, the outer circumferential surface has a convex shape. In

the pressing roller R2, for example, the outer circumferential surface is a concave shape.

[0315] First, the roller body 16 is pinched by the pressing rollers R1 and R2. After pinching the roller body 16, the pressing rollers R1 and R2 are rotated while pressing the roller body 16 by the two pressing rollers R1 and R2. In this state, the roller body 16 and the pressing rollers R1 and R2 are relatively moved in the direction of the central axis of the roller body 16.

[0316] For example, by fixing the positions of the pressing rollers R1 and R2, the roller body 16 passes between the pressing rollers R1 and R2. Then, the pressing force is applied to the roller body 16 from a first end 16f to a second end 16s. The stress remaining in the roller body 16 is adjusted by the pressing force.

(2) Rolling Step

[0317] Next, a case in which a rolling step is performed will be described.

[0318] The roller step refers to a so-called step through-feed rolling (which is also called step rolling or through rolling) using two rolling rollers 201 and 202.

[0319] Specifically, as shown in Fig. 41B, the two rolling rollers 201 and 202 which are arranged so as to interpose the roller body 16 tightly squeeze the roller body 16 with a predetermined pressure. In this state, the two rolling rollers 201 and 202 are rotated in the same direction. In the through-feed rolling, by rotating the rolling rollers 201 and 202, the roller body 16 is moved in an axial direction H while being rotated in a direction reverse to the rotation direction of the rolling rollers 201 and 202.

[0320] For example, spiral concave portions 201a and 202a are formed on the rolling rollers 201 and 202, respectively, in order to form a high friction region 50. A lattice-shaped uneven portion 203 is formed on the surface of the roller body 16, when the concave portions 201a and 202a deform the surface of the roller body 16.

[0321] The uneven portion 203 is formed from the first end 16f to the second end 16s of the roller body 16. The stress remaining in the roller body 16 is adjusted by forming the unevenness 203. The depth (stepped difference of the unevenness) of the uneven portion 203 can be set to be in the range from 5 μm to 50 μm .

[0322] In the rolling step, for example, by allowing the sizes of the rolling rollers 201 and 202 in the axis direction to be the same as the size of the roller body 16 in the axial direction, the pressing force is applied to the entire roller body 16. Even in this case, the stress remaining in the roller body 16 is adjusted.

(3) Rotation Pressing Step

[0323] Next, a case in which a rotation processing step is performed will be described.

[0324] In the rotation pressing step, pressing members and the roller body 16 are relatively moved in the central axis direction of the roller body 16 by rotating the roller

body 16 in a state where the pressing members are pressed to the roller body 16.

[0325] In the rotation pressing step, for example, as shown in Fig. 41C, the roller body 16 is moved. In this case, for example, pressing members R3 and R4 are fixed onto a table TBL. For example, the distance between the pressing members R3 and R4 is set to be slightly smaller than the diameter of the roller body 16.

[0326] In this state, the roller body 16 passes between the pressing members R3 and R4, while the roller body 16 is rotated. The pressing members R3 and R4 press the roller body 16 with the roller body 16 interposed therebetween. Thus, the pressing force is added to the roller body 16 from the first end 16f to the second end 16s. The stress remaining in the roller body 16 is adjusted by the pressing force.

[0327] In the rotation pressing step, as shown in Fig. 41D, for example, the roller body 16 is not moved and a pressing member R5 is moved. In this case, for example, the roller body 16 is rotated about the central axis in a state where the position of the roller body 16 is fixed. In this state, the pressing member R5 is moved along the central axis of the roller body 16 while squeezing the roller body 16.

[0328] Therefore, the pressing force is further applied from the first end 16f to the second end 16s of the roller body 16. The stress remaining in the roller body 16 is adjusted by the pressing force. It is desirable that the front end (which is a portion coming into contact with the roller body 16) of the pressing member R5 is formed in, for example, a roller shape.

[0329] When each of the above-described steps (1) to (3) is performed, the pressing force may be added to the roller body 16 in a state where a cored member (not shown) is inserted into the inside of the roller body 16. Then, the roller body 16 can be prevented from being deformed by the pressing force.

[0330] Next, another example of the method of manufacturing the transport roller 15 will be described. Fig. 42 is a flowchart illustrating the manufacturing steps.

[0331] As shown in Fig. 42, for example, a pressing step, a spot welding step, a rough centerless processing step, a stress adjustment step, a finish centerless processing step (centerless grinding step), a plating step, and a coating step are sequentially performed among the above-described steps. In this case, the transport operation between the steps can be smoothly performed.

[0332] This manufacturing method is just an example. Therefore, for example, the respective steps may be performed in a sequence different from the above sequence. For example, some of the steps may be not performed. For example, another step such as an appropriate heating step, a cooling step, or a step of applying a force to the roller body 16 may suitably be performed between the above steps.

[0333] For example, as shown in Fig. 43, a transport area CA coming into contact with the print sheet P in a longitudinal direction (axial direction) may be defined in

addition to the above-described configuration. The transport driving gear 35 and the inner gear 36 may be disposed at one end (right side in Fig. 43) of the transport area CA and a third driving gear 37 may be disposed at the other end (left side in Fig. 43) of the transport area CA.

[0334] The transport driving gear 35 is a gear that rotates the transport roller 15 and is integrally connected by press insertion to the end of the transport roller 15 in which the driving unit 6 is disposed. The transport driving gear 35 meshes with the pinion 33, and the driving force of the transport roller 32 is delivered to the transport roller 15 via the pinion 33 and the transport driving gear 35 so that the transport roller 15 is rotated. The inner gear 39 is a gear that delivers the driving force of the transport motor 32 to the discharge roller 27 as a processing device. The inner gear 39 has a diameter smaller than that of the transport driving gear 35 and is disposed near the transport driving gear 35 so as to have the same axis as that of the transport driving gear 35.

[0335] The third driving gear 37 delivers the rotation driving force of the transport roller 15 to a pump that covers (caps) and suctions the other device 38 such as the nozzles of an ejecting head 51. More specifically, a device to which the rotation driving force is delivered via the third driving gear 37 is set as a device which does not operate when the transport roller 15 transports the print sheet P.

[0336] The discharge driving gear 43 is integrally disposed at the end of the discharge roller 27 on the side of the driving unit 6. An intermediate gear 41 is disposed between the discharge driving gear 43 and the inner gear 39. The intermediate gear 41 meshes with the inner gear 39 and the discharge driving gear 43. That is, the driving force of the transport motor 32 is delivered to the discharge roller 27 via the inner gear 39, the intermediate gear 41, and the discharge driving gear 43, and then the discharge roller 27 is rotated so that discharging is performed as processing of the printing.

[0337] Since both the transport driving gear 35 and the inner gear 39 are disposed in one of the transport roller 15 out of the transport area CA, it is possible to prevent the transport accuracy and the print accuracy of the print sheet P from deteriorating. Since the joint 80 in end of the transport roller 15 on the disposed side of the transport driving gear 35 and the inner gear 39 has the bent portion 85 formed by the fitting of the concave and convex portions and the joint 80 has the intersection portion 85a, for example, as shown in Fig. 44, the joint 80 can be prevented from being deviated in the direction of the central axis 16c. Therefore, since the transport roller 15 (the roller body 16) can be prevented from being deformed, the transport accuracy of the transport roller 15 can be prevented from deteriorating due to the deformation.

[0338] The discharge roller 27 is rotatably driven, even while the driving force of the transport motor 32 delivered to the transport roller 15 via the transport driving gear 35 is delivered via the inner gear 39 and the print sheet P is transported by the driving of the transport roller 15.

Since both the transport driving gear 35 and the inner gear 39 are disposed at the end of the transport roller 15 out of the transport area CA, the torque applied to the transport roller 15 (the roller body 16) does not operate in the transport area CA. Therefore, declination does not occur in the joint 80 (the middle straight line portion 86) in the transport area CA. Accordingly, even when a problem that the print sheet P is transported obliquely, not only the transport accuracy but also the print accuracy can be prevented from deteriorating.

[0339] On the other hand, the driving force of the transport roller 32 delivered to the transport roller 15 via the transport driving gear 35 is delivered to the other device 38 via the third driving gear 37. In this case, since the third driving gear 37 is disposed on the other side of the transport roller 15 which is the opposite side of the transport driving gear 35 with the transport area CA interposed therebetween, the torque generated by the operation of the other device 38 is applied in the transport area CA. However, since the third driving gear 37 is connected to the device 38 which does not operate when the transport roller 15 transports the print sheet P, the print sheet P is not transported when the device 38 operates. Therefore, not only the transport accuracy but also the print accuracy does not deteriorate with such a configuration, the joint 80 of the transport roller 15 in the transport area CA is the middle straight line portion 86 and the length of the joint 80 is set to be the minimum. Therefore, the transport accuracy and the print accuracy can be more reliably prevented from deteriorating due to the joint 80.

[0340] Since both the transport driving gear 35 and the inner gear 39 are disposed on the one end of the transport roller 15 out of the transport area CA, the transport accuracy and the print accuracy of the print sheet P can be prevented from deteriorating. Moreover, the joint 80 in the one end of the transport roller 15 on the disposed side of the transport driving gear 35 and the inner gear 39 has the bent portion 85 formed by the fitting of the concave and convex portions and the joint 80 has the intersection portion 85a, the joint 80 can be prevented from deviated in the direction of the central axis 16c. Therefore, since the transport roller 15 (the roller body 16) can be prevented from being deformed, the transport accuracy of the transport roller 15 can be prevented from deteriorating due to the deformation.

[0341] In order for the transport roller 15 to transport the print sheet P, the device 38, which does not operate, is connected to the third driving gear 37 disposed on the other end of the transport roller 15. Then, the driving force of the transport motor 32 is efficiently used without deterioration in the transport accuracy, thereby contributing to the miniaturization and lowering of cost of the apparatus. Moreover, since the joint 80 disposed at the other end of the transport roller 15 on the disposed side of the third driving gear 37 also has the intersection portion 85b, the joint 80 can be prevented from being deviated in the direction of the central axis 16c. Therefore, since the transport roller 15 (the roller body 16) can be prevented

from being deformed, the transport accuracy of the transport roller 15 can also be prevented from deteriorating due to the deformation.

Claims

1. A transport roller comprising:

a cylindrical shaft which is formed in a cylindrical shape in which a pair of ends of a metal plate faces each other and has a joint between the pair of ends, wherein in a cross-sectional shape perpendicular to an axis of the cylindrical shaft, thicknesses of first axis facing portions facing each other along a first straight line passing through the joint and the axis are smaller than thicknesses of second axis facing portions facing each other along a second straight line perpendicular to the first straight line with respect to the axis.

2. The transport roller according to claim 1, wherein in the cross-sectional shape, thicknesses of the cylindrical shaft between the first axis facing portions and the second axis facing portions gradually vary from the first axis facing portions to the second axis facing portions.

3. The transport roller according to claim 2, wherein in the cross-sectional shape, an outer diameter shape of the cylindrical shaft is a circular shape where the axis is a center, and an inner diameter shape of the cylindrical shaft is an elliptical shape where the axis is the center.

4. A transport unit comprising:

the transport roller according to claim 1; a driving device rotatably driving the transport roller.

5. A transport unit comprising:

the transport roller according to claim 2; a driving device rotatably driving the transport roller.

6. A transport unit comprising:

the transport roller according to claim 3; a driving device rotatably driving the transport roller.

7. A printing apparatus comprising:

the transport unit according to claim 4; and a printing unit performing printing on a print me-

dium transported by the transport unit.

8. A printing apparatus comprising:

the transport unit according to claim 5; and a printing unit performing printing on a print medium transported by the transport unit.

9. A printing apparatus comprising:

the transport unit according to claim 6; and a printing unit performing printing on a print medium transported by the transport unit.

10. A method of manufacturing a transport roller having a cylindrical shaft which is formed in a cylindrical shape in which a pair of ends of a metal plate faces each other and has a joint between the pair of ends by pressing the metal plate, the method comprising:

adjusting thicknesses so that, in a cross-sectional shape perpendicular to an axis of the cylindrical shaft, thicknesses of first axis facing portions facing each other along a first straight line passing through the joint and the axis are smaller than thicknesses of second axis facing portions facing each other along a second straight line perpendicular to the first straight line with respect to the axis.

11. The method according to claim 10, further comprising:

forming the cylindrical shaft with an elliptical shape in which portions corresponding to the first axis facing portions correspond to a longer diameter by facing the pair of ends toward each other in pressing for the metal plate in the step of adjusting the thicknesses; and centerless-grinding the portions corresponding to the first axis facing portions of the cylindrical shaft with the elliptical shape according to a thickness difference between the thickness of the first axis facing portion and the second axis facing portion.

FIG. 1

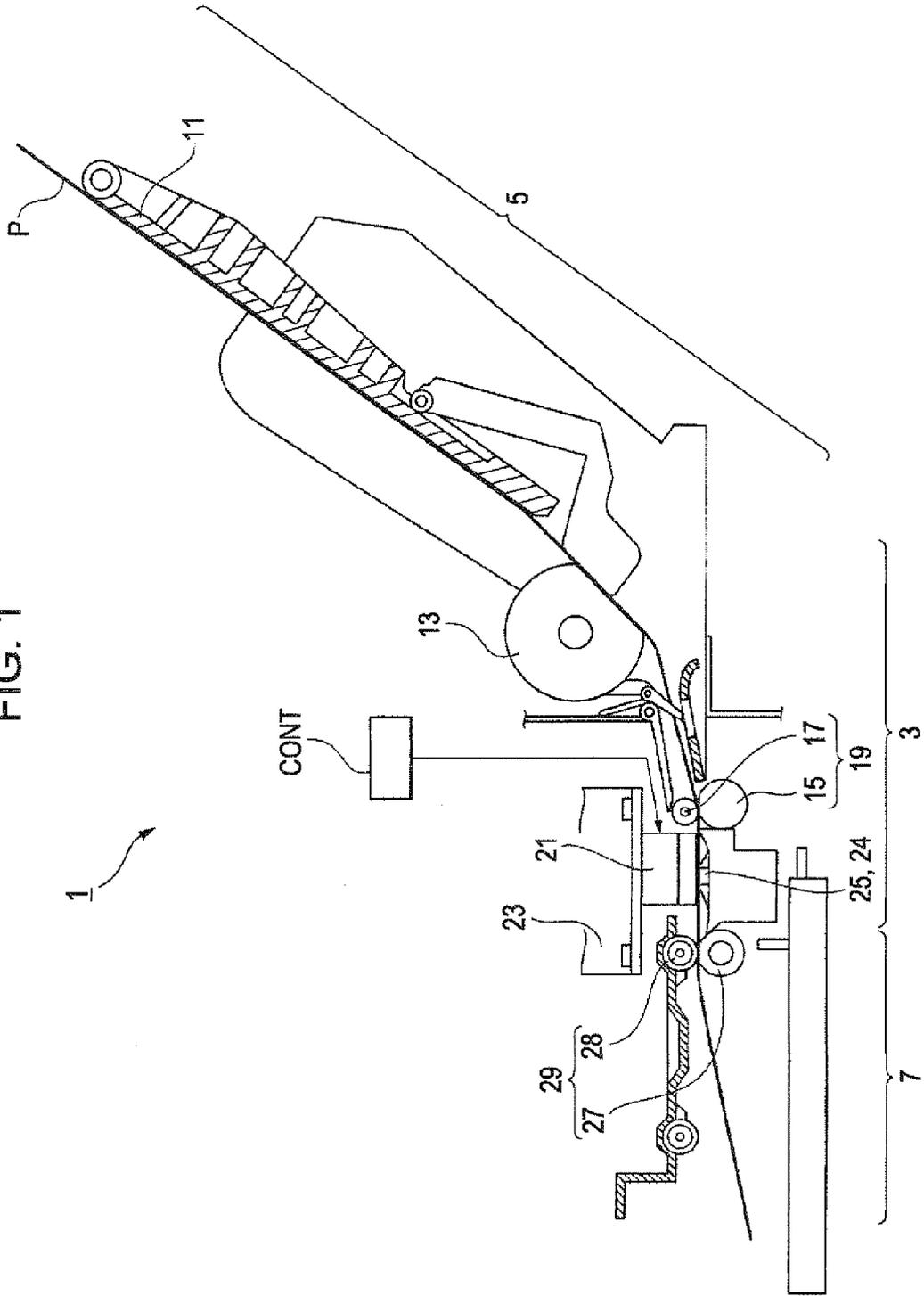


FIG. 2A

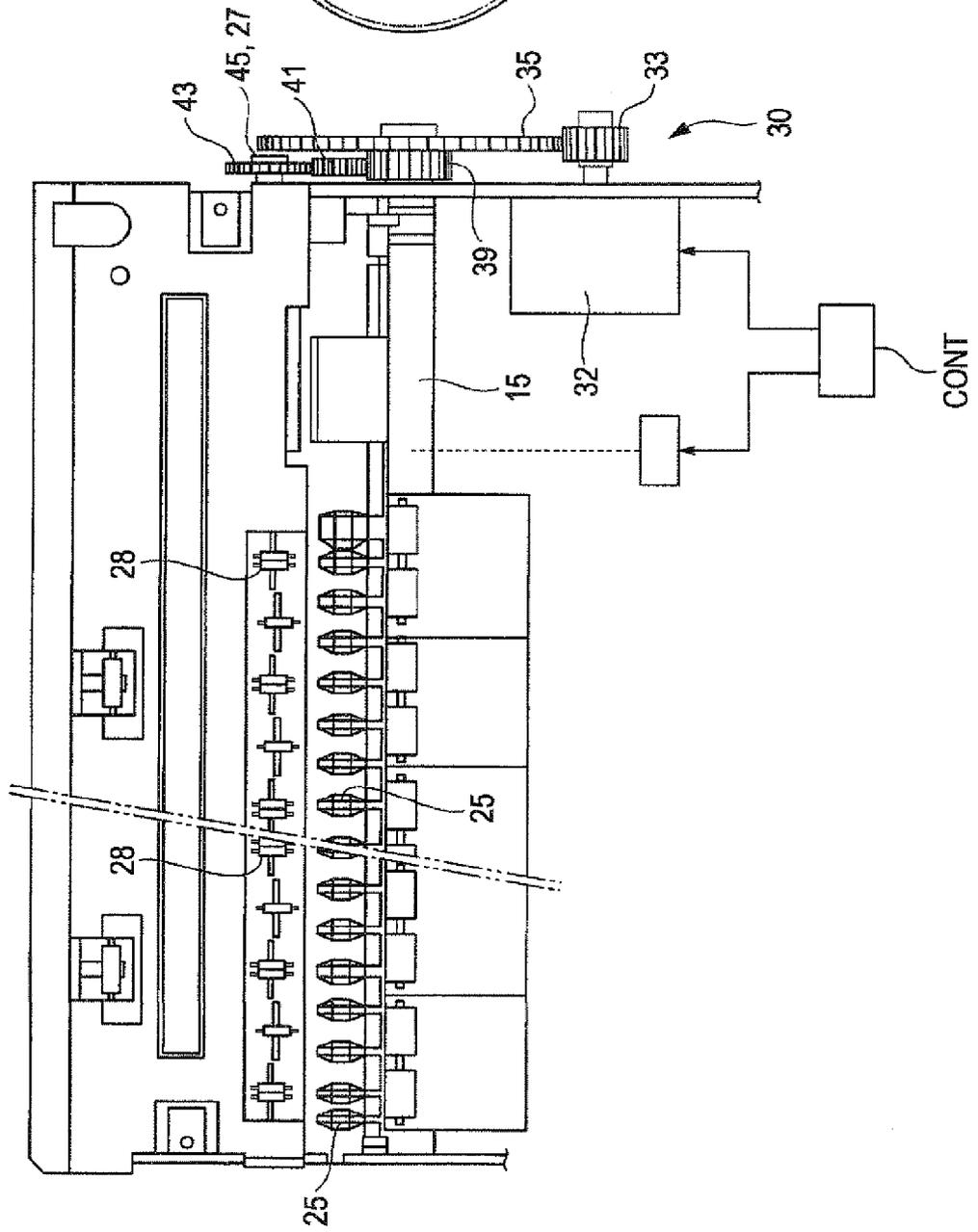
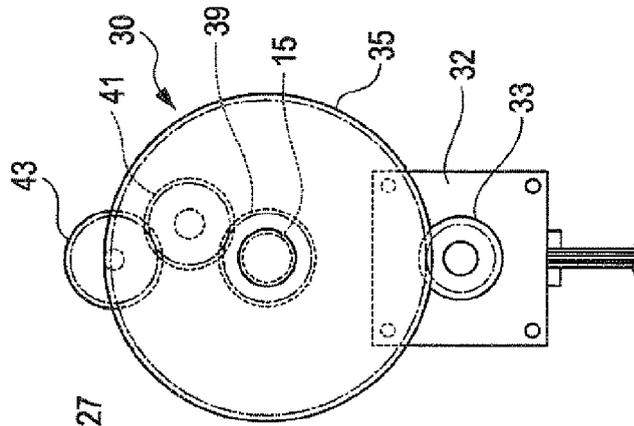


FIG. 2B



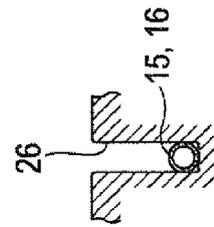
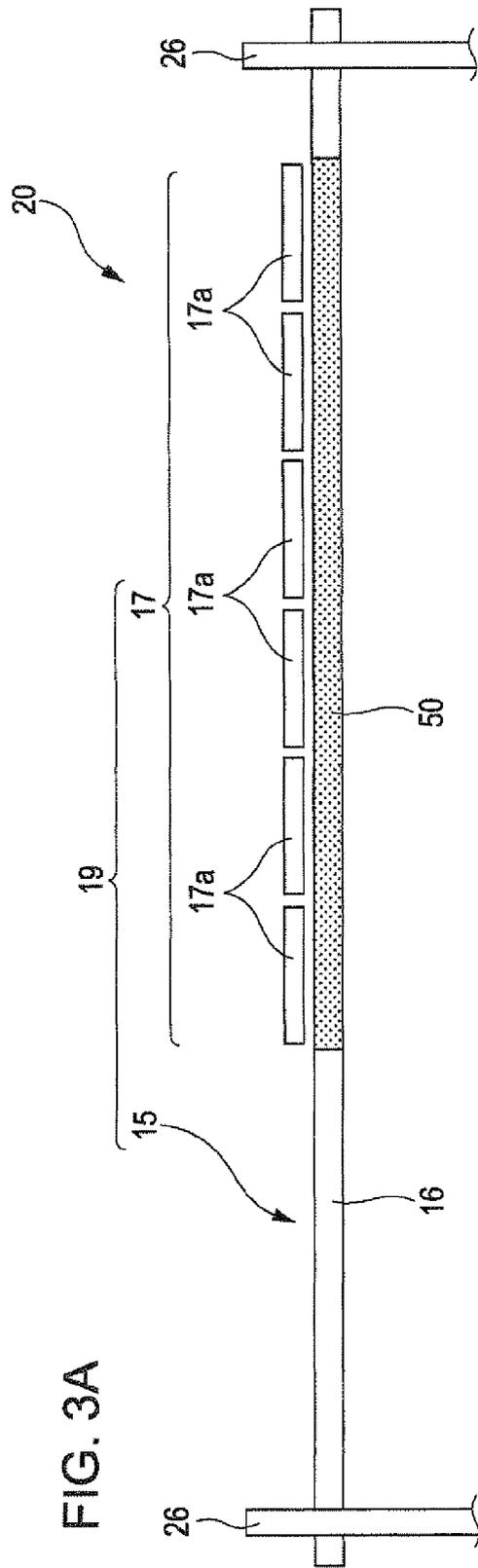


FIG. 4

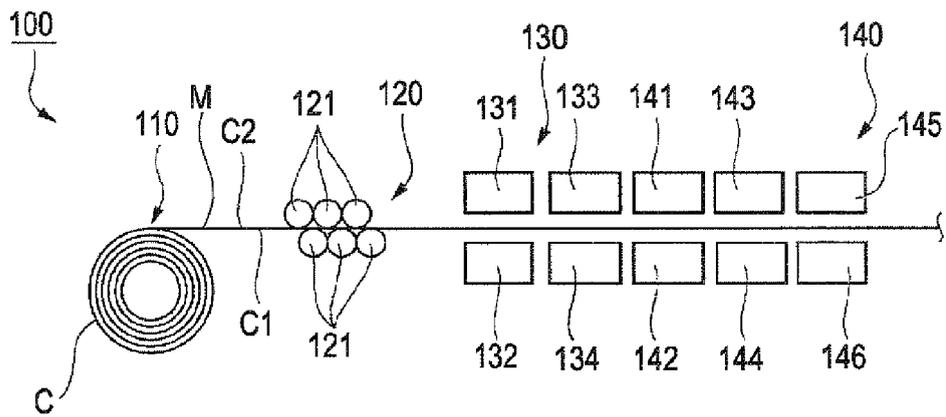


FIG. 5A

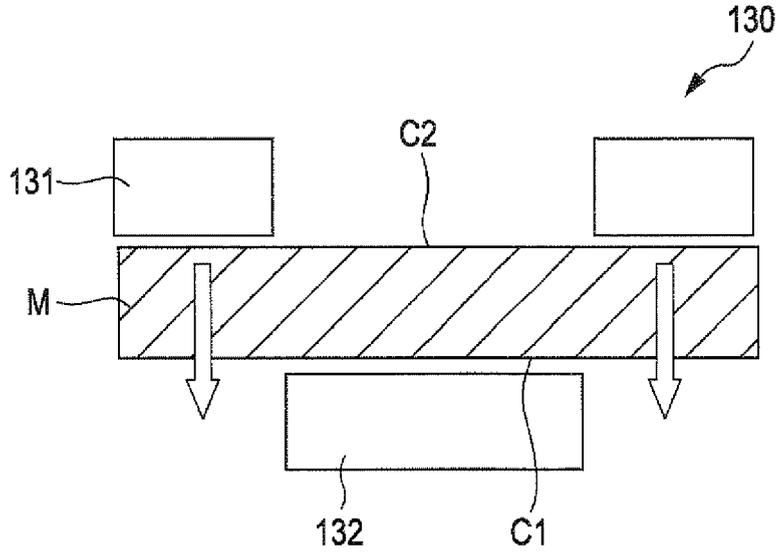


FIG. 5B

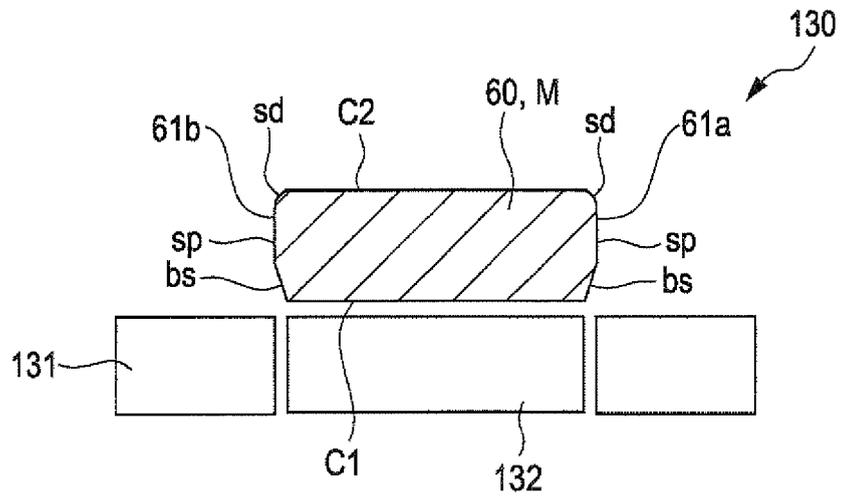


FIG. 6

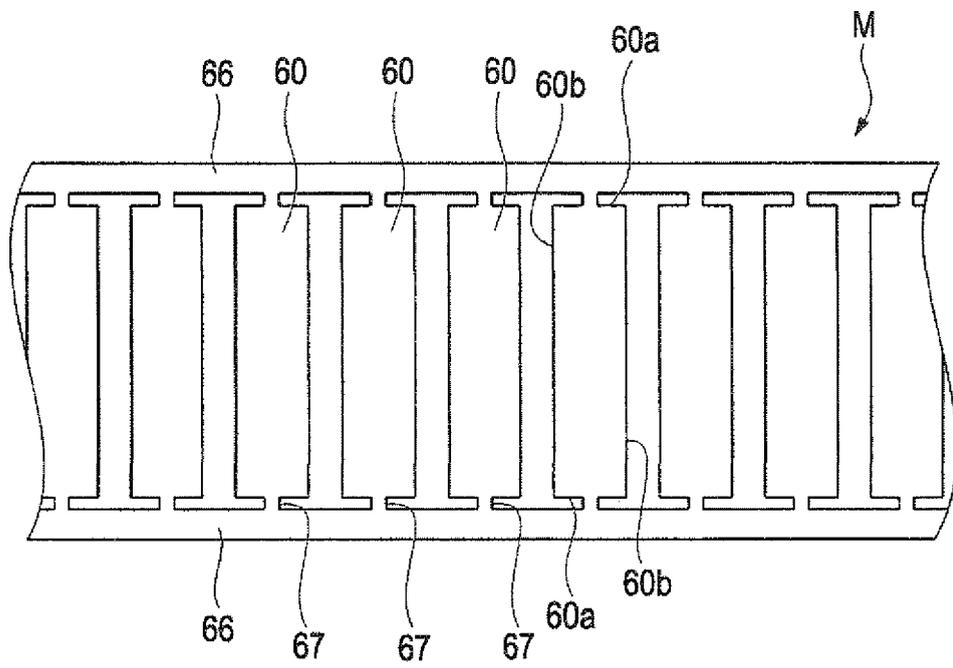


FIG. 7A

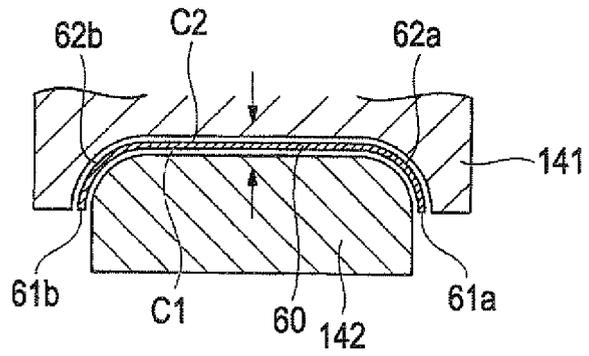


FIG. 7B

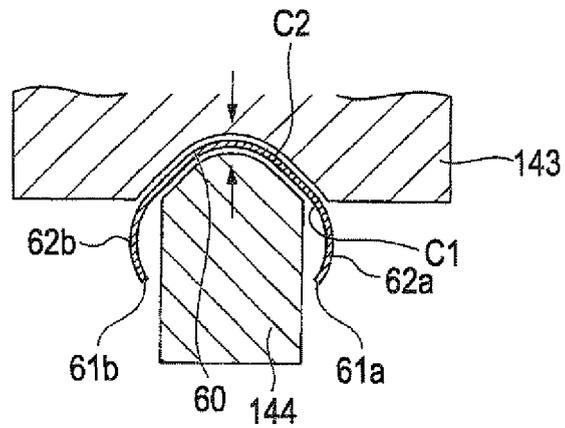


FIG. 7C

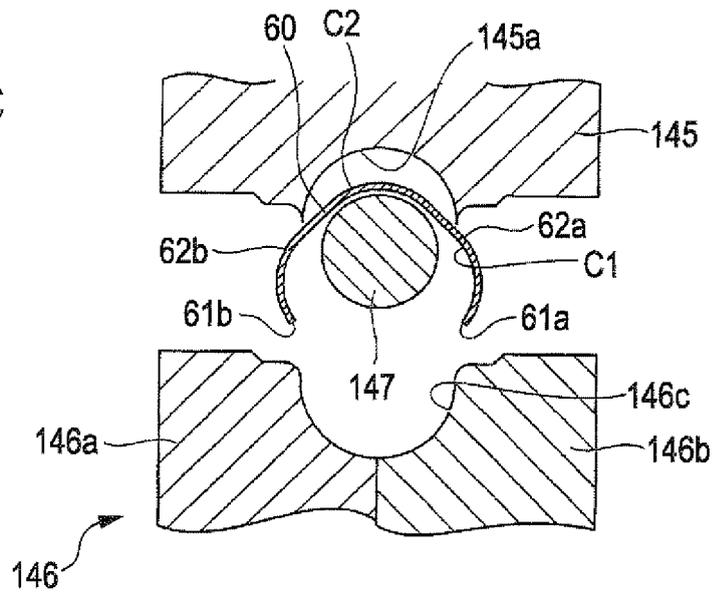


FIG. 8A

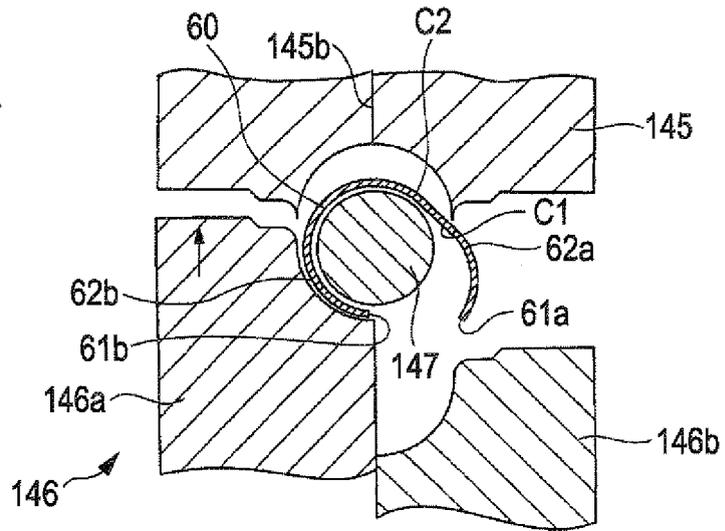


FIG. 8B

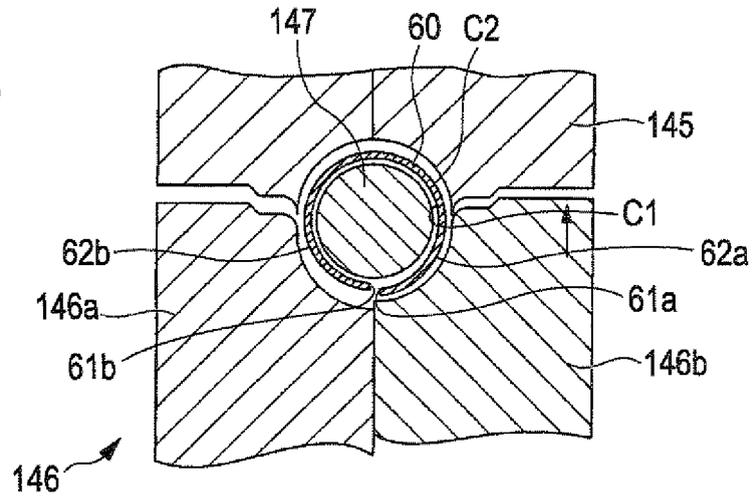


FIG. 8C

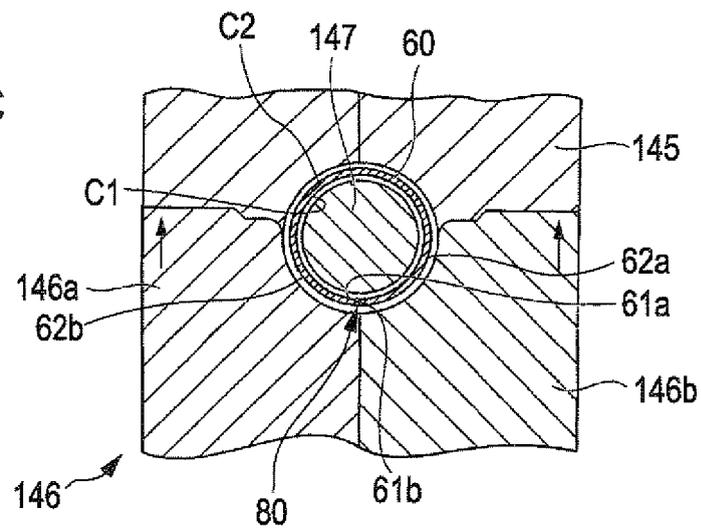


FIG. 9

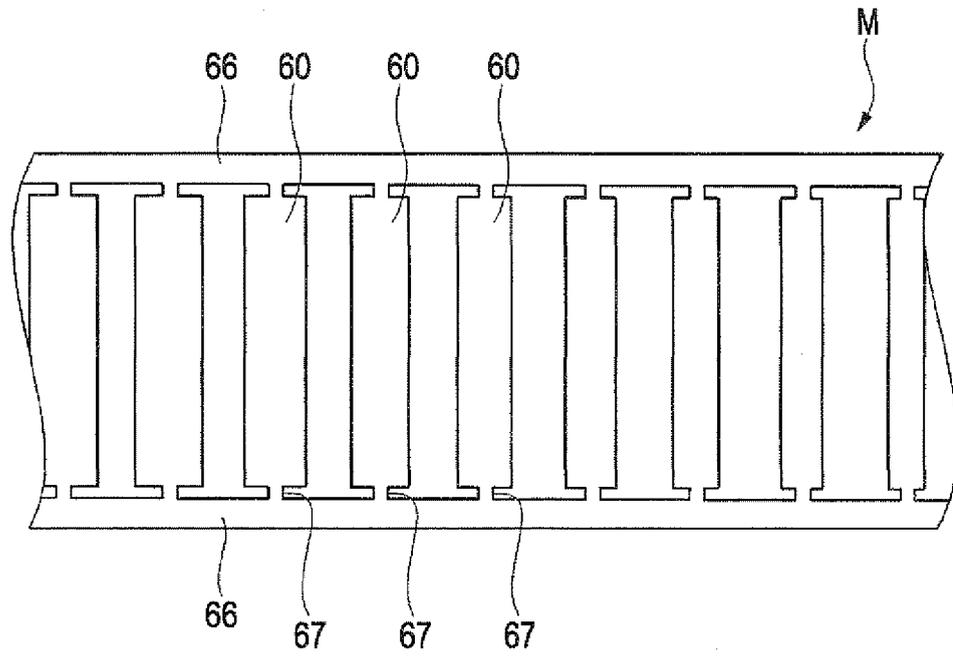


FIG. 10

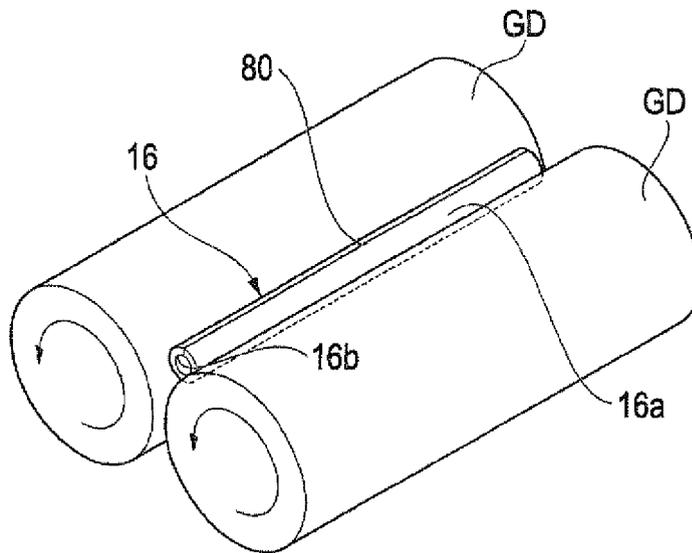


FIG. 11A

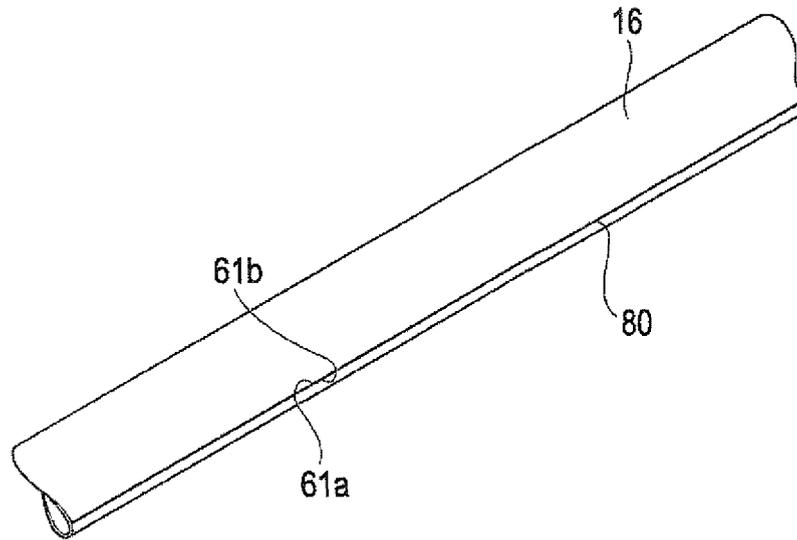


FIG. 11B

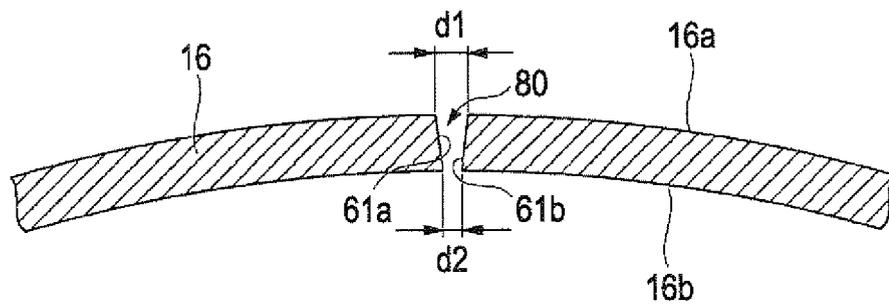


FIG. 12A

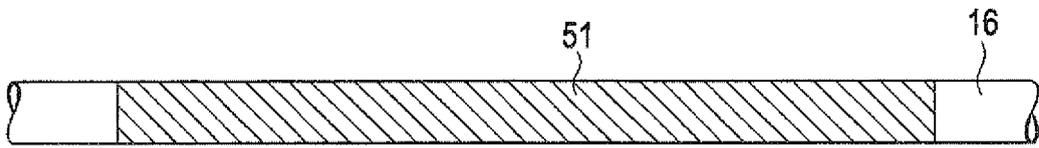


FIG. 12B

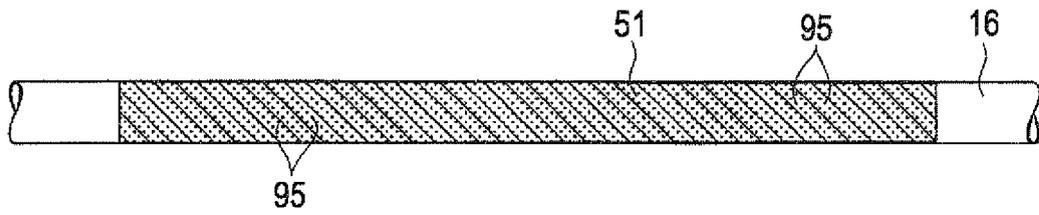


FIG. 12C

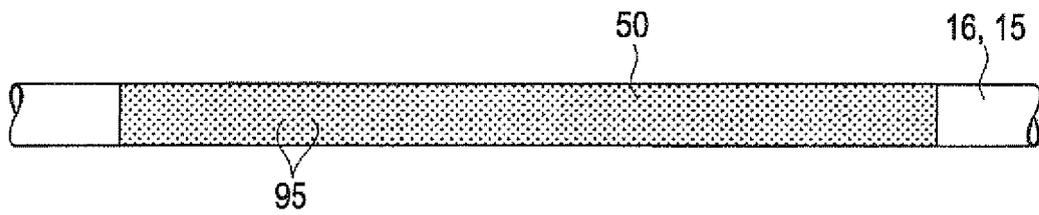


FIG. 13

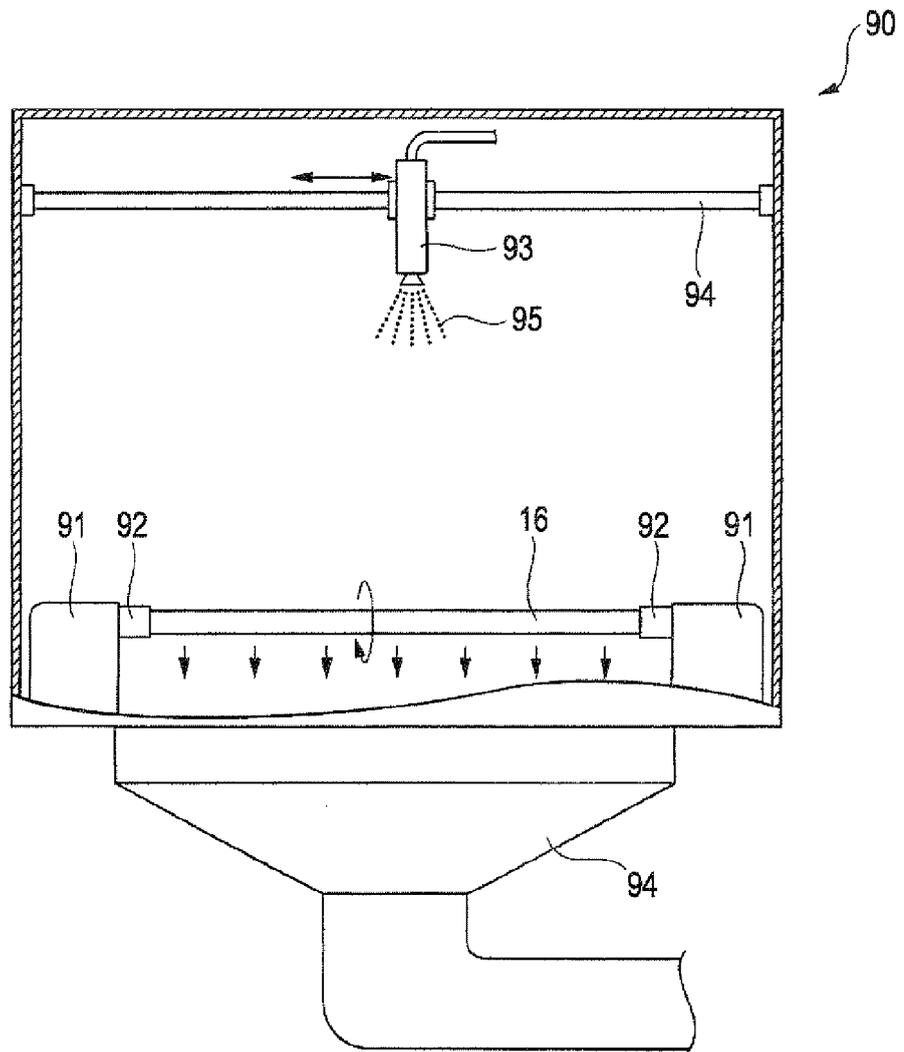


FIG. 14

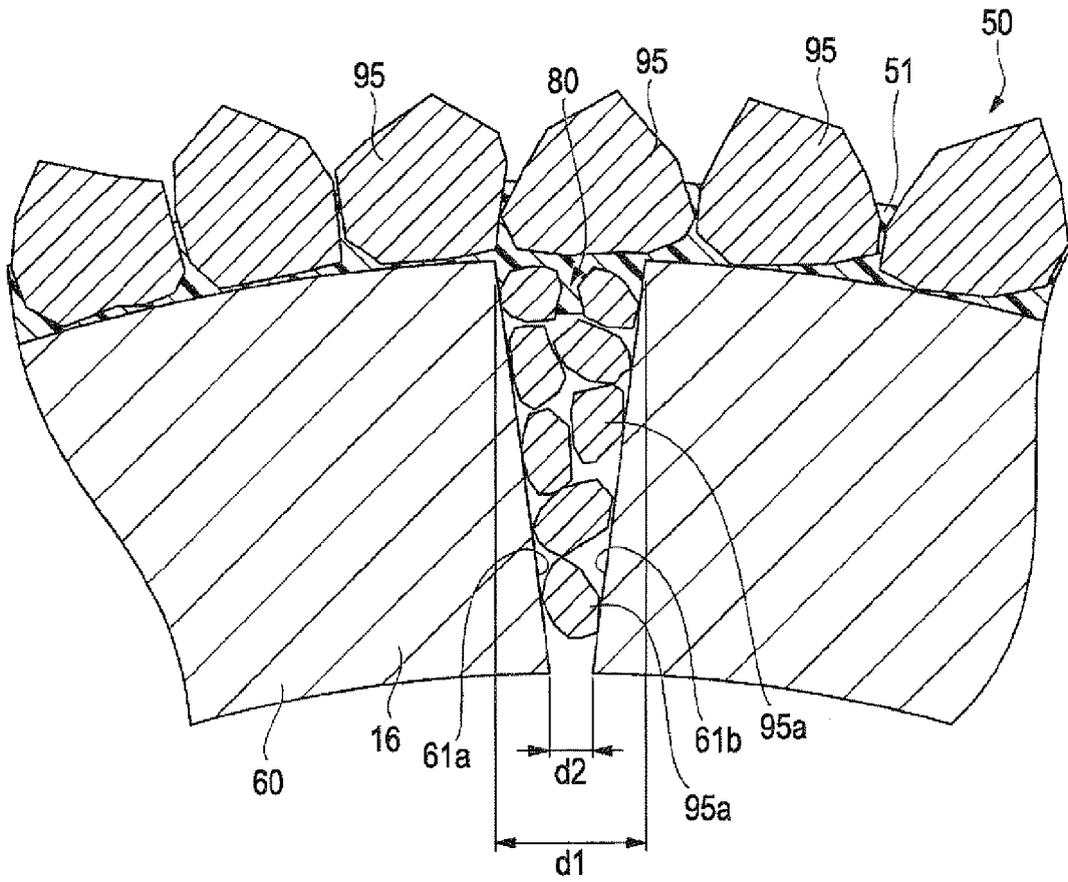


FIG. 15A

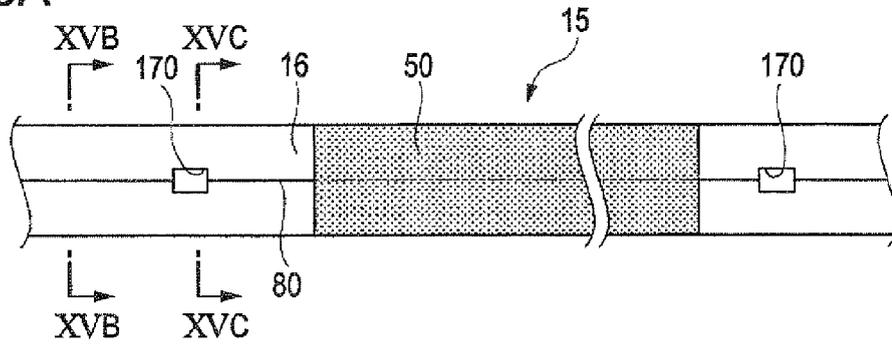


FIG. 15B

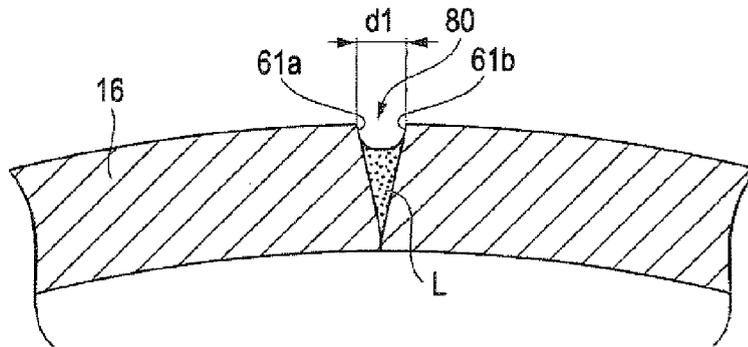


FIG. 15C

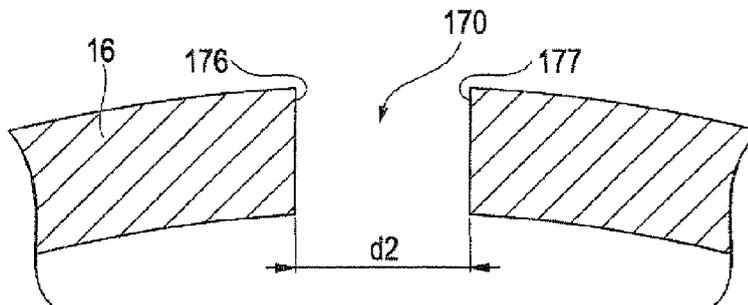


FIG. 15D

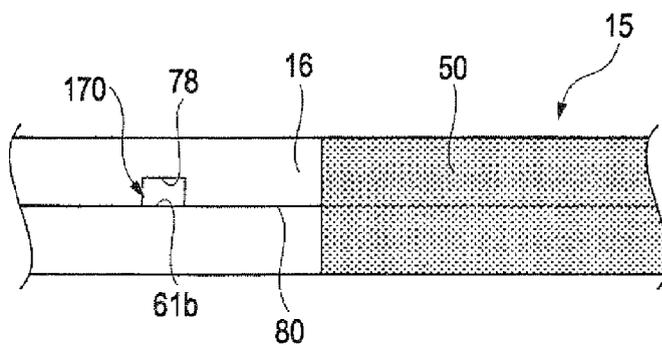


FIG. 16A

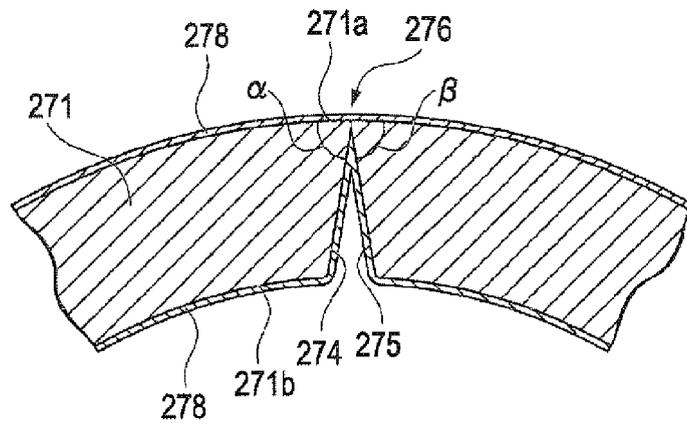


FIG. 16B

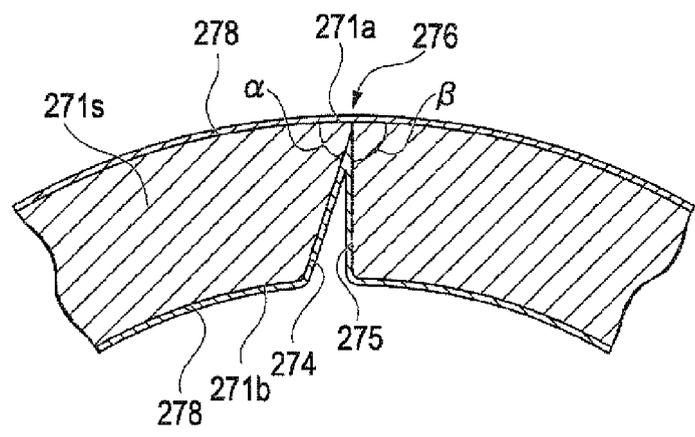


FIG. 16C

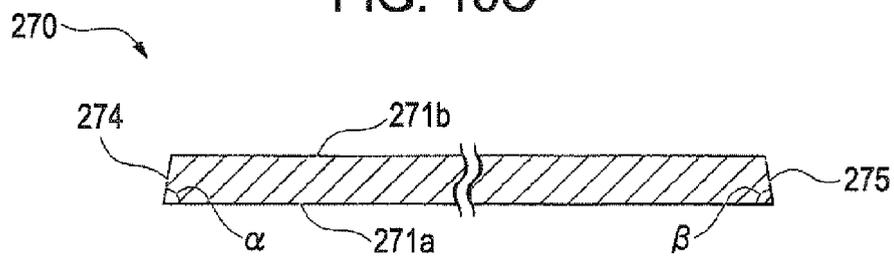


FIG. 17A

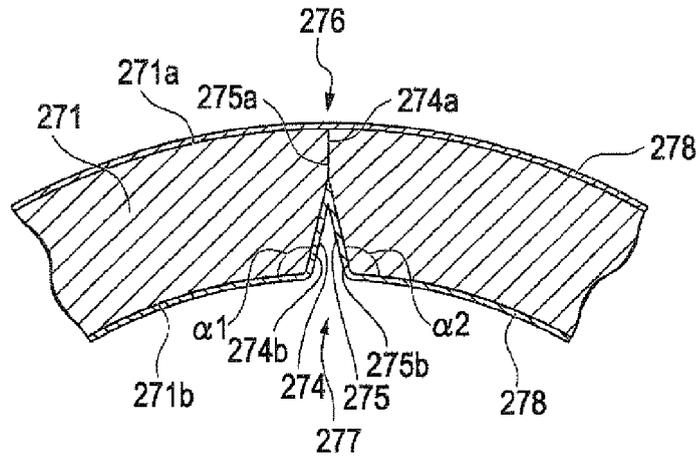


FIG. 17B

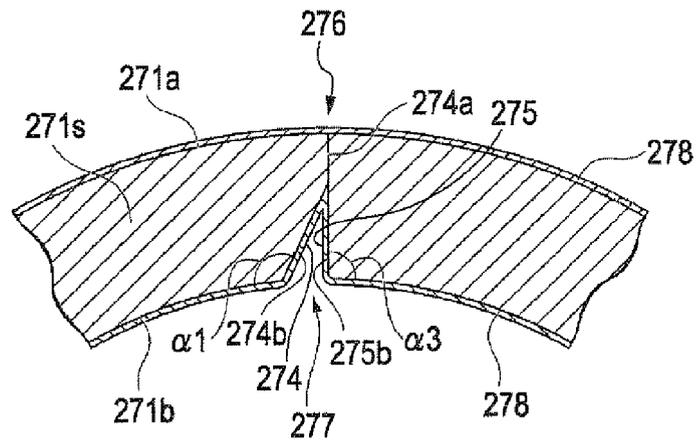


FIG. 18

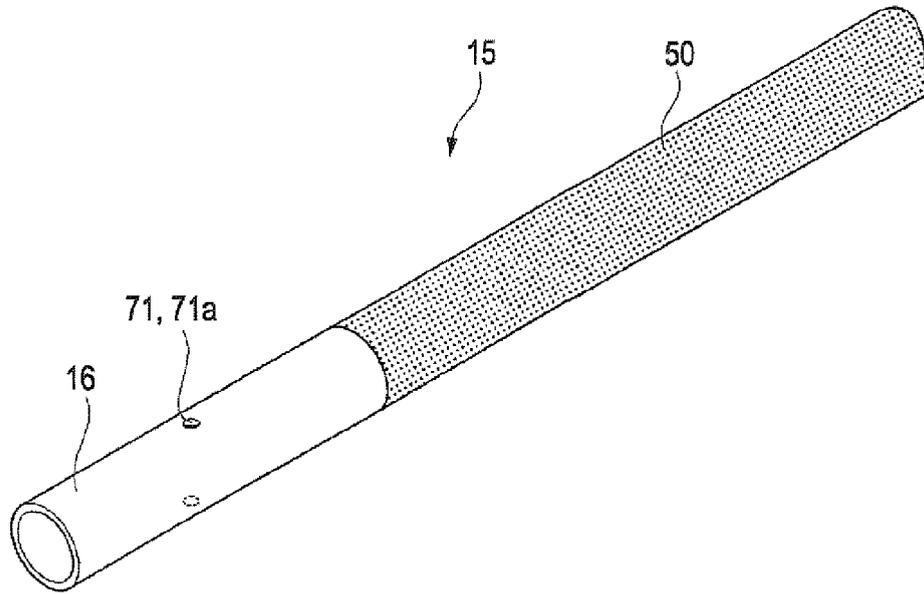


FIG. 19

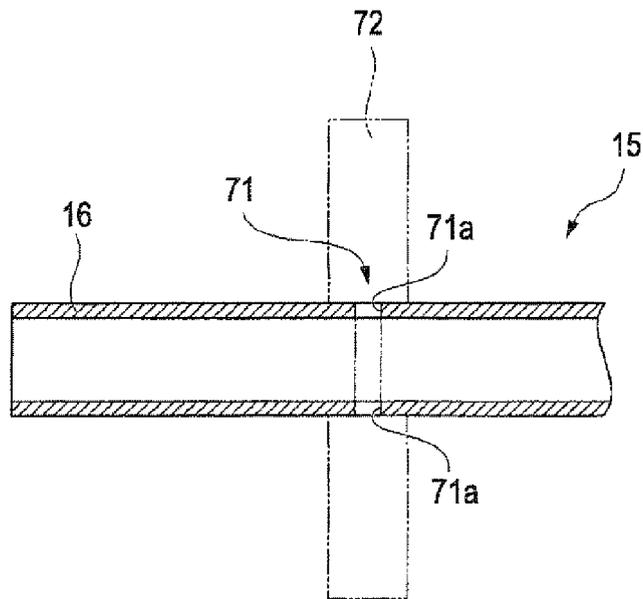


FIG. 20A

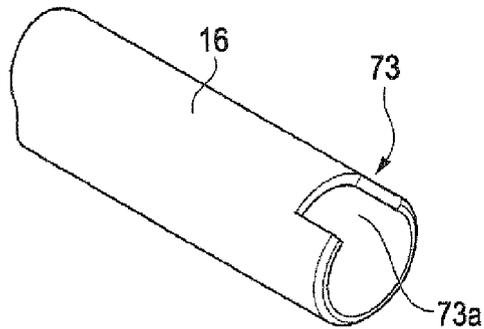


FIG. 20B

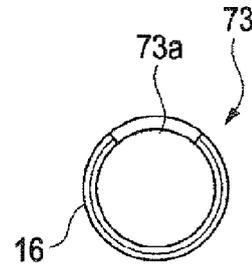


FIG. 20C

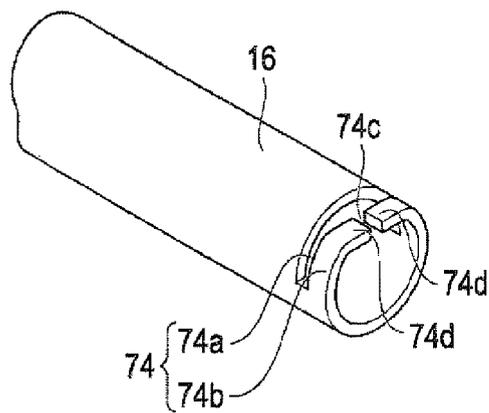


FIG. 20D

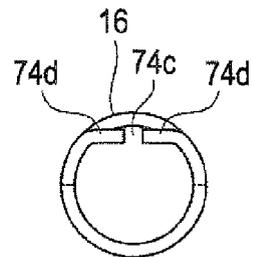


FIG. 20E

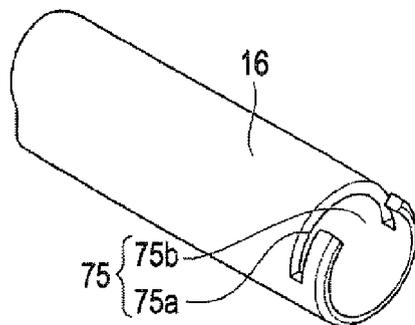


FIG. 20F

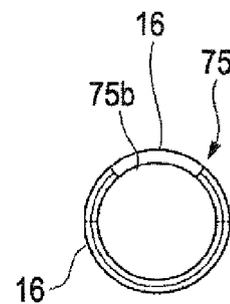


FIG. 21A

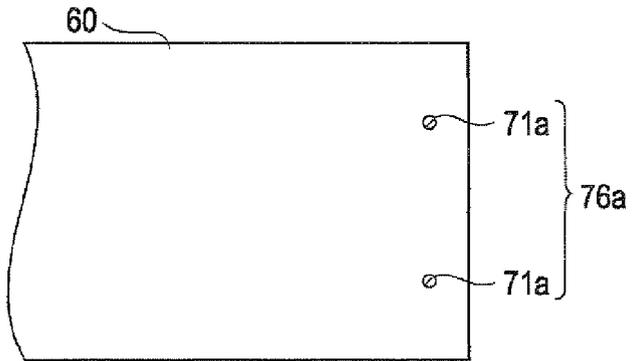


FIG. 21B

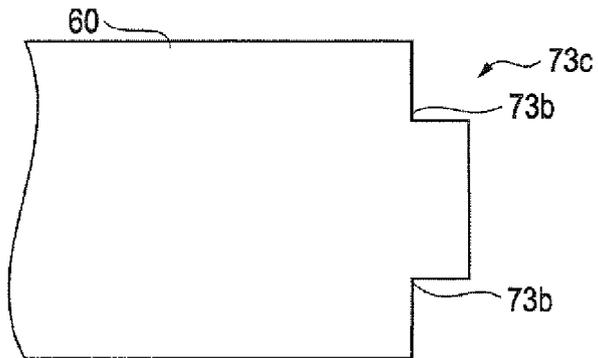


FIG. 21C

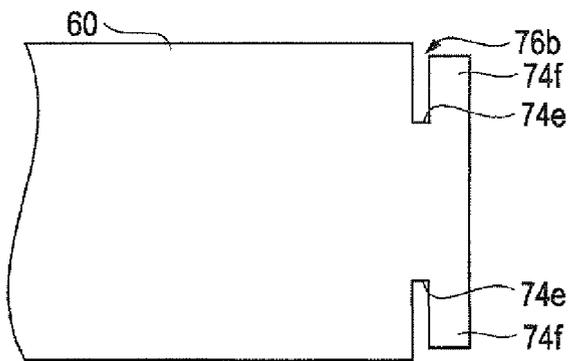


FIG. 21D

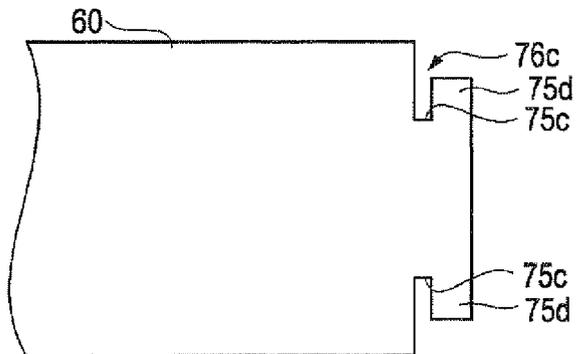


FIG. 22A

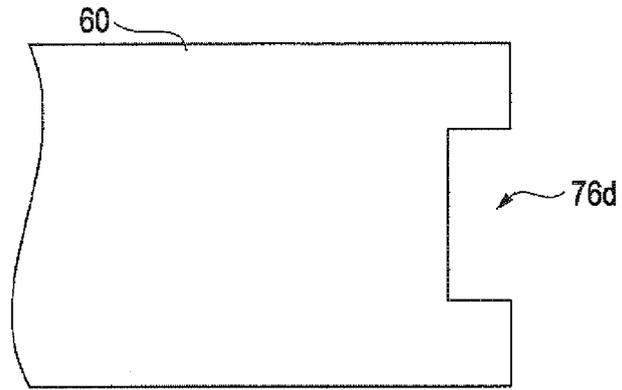


FIG. 22B

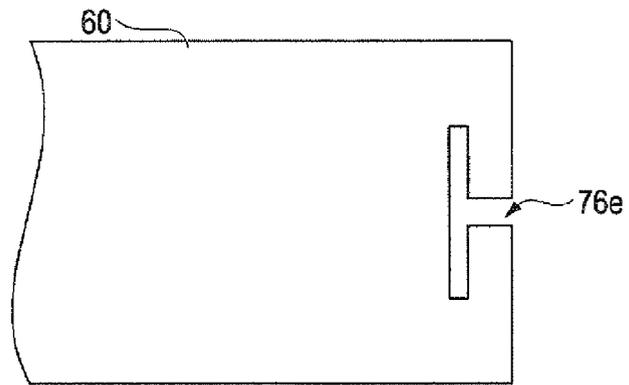


FIG. 22C

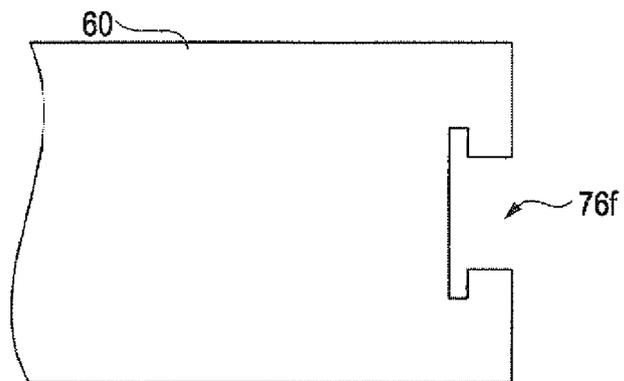


FIG. 23A

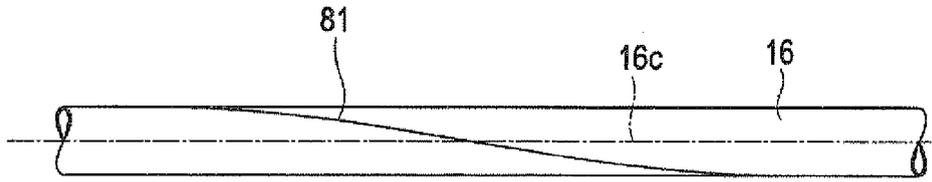


FIG. 23B

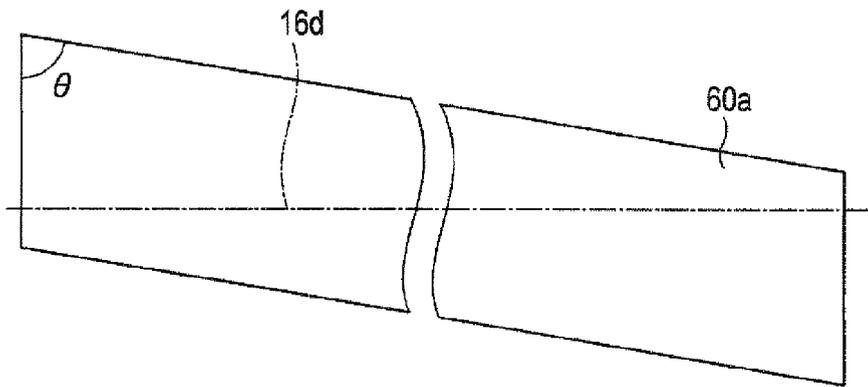


FIG. 23C

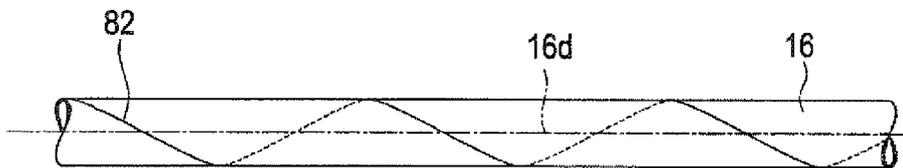


FIG. 24A

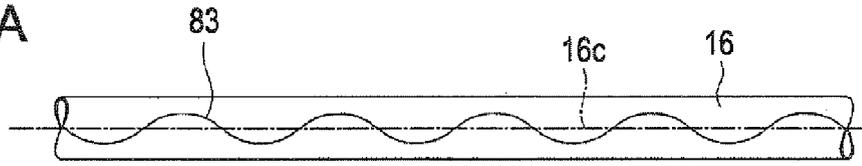


FIG. 24B

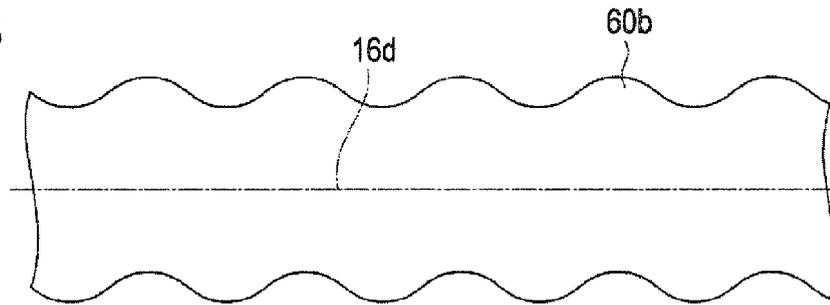


FIG. 25A

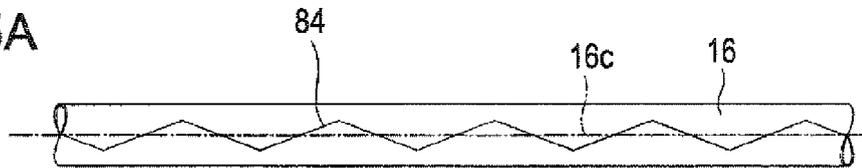


FIG. 25B

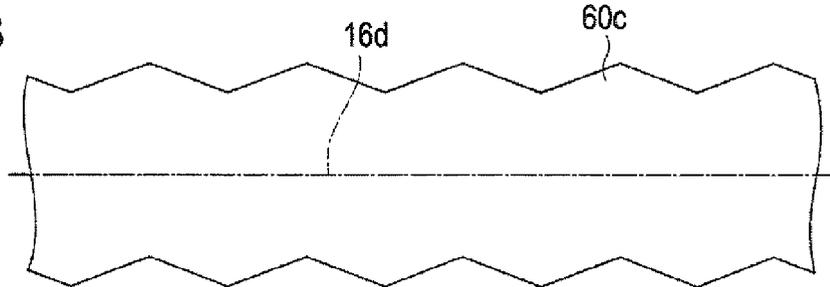


FIG. 26

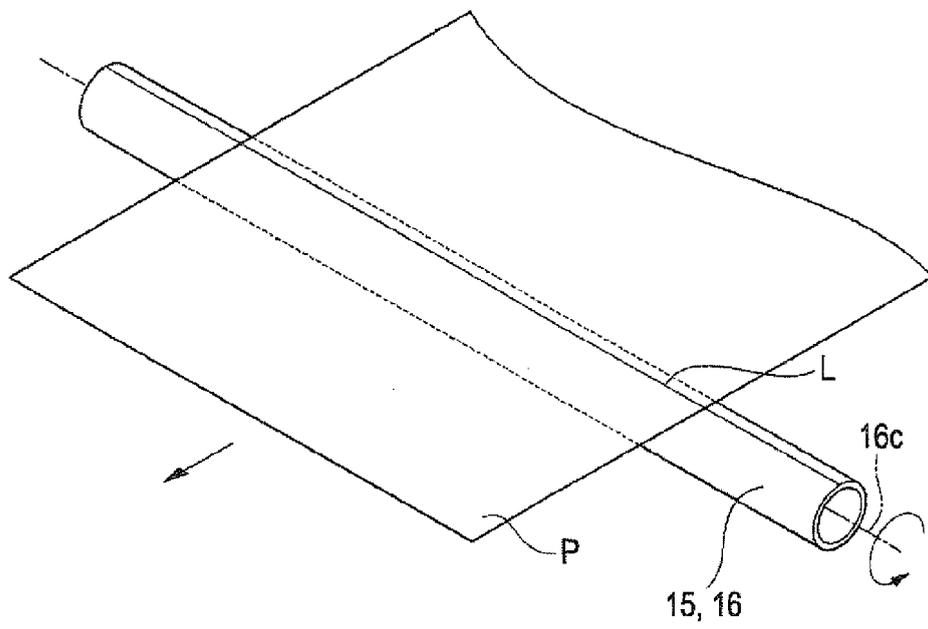


FIG. 27A

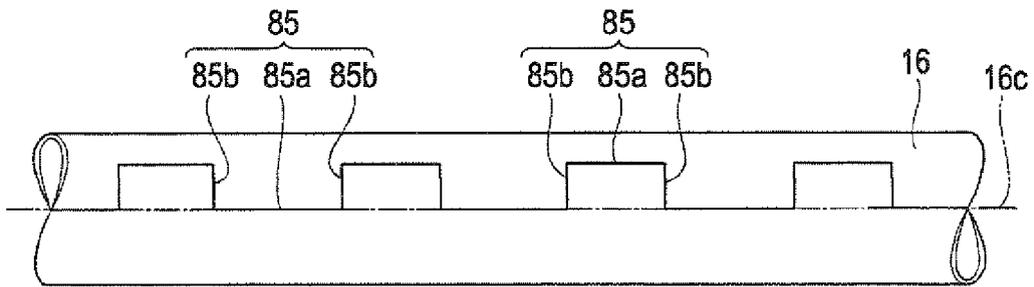


FIG. 27B

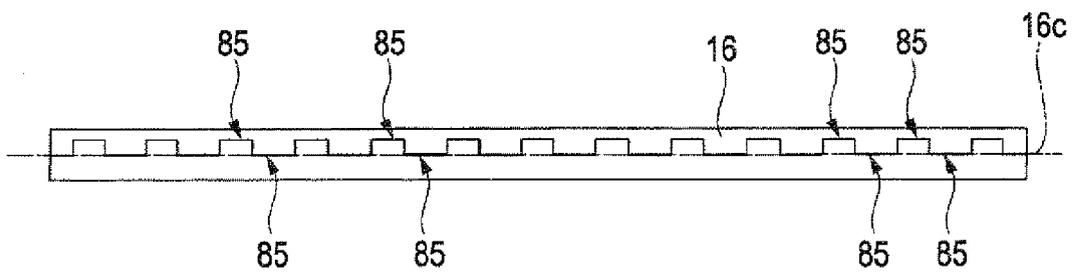


FIG. 27C

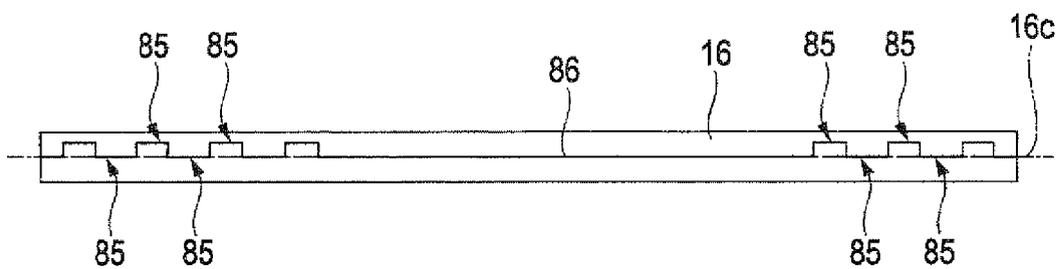


FIG. 28A

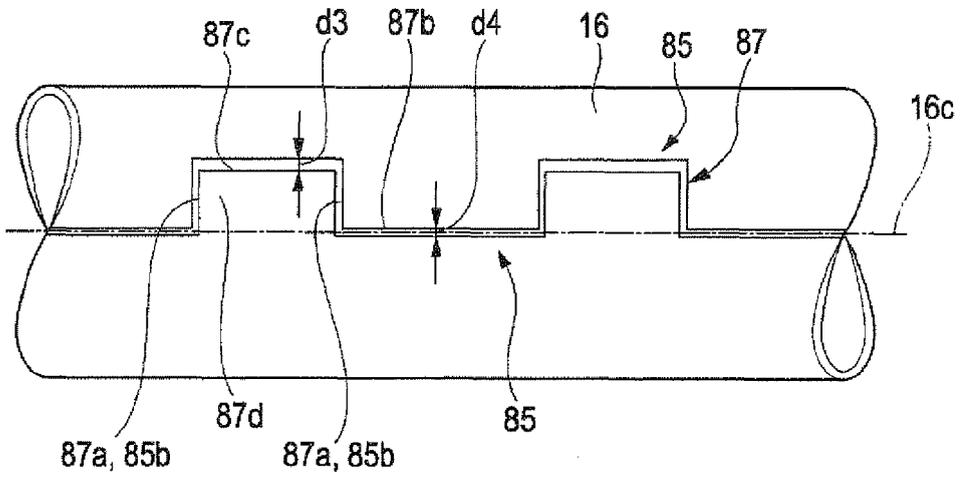


FIG. 28B

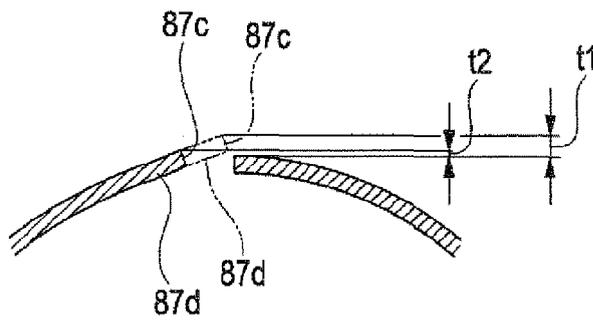


FIG. 29

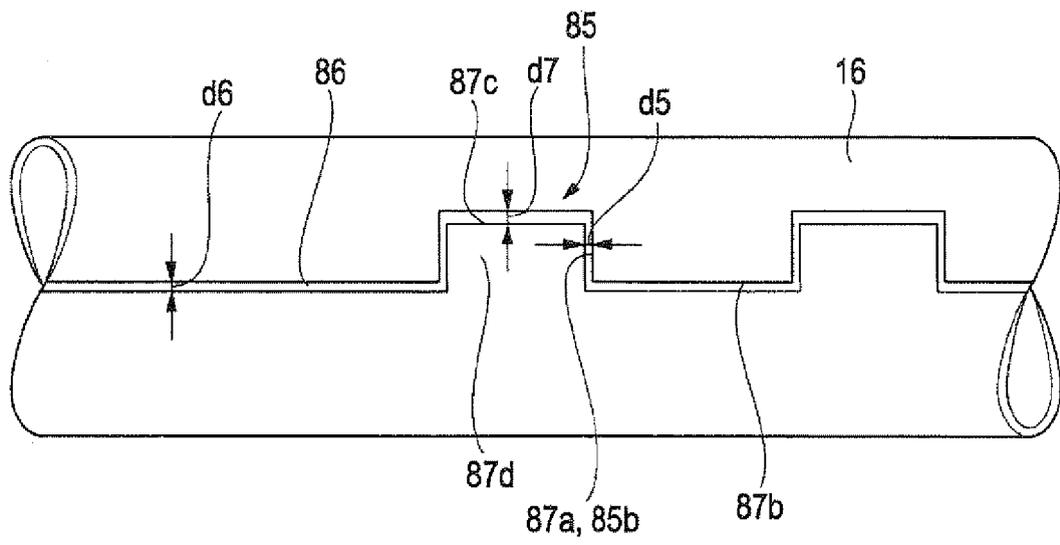


FIG. 30A

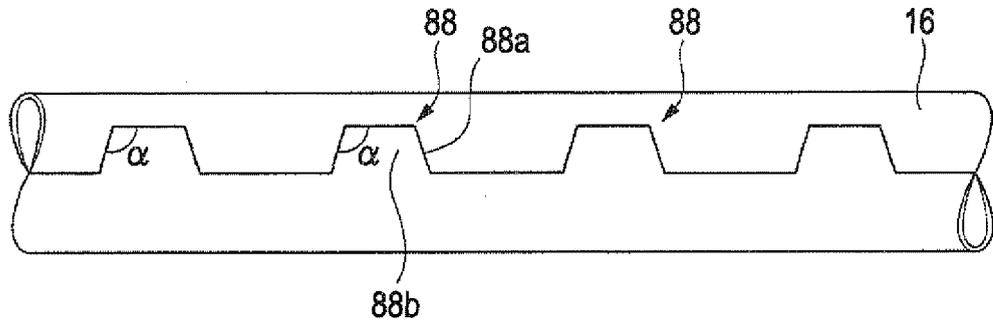


FIG. 30B

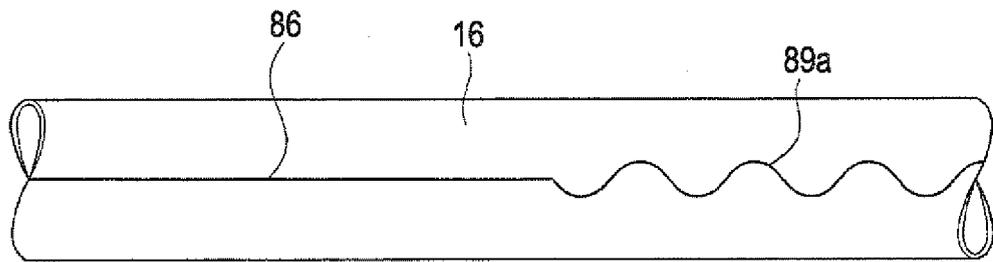


FIG. 30C

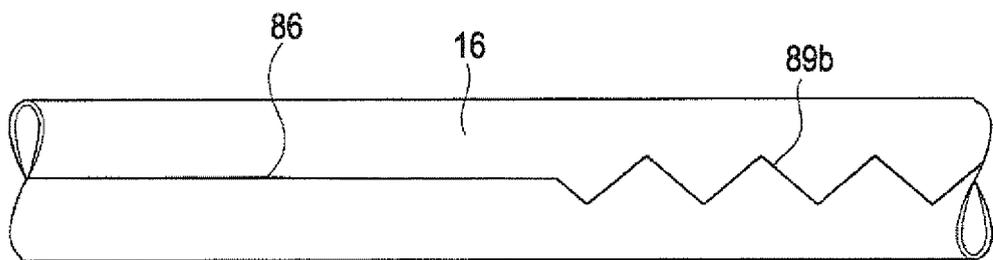


FIG. 31A

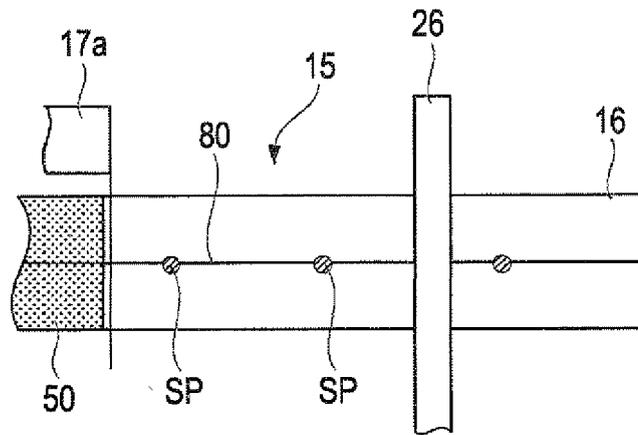


FIG. 31B

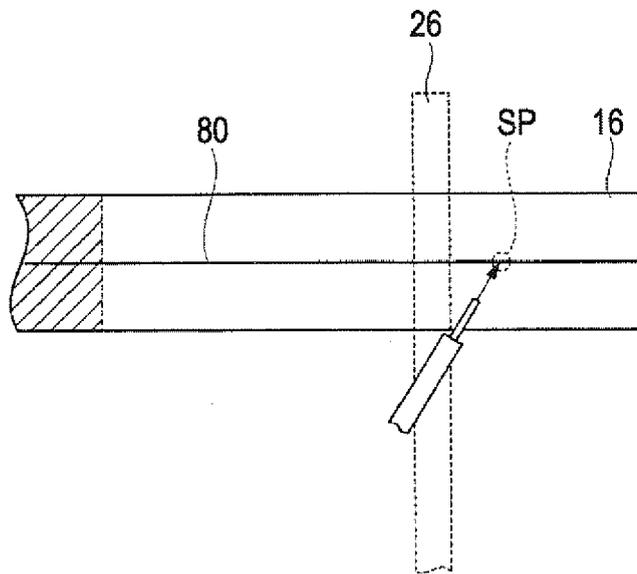


FIG. 32

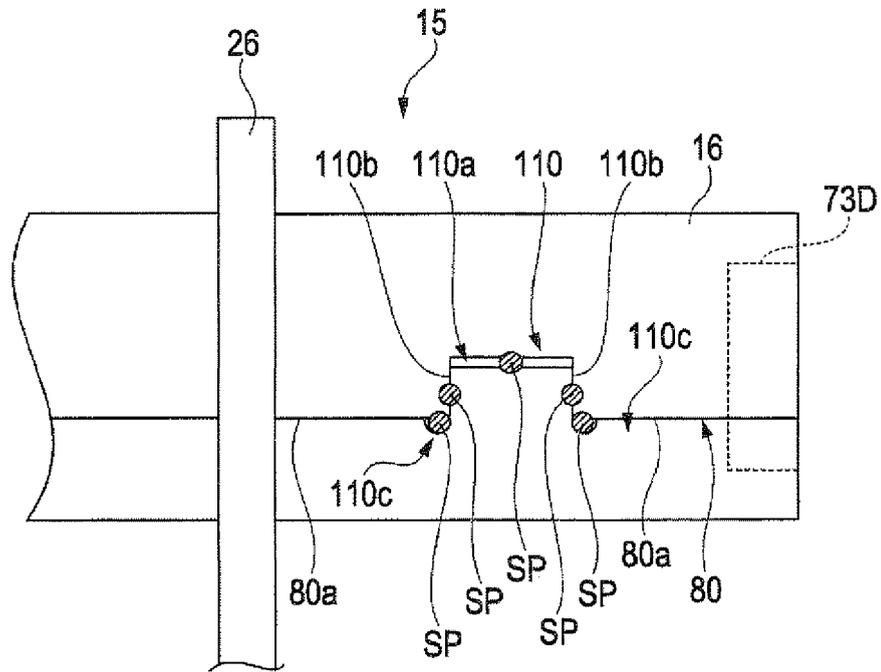


FIG. 33A

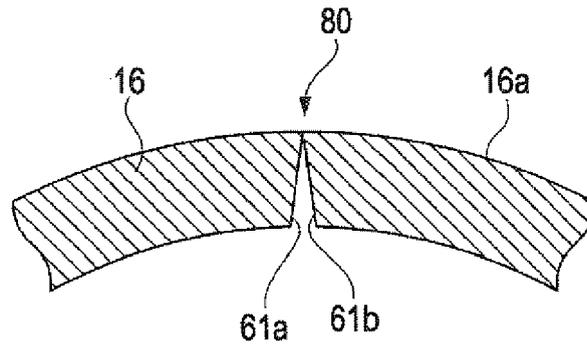


FIG. 33B

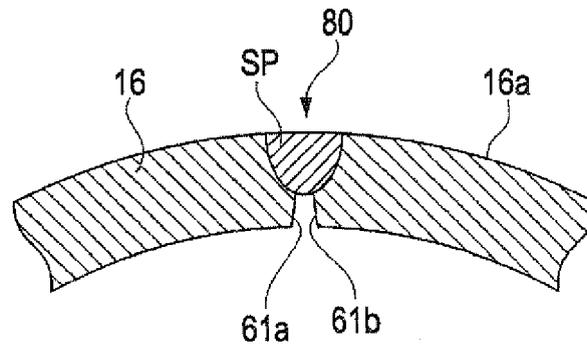


FIG. 34

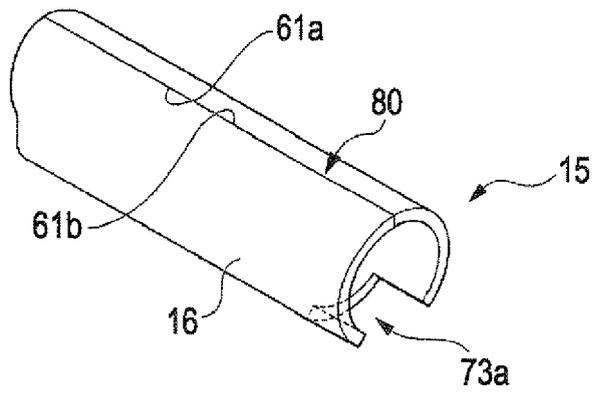


FIG. 35A

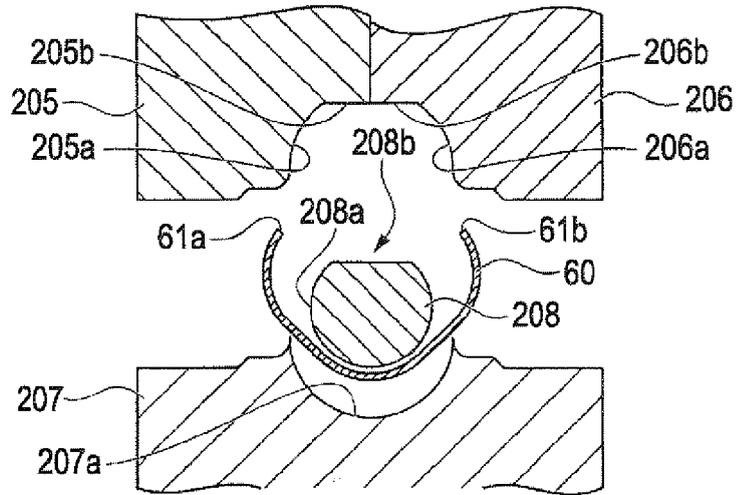


FIG. 35B

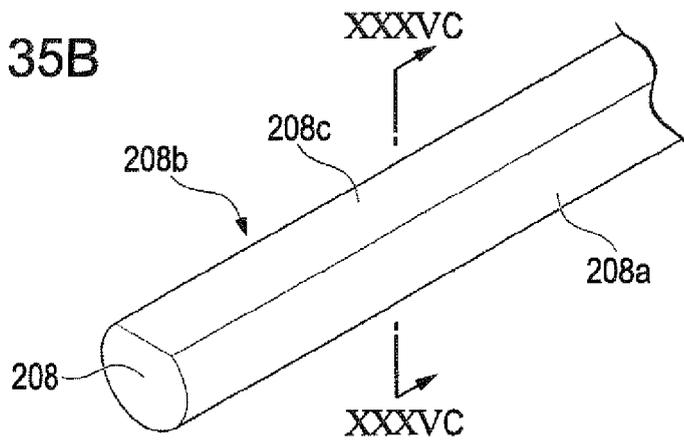


FIG. 35C

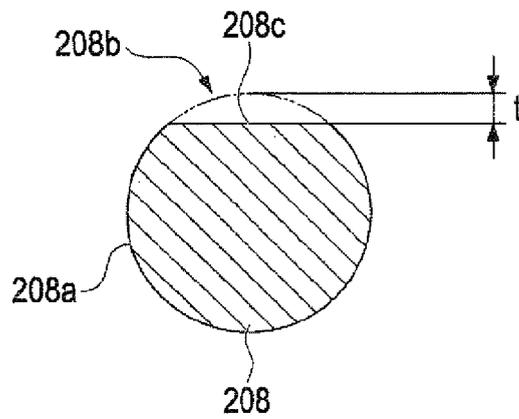


FIG. 36A

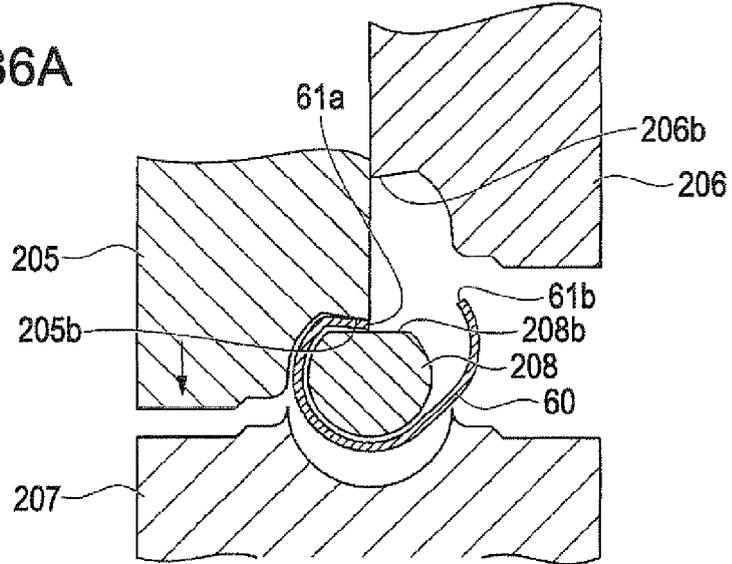


FIG. 36B

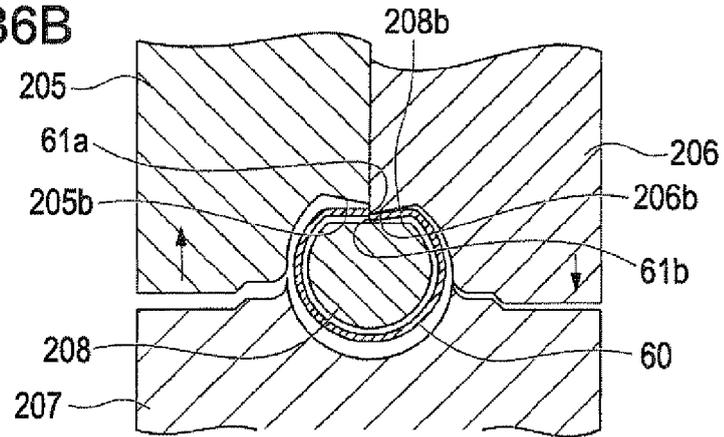


FIG. 36C

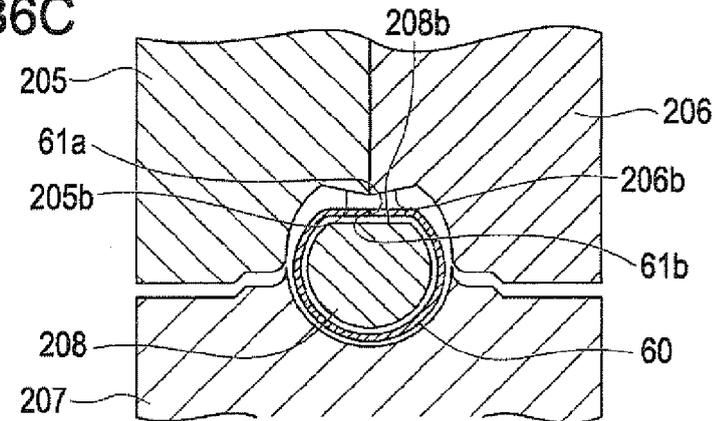


FIG. 37A

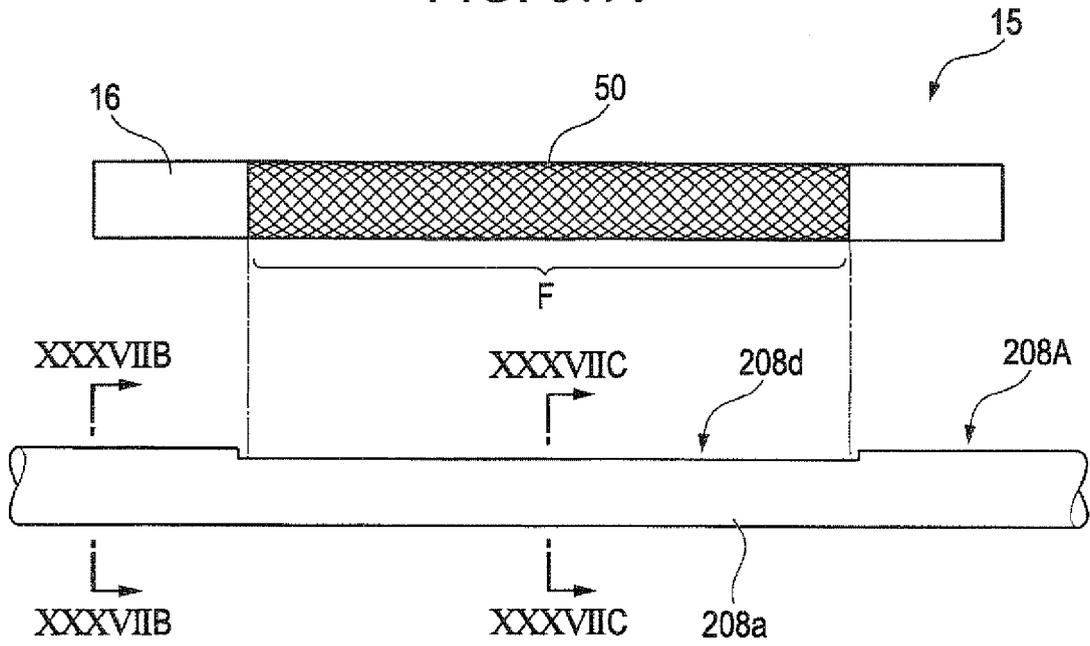


FIG. 37B

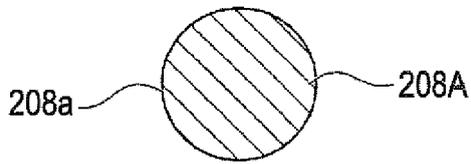


FIG. 37C

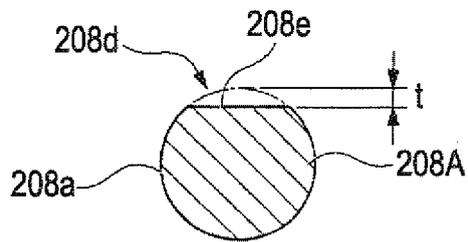


FIG. 38A

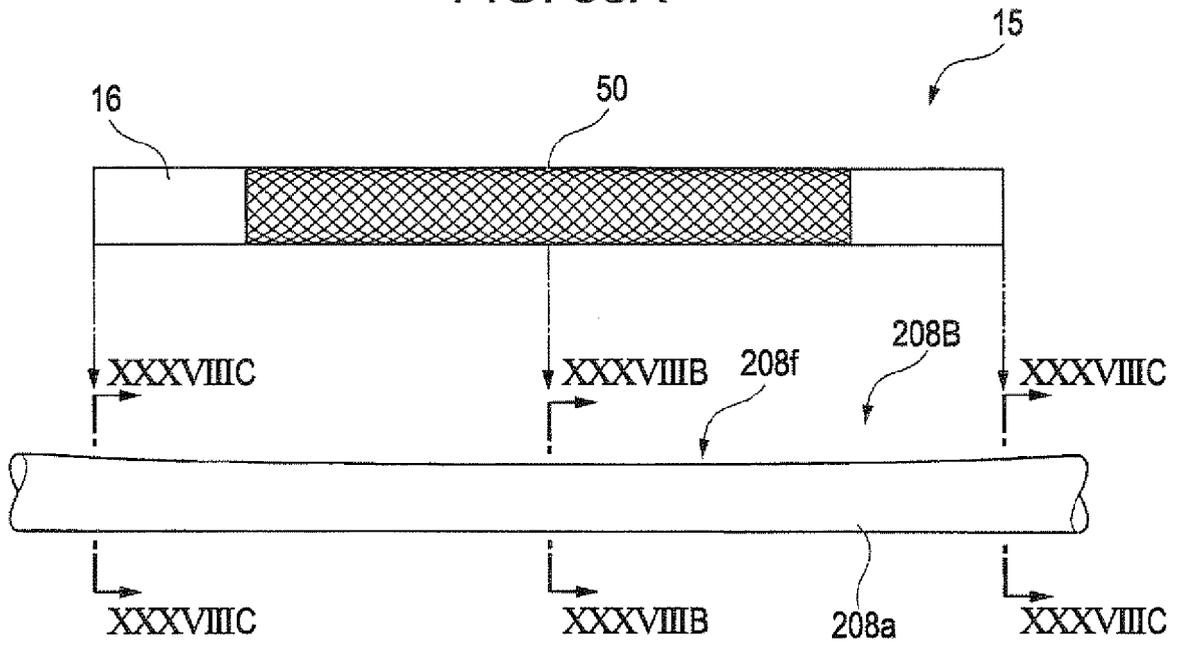


FIG. 38B

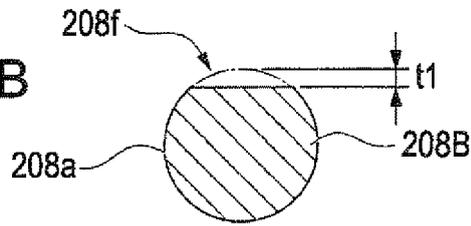


FIG. 38C

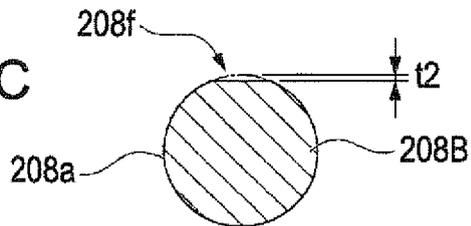


FIG. 39

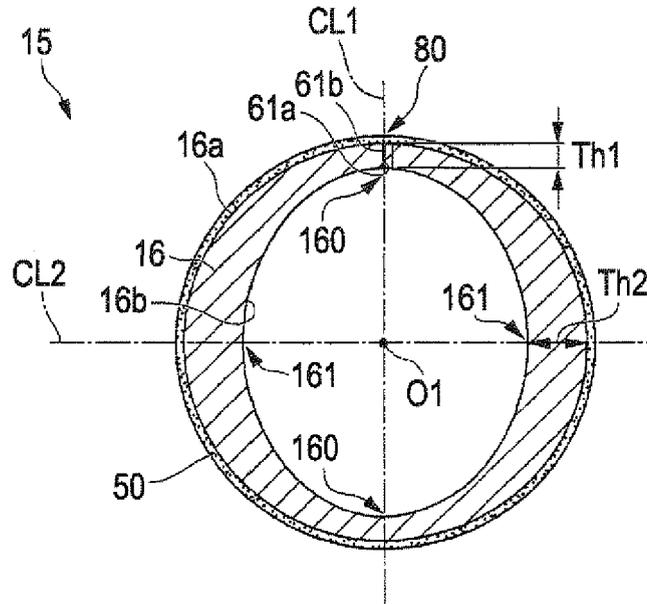


FIG. 40

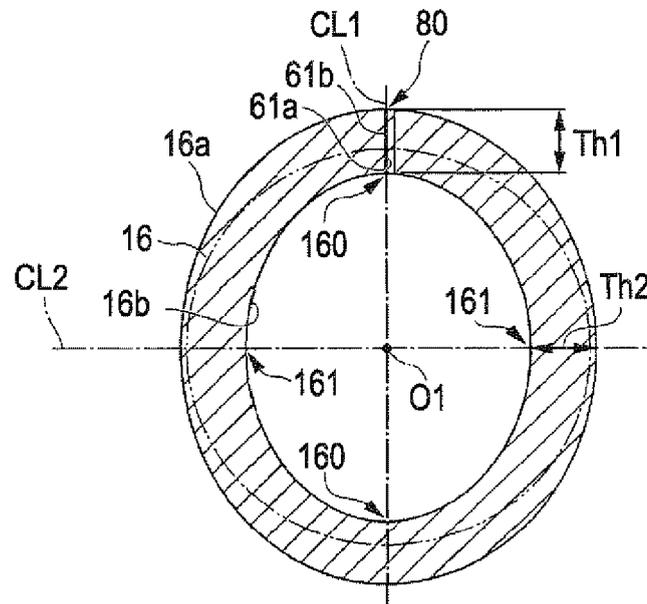


FIG. 41A

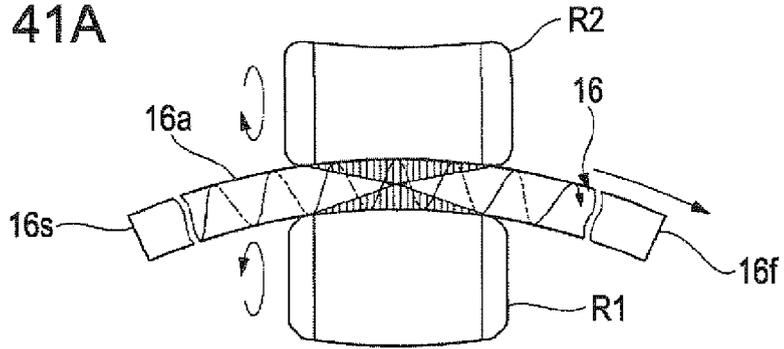


FIG. 41B

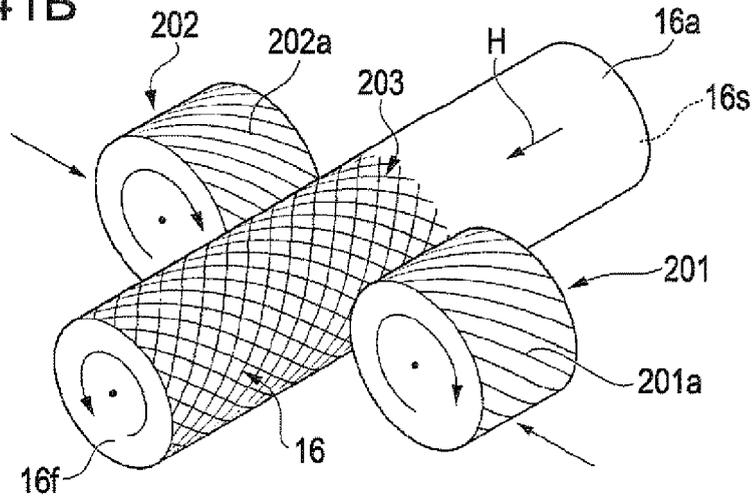


FIG. 41C

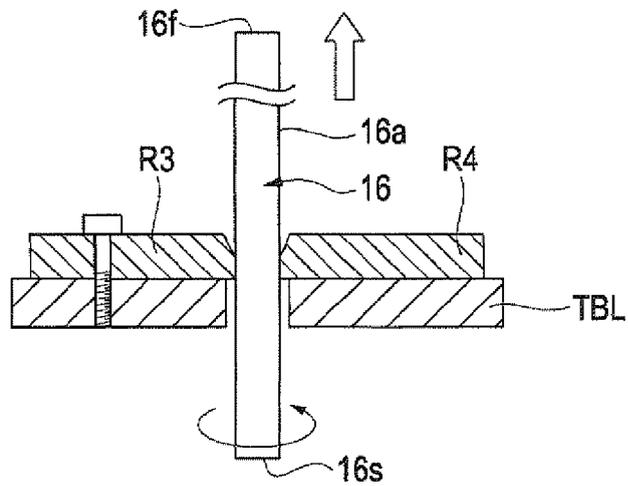


FIG. 41D

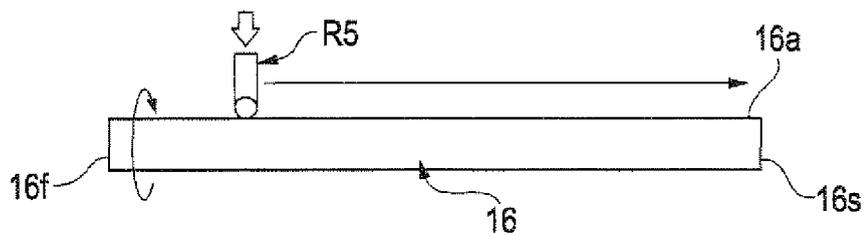


FIG. 42

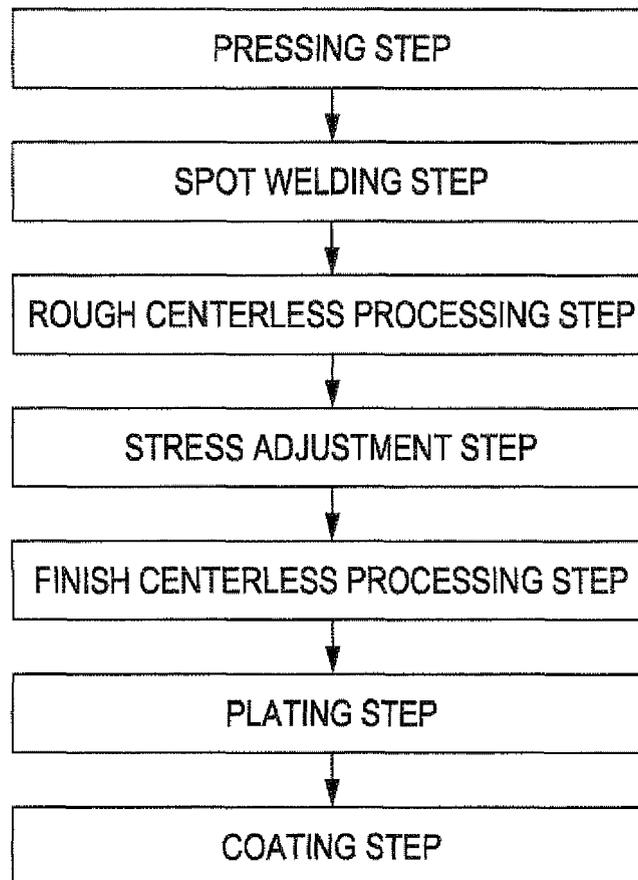


FIG. 43

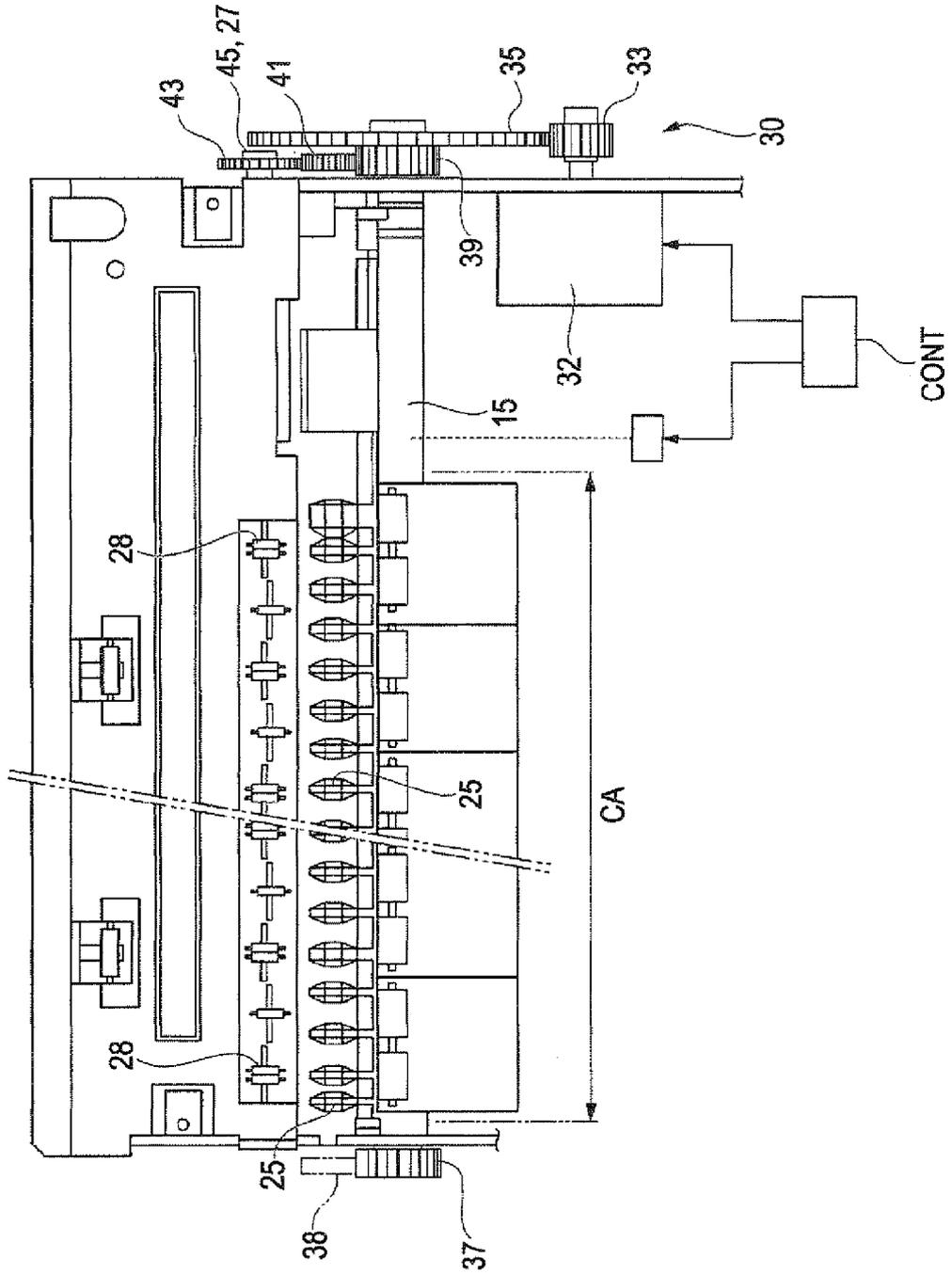
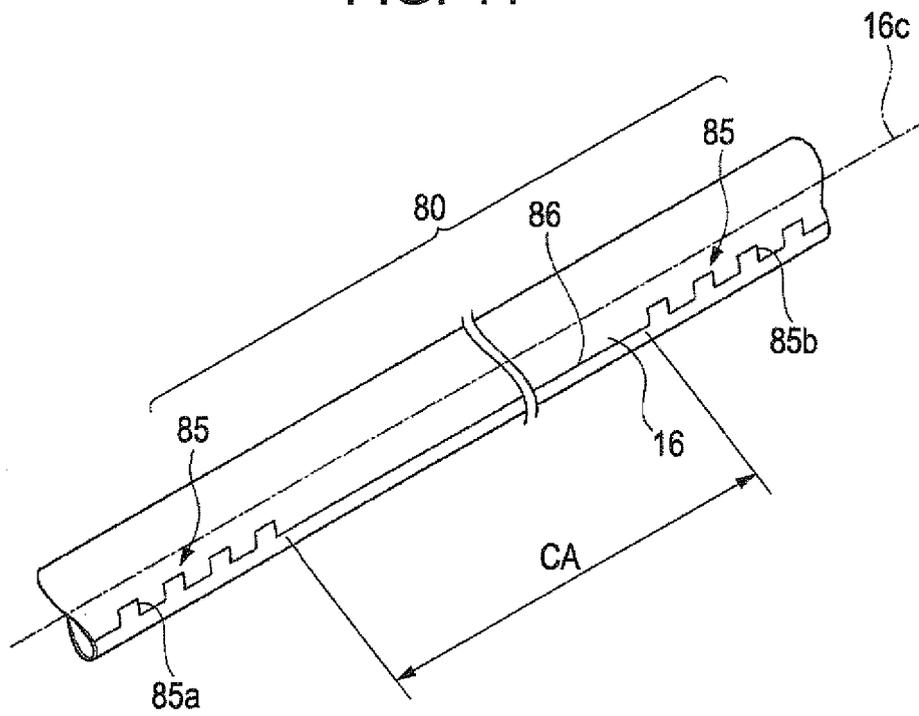


FIG. 44



REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 3271048 B [0002]