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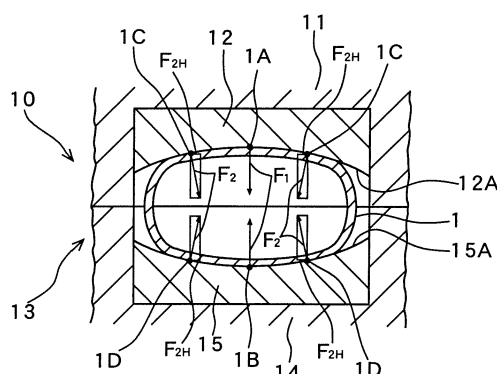
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(54) **DEVICE AND METHOD FOR ELLIPTICALLY PROCESSING METAL TUBE AND METAL TUBE PRODUCT**

(57) A device and a method for elliptically processing a metal tube capable of flattening the metal tube without producing a recessed part by only two press molds such as a cope and a drag or by using these two press molds as major technical elements. Two press molds for flattening by pressurizing a metal tube (1) having a circular vertical section to the tube center axis are a cope and a drag (10, 13) having pressuring molds (12, 15). The surfaces (12A, 15A) of the pressuring molds (12, 15) facing the metal tube (1) are formed from curved recessed surfaces or a combination of a plurality of flat surfaces, and a first pressuring part for pressurizing first parts (1A, 1B) which are portions on the metal tube (1) surface, and a second pressuring part for pressurizing second parts (1C, 1D) on the metal tube (1) surface on both sides of the metal tube 1 in the circumferential direction with respect to the first parts (1A, 1B) exist on the surfaces (12A, 15A). The first pressuring part pressurizes the first parts (1A, 1B) with pressuring force (F_1) toward the center of the metal tube (1), and the second pressuring part pressurizes the second parts (1C, 1D) with pressuring force (F_2) having a pressuring component (F_{2H}) toward the first parts (1A, 1B).

FIG. 3



Description

Technical Field

5 **[0001]** The present invention relates to a device and a method for elliptically processing a metal tube having a circular vertical section to the center axis of the tube using press molds, and metal tube products which can be applied for the time when producing such as a brake pedal arm and a suspension arm for four-wheeled vehicles, a main frame for two-wheeled vehicles etc. by elliptically processing of a metal tube.

10 Background Art

[0002] FIG 22 shows portions of two press molds when a metal tube 200 having a circular vertical section to the center axis of the tube is flattened with a press device having two press molds, of which pressuring faces are flat. A cope 210 which is one press mold moves vertically relative to a drag 211 which is the other press mold fixedly set at a position vertically facing the cope 210. The faces of the cope 210 and the drag 211 facing the metal tube 200 are flat faces 210A and 211 A, and the metal tube 200 is flattened by a pressuring force from the flat faces 210A and 211A which are pressuring faces when the cope 210 descends to the drag 210 as shown in FIG. 23. Two-dot chain lines 212 and 213 in FIG 22 show relative positions of the flat faces 210A and 211A to the metal tube 200 when the metal tube 200 is flattened to a prescribed thickness by the cope 210 and the drag 211.

20 **[0003]** The length in the circumferential direction of a portion 200A on the side above the two-dot chain line 212 and the length in the circumferential direction of a portion 200B on the side below the two-dot chain line 213 in the metal tube 200 are longer than the lateral length L of the flat faces 210A and 211A, shown in FIG 23, on which these portions 200A and 200B abut. Therefore, when the metal tube 200 is flattened by the cope 210 and the drag 211, a compressive load in the direction shown by the arrows in FIG. 23 is generated in the upper portion 200A and the lower portion 200B. As a result, during the flattening of the metal tube 200, a recessed part 200C recessed toward inside of the metal tube 200 is produced in the upper portion 200A and the lower portion 200B by buckling of these portions 200A and 200B.

25 **[0004]** The following Patent Documents 1 and 2 disclose a technology to form a metal tube in a prescribed sectional shape. The technology disclosed in Patent Document 1 is a bulge processing including the steps of filling a pressurized liquid in the inside of a metal tube and forming the metal tube in a prescribed sectional shape by the pressure, and the technology disclosed in Patent Document 2 is a method of inserting a core member into the inside of a metal tube molded by two press molds and forming the metal tube in a prescribed sectional shape from the core member. Patent Document 1 : Japanese Patent Application Laid-open No. Hei 11-333526
Patent Document 2 : Japanese Patent Application Laid-open No. 2002-86217

35 Disclosure of Invention

Problem to be solved by the Invention

40 **[0005]** A pressurized liquid is a major technical element for the technology in Patent Document 1, and a core member is a major technical element for the technology in Patent Document 2. When a metal tube is planed to be flattened using the technologies in Patent Documents 1 and 2, the manufacturing cost for the whole press device or the cost for the flattening of the metal tube will be increased due to these technical elements. Accordingly, it is requested to develop a technology capable of flattening the metal tube without producing a recessed part by only two press molds such as a cope and a drag or the like, or by using these two press molds as major technical elements.

45 **[0006]** The object of the present invention is to provide a device and a method for elliptically processing a metal tube capable of flattening the metal tube without producing a recessed part by only two press molds such as a cope and a drag or by using these two press molds as major technical elements, and to provide metal tube products thereof.

Means for solving the Problem

50 **[0007]** A device for elliptically processing a metal tube capable of flattening the metal tube relating to the present invention having two press molds facing each other, and flattening the metal tube having a circular vertical section to the center axis of the tube by pressuring with the above-described two press molds is characterized in that at least one press mold out of the two press molds includes: a first pressuring part pressurizing a first portion being a part of the surface of the metal tube toward the center of the metal tube; and a second pressuring part pressurizing a pressuring part existing on both sides of the metal tube in the circumferential direction, sandwiching the first pressuring part, and being the second portions of the metal tube surface, where are displaced in the inside direction of the above-described metal tube from the first portion while generating a pressuring component toward the first portion side.

[0008] According to the device for elliptically processing a metal tube capable of flattening the metal tube, at least one press mold out of two press molds includes the first pressuring part pressurizing the first portion being a part of the surface of the metal tube toward the center of the metal tube, and the second pressuring part pressurizing the second portions of the surface of the metal tube, which are pressuring parts on both sides of the metal tube in the circumferential direction, sandwiching the first pressuring part and displaced in the inside direction of the metal tube from the first portion by generating pressuring components toward the first portion side. Therefore, the first pressuring part pressurizes the first portion of the metal tube toward the center of the metal tube, and the second pressuring part pressurizes the second portion of the metal tube while generating pressuring components toward the first portion side. Since the second portion of the metal tube pressurized by the second pressuring part in this manner is a portion on the surface of the metal tube displaced in the inside direction of the metal tube from the first portion, it is possible to prevent a recessed part recessed on the inside of the metal tube from producing in the metal tube by the pressuring components of the pressuring force of these second pressuring parts.

[0009] The work to flatten the metal tube while preventing production of the recessed part as in this manner can be completed by only one press work on the metal tube with only two press molds, so that flattening work of the metal tube can be performed efficiently.

[0010] In the device for elliptically processing a metal tube capable of flattening the metal tube relating to the present invention, it is possible to finish a section of the metal tube after the flattening in an arbitrary shape by forming the surfaces of the above-described two press molds facing the metal tube to be an arbitrary shape.

[0011] An example of forming a face of the one press mold facing the metal tube to be a face in an arbitrary shape is that the face is formed containing a curved recessed surface having a radius of curvature greater than the above-described vertical section of the metal tube. In the case of this example, it is possible to provide the first pressuring part and the second pressuring part in the curved recessed surface. In the case of this example, the curved recessed surface may be a concave surface having a radius of curvature, or may be a concave surface in which a plurality of surfaces having a plurality of radius of curvatures are combined.

[0012] Another example of forming a surface of the one press mold facing the metal tube to be a surface having an arbitrary shape is to be a surface containing at least one flat surface. In the case of this example, it is possible to provide one pressuring part out of the first pressuring part and the second pressuring part on this one flat surface. The other pressuring part may be provided on the other flat surface formed on the one press mold, or may be provided on the curved recessed surface formed on the one press mold.

[0013] The first pressuring part and the second pressuring part may be provided on one press mold out of the two press molds or may be provided on both two press molds.

[0014] When the first and second pressuring parts are provided on one press mold out of the two press molds, the surface of the other press mold facing the metal tube may be formed from, for instance, a curved recessed surface having the same radius of curvature as the vertical section of the metal tube having the circular vertical section to the center axis of the tube.

[0015] When the first and the second pressuring parts are provided on both of the two press molds, the magnitude of the pressuring components generated by the second pressuring parts of these press molds may be different from each other, or may be the same. When the magnitude of these pressuring components are the same, it is possible to flatten the metal tube while the sectional shapes at the portions of the metal tube to be flattened with each of the two press molds are made symmetric with each other.

[0016] The device for elliptically processing a metal tube capable of flattening the metal tube relating to the present invention can be applied when the device serves as a mold to bend the metal tube while the above-described two press molds flatten the metal tube.

[0017] When the above-described two press molds serve as a mold to bend the metal tube while flattening it as in this manner, the above-described first pressuring part and the second pressuring part are used as a pressuring part to pressurize an unbent part where the metal tube is not bent, and a press mold out of the above-described two press molds, which faces the compressed side of the metal tube compressed by at least bending processing includes a third pressuring part for pressurizing a third portion being a portion on the surface of the metal tube toward the center of the metal tube, and fourth pressuring parts which are pressuring parts existing on both sides of the metal tube in the circumferential direction, sandwiching the third pressuring part, and for pressurizing fourth portions on the surface of the metal tube which are displaced in the inside direction of the metal tube from the third portion while generating a pressuring component toward the third portion side, in which the pressuring components of pressuring forces of the fourth pressuring parts are made greater than the above-described pressuring component of the pressuring force of the second pressuring part.

[0018] When a metal tube is bent, a compression force toward the center axis of the tube is generated owing to the bending on the compression side of the metal tube compressed by the bending. Therefore, the portion of the metal tube, on which bending is performed, is compressed significantly, influenced also by the above-described flattening, and thus, a portion recessed toward the inside of the metal tube is more easily created in the metal tube.

[0019] However, at least one press mold out of the above-described two press molds, which faces the compression side of the metal tube compressed by bending is provided with a third pressuring part to pressurize the third portion which is a portion on the surface of the metal tube, toward the center of the metal tube, and fourth pressuring parts which are the pressuring parts existing on both sides of the metal tube in the circumferential direction, sandwiching the third pressuring part, and pressurize fourth portions on the surface of the metal tube which are displaced in the inside direction of the metal tube from the third portion while generating pressuring components toward the third portion side, and by making the pressuring components of the pressuring force of the fourth pressuring parts greater than the pressuring components of the pressuring force of the second pressuring parts, it is possible to flatten the metal tube including the portion to be bent while preventing the recessed part toward inside of the metal tube from being produced in the bent part of the metal tube.

[0020] Thus, when the third pressuring part and the fourth pressuring part are provided in one press out of the two press molds, which faces the compression side of the metal tube compressed at least by bending, a surface of the press mold to face the bent part in the metal tube, which faces the compression side of the metal tube compressed by the bending, in other words, the surface provided with the third pressuring part and the fourth pressuring parts, can be a surface having an arbitrary shape.

[0021] One of the examples is to make the surface to that including a curved recessed surface having a radius of curvature greater than the above-described vertical section of the metal tube. In the case of this example, it is possible to provide the third pressuring part and the fourth pressuring part in the curved recessed surface. In addition, it may be a concave surface by one radius of curvature or a concave surface formed by a combination of plural surfaces by a plurality of radiuses of curvatures.

[0022] Another example of the surface provided with the third pressuring part and the fourth pressuring part is to make the surface to that including at least one flat surface. In the case of this example, it may be provided one pressuring part out of the third pressuring part and the fourth pressuring part on this one flat surface. The other pressuring part may be provided on another flat surface formed on the press mold which faces the compression side of the metal tube to be compressed by bending, or may be provided on a curved recessed surface formed on this press mold.

[0023] Furthermore, the third pressuring part and the fourth pressuring part may be provided on a press mold facing the compression side of the metal tube to be compressed by the bending out of the above-described two press molds, or may be provided in both of two press molds.

[0024] When the third pressuring part and the fourth pressuring part are provided on a press mold facing the compression side of the metal tube to be compressed by bending out of the above-described two press molds, a surface of the remaining press mold facing the portion of the metal tube to be bent can be formed from a curved recessed surface having a radius of curvature the same as that of the vertical section of the metal tube having, for instance, a circular vertical section to the center axis of the tube.

[0025] When the third pressuring part and the fourth pressuring part are provided on both of the above-described two press molds, the magnitude of the pressuring components of pressuring force of the fourth pressuring parts on these press molds may be different from each other, or may be the same. When the magnitude of these pressuring components are the same, it is possible to flatten the metal tube in a manner that the sections of the portions to be flattened by each of the two press molds in the portions of the metal tube to be bent are made symmetrical.

[0026] In addition, the device for elliptically processing a metal tube capable of flattening the metal tube relating to the present invention may include an end face displacement controlling part for restricting displacement of one end face toward outside in the direction of the tube center axis by abutting the one end face in the direction of the tube center axis of the metal tube. The respective surfaces of the above described two press molds facing the outer peripheral surface of the other end part in the direction of the tube center axis of the metal tube may be formed from curved recessed surfaces having the same radius of curvature as those of the other end part having the above-described vertical circular section relating to the center axis of the tube, and the outer peripheral surface of the other end part at the time of completion of the flattening work of the metal tube formed by the two press molds may be surrounded by these curved recessed surfaces.

[0027] According to this structure, when the metal tube is flattened by the two press molds, the full length of the metal tube extends along the center axis direction of the tube owing to pads of the metal tube material produced by the flattening. However, since one end face in the direction of the tube center axis of the metal tube abuts on the above-described end face displacement controlling part, extension in the full length of the metal tube appears as an extension toward the other side in the center axis direction of the tube. When the full length of the metal tube extends toward the other side of the center axis direction of the tube as in this manner, the respective surfaces of the above described two press molds facing the outer peripheral surface of the other end part in the direction of the tube center axis of the metal tube is formed from a curved recessed surface having the same radius of curvature as that of the other end part having the above-described circular vertical section to the center axis of the tube, and the outer peripheral surface of the other end part at the time of completion of the flattening of the metal tube formed by the two press molds is surrounded by these curved recessed surfaces. Accordingly, the other end part is never flattened by the above-described two press

molds.

[0028] Accordingly, when a metal tube having the full length larger than the prescribed is cut with a cutter transferring in the direction perpendicular to the center axis of the tube so as to obtain the prescribed length after completion of the flattening, it is possible to cut a portion of the metal tube where is not flattened and keeps the above-described circular section. Therefore, the cutting work can be performed smoothly without crushing and deforming the metal tube.

[0029] When the end face displacement controlling part, on which one end face of the metal tube in the direction of the tube center axis abuts so as to restrict outward displacement of the end face in the direction of the tube center axis by this abutting, is installed on the device for elliptically processing a metal tube capable of flattening the metal tube, at least one press mold out of the two press molds is formed together from a mold main body and a pressuring mold of which at least one portion is buried in the mold main body, so that the end face displacement controlling part may be used as a rising wall formed in the mold main body for the purpose of fixing at least one portion of the pressuring mold. In other words, the end face displacement controlling part may be formed by using a rising wall portion such as a recessed part, a through hole, or the like formed in the mold main body for the purpose of fixing at least one portion of the pressuring mold.

[0030] The device for elliptically processing a metal tube capable of flattening the metal tube relating to the present invention may include a core member which is inserted until it reaches the midpoint of the full length of the metal tube from one end part in the direction of the tube center axis of the metal tube toward the inside of the metal tube, when the metal tube is flattened by the two press molds.

[0031] According to this invention, in regard to a range in the length in which the core member is inserted along the full length of the metal tube, the sectional shape of the metal tube can be formed in a shape exactly corresponding to the shape of the core member by the pressing action of the two press molds. In addition, since the range in the length among the full length of the metal tube, in the device for elliptically processing a metal tube capable of flattening the metal tube, the two press molds are structured as major technical elements and the core member is taken as an subsidiary technical element in the device for elliptically processing a metal tube capable of flattening the metal tube.

[0032] As described above, when the device for elliptically processing a metal tube capable of flattening the metal tube is structured as a device provided with the core member, at least one punch member to make a hole in the metal tube may be installed on one press mold out of the two press molds, and a guide hole to guide the punch member may be formed in the core member.

[0033] According to this formation, it is possible to use the core member as a guide member for guiding the punch member at the time of making a hole in the metal tube.

[0034] A method for elliptically processing a metal tube capable of flattening the metal tube relating to the present invention to flatten the metal tube by pressurizing the metal tube having a circular vertical section to the center axis of the tube with two press molds facing each other, the method includes the steps of:

pressurizing a first portion being a part on the surface of the metal tube toward the center of the metal tube by the two press molds as a first step, and

pressurizing the metal tube at a second portion on the surface of the metal tube displaced in the inside direction of the above-described metal tube from the first portion, the second portion being a portion on both sides of the metal tube in the circumferential direction with respect to the above-described first portion, while generating a pressuring component toward the first portion side as a second step.

[0035] According to the method for elliptically processing a metal tube capable of flattening the metal tube, following the first pressuring step to pressurizing the first portion being a portion on the surface of the metal tube toward the center of the metal tube by two press molds, the second pressuring step is conducted to pressurize the second portions on the surface of the metal tube being portions on both sides of the metal tube in the circumferential direction with respect to the first portion while generating pressuring components toward the first portion side by at least one press mold out of two press molds. Since the second portions are portions on the surface of the metal tube displaced in the inside direction of the metal tube from the first portion, it is possible to flatten the metal tube while preventing a recessed part recessed toward the inside of the metal tube from producing in the metal tube by the pressuring component of the pressuring force acting on the second pressuring parts.

[0036] The work to flatten the metal tube while preventing production of a recessed part as in this manner can be completed by only one time of pressing work on the metal tube using only two press molds, so that the flattening work of the metal tube can be efficiently performed.

[0037] The method for elliptically processing a metal tube capable of flattening the metal tube relating to the present invention may include a core member inserting step to insert the core member until it reaches the midpoint of the full length of the metal tube from one end part in the direction of the tube center axis of the metal tube toward the inside of the metal tube.

[0038] Further, the method for elliptically processing a metal tube capable of flattening the metal tube may include a hole making step to make a hole in the metal tube by a punch member disposed at least one piece in one press mold out of the two press molds and guided by a guide hole formed in the above-described core member.

[0039] The metal tube products relating to the present invention are those manufactured by the devices or methods relating to the present invention explained as above.

[0040] The present invention explained as above can be applied both to the case of flattening the whole along the full length of the metal tube, in other words, flattening the whole part in the full length in the longitudinal direction of the metal tube, and the case of flattening a portion in the longitudinal direction of the metal tube. The metal tube may be preliminarily processed such as bending, enlarging of the diameter to enlarge the diameter of a portion in the longitudinal direction of the metal tube, or reduction processing of the diameter to reduce the diameter of a portion in the longitudinal direction of the metal tube before flattened. The metal tube to be flattened may be a piece of tube or that connected in series with a plurality of pipes of different or the same in diameter.

[0041] A flattened metal tube or metal tube product manufactured by a device or a method relating to the present invention can be applied to arbitrary uses. An example of the uses is a brake pedal arm for vehicles, another example is a vehicle suspension arm, and still another example is a main frame of a two-wheeled car.

[0042] When the metal tube product relating to the present invention is used for a brake pedal arm for vehicles, the arm is formed from a flattened metal tube having a cavity maintained in the inside.

[0043] The cavity may be continuous over the full length of the metal tube, or may be limited to a portion of the full length of the metal tube. In the latter case, a portion in the longitudinal direction where there is no cavity inside along the full length of the metal tube may be crushed simultaneously at the time of the flattening, or may be crushed by a process conducted after the flattening.

[0044] A metal tube used for brake pedal arm for vehicles includes a large dimensional part having a long vertical length and a small dimensional part having a vertical length shorter than that of the large dimensional part, and it is preferable that a hole through which a pivot center axis of the brake pedal arm is horizontally inserted is formed in the large dimensional part.

[0045] When taking this structure, a big load is applied at the time of depressing down the break pedal for the purpose of braking a wheel, and a bending moment generated in the brake pedal arm by this load is at the maximum at a part where the hole is formed, through which the pivot center axis of the brake pedal arm is horizontally inserted. This part is the large dimensional part where the vertical dimension is larger than that of the small dimensional part, and the section modulus for the horizontal neutral axis of the large dimensional part is large due to this large vertical dimension. Therefore, the strength of the brake pedal arm for the bending moment can be enhanced.

[0046] As described above, when the large dimensional part having a long vertical length and the small dimensional part having a vertical length shorter than that of the large dimensional part are provided in the brake pedal arm and the hole is formed through which the pivot center axis of the brake pedal arm is horizontally inserted in the large dimensional part, two surfaces facing each other in the lateral direction of the large dimensional part may be flat surfaces parallel to each other, or may be convex surfaces protruded by curving outward.

[0047] When the two surfaces facing each other in the lateral direction of the large dimensional part are made flat surfaces parallel to each other, the vertical dimension of the large dimensional part can be bigger than that in the case of these two surfaces being convex surfaces protruded by curving outward. Therefore, the above-described section modulus of the large dimensional part can be made great.

[0048] When the two surfaces facing each other in the lateral direction of the large dimensional part are made convex surfaces protruded by curving outward, the large dimensional part can be molded by flattening with two press molds without use of the core member to be inserted in the inside of the metal tube.

Advantage of the Invention

[0049] According to the present invention, it is possible to obtain an effect to flatten the metal tube without producing a recessed part by only two press molds such as a cope and a drag or by using two press molds as a major technical element.

Brief Description of Drawings

[0050]

FIG. 1 is a cross section of a device for elliptically processing a metal tube capable of flattening the metal tube showing parts of a cope and a drag, which are two press molds relating to a first embodiment of the present invention; FIG 2 is a cross section taken along the line S2-S2 in FIG 2; FIG 3 is a cross section showing the metal tube flattened by the cope and the drag in FIG. 2;

FIG 4 is a view similar to FIG 2 showing a second embodiment;
 FIG. 5 is a view similar to FIG 3 showing the second embodiment;
 FIG 6 is a view similar to FIG 1 showing the third embodiment in which the cope and the drag are molds for bending a metal tube;
 5 FIG. 7 is a cross section showing the time of flattening a metal tube at the position taken along the line S7-S7 in FIG 6 which is the position corresponding to an unbent part of the metal tube;
 FIG 8 is a cross section showing the time of flattening the metal tube at the position taken along the line S8-S8 in FIG. 6, which is at the position corresponding to a bent part of the metal tube;
 10 FIG. 9 is a view similar to FIG 7 showing a fourth embodiment in which the cope and the drag are the molds for bending a metal tube, and the pressuring face of the pressuring molds are formed of a plurality of flat surfaces;
 FIG. 10 is a view similar to FIG. 8 showing the fourth embodiment;
 FIG. 11 is a perspective view showing the metal tube before flattening, which are used in a fifth embodiment;
 FIG 12 is a perspective view showing the metal tube after flattening in FIG 11;
 15 FIG 13 is a cross section of the principal portion of the device for elliptically processing a metal tube capable of flattening the metal tube showing portions of the cope and the drag which are two press molds relating to the fifth embodiment;
 FIG 14 is an arrow diagram taken along the line S14-S14 in FIG 13;
 FIG 15 is a cross section of the principal portion of the device for elliptically processing a metal tube capable of flattening the metal tube in the fifth embodiment after flattening the metal tube;
 20 FIG. 16 is a view similar to FIG. 15 showing a sixth embodiment;
 FIG. 17 is a plan view showing a brake pedal arm for vehicles made from a metal tube product manufactured by the device for elliptically processing a metal tube capable of flattening the metal tube in the sixth embodiment and a brake pedal attached to the arm;
 FIG. 18 is a side view showing the brake pedal arm and the brake pedal in FIG 17;
 25 FIG 19 is a cross section taken along the line S19-S19 in FIG 18;
 FIG. 20 is a cross section taken along the line S20-S20 in FIG 18;
 FIG. 21 is a view similar to FIG 20 showing a brake pedal arm relating to another embodiment;
 FIG. 22 is a cross section showing the situation before pressurizing when the metal tube is flattened by the cope and the drag in which the pressuring faces are flat; and
 30 FIG 23 is a cross section showing a situation when the metal tube is flattened by the cope and the drag in FIG 22.

Explanation of Symbols

[0051]

1,31,71 METAL TUBE

1A, 1B, 31A, 31B	FIRST PORTION
1C, 1D, 31C, 31D	SECOND PORTION
31E, 31F	THIRD PORTION
31G, 31H	FOURTH PORTION
10, 13, 20, 23, 40, 43, 50, 53, 80, 83	COPE AND DRAG
PRESS	(MOLDS)
11, 14, 21, 24, 41, 44, 51, 54, 81, 84	MAIN BODY
12, 15, 22, 25, 42, 45, 52, 55, 82, 85	PRESSURING MOLD
12A, 15A, 42A, 45A, 82A, 85A	PRESSURING SURFACE FORMED FROM CURVED RECESSED SURFACE
22A, 25A, 52A, 55A	PRESSURING SURFACE FORMED FROM FLAT SURFACE
26, 27, 28, 29, 56, 57, 58, 59, 60, 61, 62, 63	FLAT SURFACE
71'	METAL TUBE PRODUCT (METAL TUBE AFTER FLATTENING)
72A	END FACE ON ONE SIDE IN THE DIRECTION OF TUBE CENTER AXIS
73A	END PART ON THE OTHER SIDE IN THE DIRECTION OF TUBE CENTER AXIS
84B	RISING WALL (END FACE DISPLACEMENT CONTROLLING PART)
90	CORE MEMBER
90A, 90B, 90C	GUIDE HOLE
92, 93, 94	PUNCH MEMBER

100	BRAKE PEDAL ARM
101, 101'	LARGE DIMENSIONAL PART
102	SMALL DIMENSIONAL PART
N_1, N_2, N_3	TUBE CENTER AXIS

5

Best Mode for Carrying Out the Invention

10 **[0052]** The embodiments to carry out the present invention will be explained hereinafter with reference to drawings. FIG. 1 is a cross section showing portions of the cope 10 and the drag 13 of a press device that is the device for elliptically processing a metal tube capable of flattening the metal tube relating to a first embodiment. These cope 10 and the drag 13 which are two press molds include mold main bodies 11, 14 and pressuring molds 12, 15 buried and set as a whole in recessed parts 11A, 14A formed in these molds main bodies 11, 14. A metal tube 1 relating to the present embodiment is a straight tube in which the tube center axis N_1 is straight, and the same diameter is continued over the full length, and this metal tube 1 is a circular tube, of which vertical section relating to the tube center axis N_1 is circular as shown 15 in FIG. 2 which is a cross section taken along the line S2-S2 in FIG. 1.

[0053] As shown in FIG. 2, a surface facing the metal tube 1 in the pressuring molds 12 and 15 of the cope 10 and the drag 13, in other words, the pressuring faces 12A and 15A to pressurize the metal tube 1 are curved recessed surfaces. These curved recessed surfaces are arc surfaces, and are formed at a radius of curvature greater than that of a circular vertical section of the metal tube 1. The radius of curvature of these pressuring surfaces 12A and 15A are the same. 20 When the cope 10 and the drag 13 are open, the metal tube 1 is set on the pressuring surface 15A of the pressuring mold 15 of the drag 13 as shown in FIG. 1, the metal tube 1 is flattened by the pressuring molds 12 and 15 as shown in FIG. 3, when the mold main body 11 of the descending cope 10 reaches the prescribed position where it abuts on the mold main body 14 of the drag 13.

25 **[0054]** The flattening is initiated first when the highest part 1A and the lowest part 1B at the center in the horizontal direction shown in FIGs. 2 and 3 which are portions on the surface of the metal tube 1, in other words, a first parts 1A and 1B are pressurized by the pressuring surfaces 12A and 15A of the pressuring molds 12 and 15 toward the center of the metal tube 1, and due to continuous descending of the cope 10, in the cope 10, the second part 1C that is a portion on the surface of the metal tube 1 on both sides of the metal tube 1 in the circumferential direction with respect to the first part 1A is pressurized by the pressuring surface 12A of the pressuring mold 12, while in the drag 13, the second 30 part 1D that is a portion on both sides of the metal tube 1 in the circumferential direction with respect to the first part 1B is pressurized by the pressuring surface 15A of the pressuring mold 15.

[0055] Thus, when the metal tube 1 is flattened by the pressuring molds 12 and 15, vertical pressuring forces F_1 toward the center of the metal tube 1 act on the first parts 1A and 1B of the metal tube 1 as shown in FIG. 3, pressuring forces F_2 taking a slanting direction in response to the radius of curvature of the pressuring surfaces 12A and 15A act 35 on the second parts 1C and 1D of the metal tube 1. These pressuring forces F_2 include pressuring components F_{2H} in the horizontal direction toward the first parts 1A and 1B, which are pressurized by the pressuring force F_1 . Portions generating the above-described pressuring force F_1 out of the pressuring surfaces 12A and 15A are the first pressuring parts pressurizing the first parts 1A and 1B of the metal tube 1 first after starting the descending of the cope 10. Portions generating the above-described pressuring forces F_2 , on both sides of the metal tube 1 in the circumferential direction, sandwiching the first pressuring parts 1A and 1B of the respective pressuring surfaces 12A and 15A are the second 40 pressuring parts pressurizing the metal tube next. The positions of the second pressuring parts shift to positions away from the first parts 1A and 1B in the circumferential direction of the metal tube 1.

[0056] When the metal tube 1 is pressurized by the pressuring molds 12 and 15 as described above, the length in the circumferential direction, the area along which is pressurized by the pressuring molds 12 and 15 on the metal tube 1 is 45 longer than the length of the portions of the pressuring surfaces 12A and 15A of the pressuring molds 12 and 15, on which the length in the circumferential direction abuts, similarly to the case in FIG. 22. Therefore, a compressive load toward the first parts 1A and 1B is generated on both sides of the metal tube 1 in the circumferential direction, sandwiching the first parts 1A and 1B, similarly to the case in FIG. 23. However, the above-described pressuring forces F_2 act on the metal tube 1 at the second parts 1C and 1D which are both parts on both sides of the metal tube 1 in the circumferential 50 direction with respect to the respective first parts 1A and 1B, and these pressuring forces F_2 include pressuring components F_{2H} toward the first portions 1A and 1B. The second parts 1C and 1D are portions on the surface of the metal tube 1 displaced in the inside direction of the metal tube 1 from the first parts 1A and 1B. Accordingly, the first part 1A which is the highest part of the metal tube 1 is pushed up toward the pressuring surface 12A side by the pressuring components F_{2H} of the pressuring forces F_2 acting on the second parts 1C, and the first part 1B which is the lowest part 55 of the metal tube 1 is pushed down toward the pressuring surface 15A side by the pressuring components F_{2H} of the pressuring forces F_2 acting on the second parts 1D. Therefore, the metal tube 1 is flattened without producing a recessed part recessed toward the inside of the metal tube 1.

[0057] As a result, according to the present embodiment, only by providing the pressuring molds 12 and 15 having

curved recessed pressuring surfaces 12A and 15A for pressurizing the metal tube 1, to the cope 10 and the drag 13 which are two pieces of press molds vertically facing each other, it is possible to flatten the metal tube 1 to a prescribed thickness without producing a recessed part. Since there is no need to install a specific member, or device on the pressing unit, it is possible to reduce the manufacturing cost of the whole pressing unit and the flattening costs of the metal tube 1.

[0058] In addition, since the flattening work for a piece of metal tube 1 can be completed by only one time of vertical movement of the cope 10 to the drag 13, it is possible to perform the flattening work in an efficient manner, and to process a large number of metal tubes 1 in a short time.

[0059] In addition, according to the present embodiment, since the pressuring surfaces 12A and 15A of the pressuring molds 12 and 15 separately arranged in the cope 10 and the drag 13 have curved recessed surfaces of the same radius of curvature, it is possible to flatten the metal tube 1 in such a manner that two parts of upper and lower with respect to the tube center axis N_1 , which are molded by the pressuring surfaces 12A and 15A respectively, are formed symmetrical.

[0060] FIGs. 4 and 5 show a cope 20 and a drag 23 relating to a second embodiment. Also in the present embodiment, the cope 20 and the drag 23 include their mold main bodies 21 and 24, and pressuring molds 22 and 25 which are buried and set as a whole in recessed parts 21A and 24A formed in these molds main bodies 21 and 24. However, the pressuring surfaces 22A and 25A of these pressuring molds 22 and 25 are not formed in a curved recessed surface, but they are formed from first flat surfaces 26 and 28 at the center in the horizontal radial direction of the metal tube 1, and second flat surfaces 27 and 29 provided on both sides of the metal tube 1 in the horizontal radial direction, in other words, on both sides of the metal tube 1 in the circumferential direction, with respect to these first flat surfaces 26 and 28. The second flat surface 27 on the pressuring mold 22 of the cope 20 is slanted in a downward direction from the first flat surface 26 while the second flat surface 29 on the pressuring mold 25 of the drag 23 is a slanting surface slanted in an upward direction from the first flat surface 28.

[0061] In the present embodiment, when the cope 20 descends toward the drag 23, the first parts 1A and 1B which are the highest part and the lowest part of the metal tube 1 are pressurized first toward the center of the metal tube 1 by the first flat surfaces 26 and 28 of the pressuring surfaces 22A and 25A, and then, in the cope 20, the second parts 1C that are parts on both sides of the metal tube 1 in the circumferential direction with respect to the first part 1A are pressurized by the second flat surfaces 27 of the pressuring surface 22A, while in the drag 23, the second parts 1D that are parts on both sides of the metal tube 1 in the circumferential direction with respect to the first part 1B are pressurized by the second flat surfaces 29 of the pressuring surface 25A. This pressuring state is shown in FIG. 5.

[0062] Accordingly, in the present invention, first pressuring parts for pressurizing the metal tube 1 first exist on the first flat surfaces 26 and 28 of the pressuring surfaces 22A and 25A, and second pressuring parts which are on both sides of the metal tube 1 in the circumferential direction, sandwiching the first pressuring part exist on the second flat surfaces 27 and 29 of the pressuring surfaces 22A and 25A, for pressurizing the metal tube 1 next. Vertical pressuring forces F_3 toward the center of the metal tube 1 act on the first parts 1A and 1B pressurized by the first pressuring part, and pressuring forces F_4 in a slanting direction in response to tilt angles of the second flat surfaces 27 and 29 act on the second parts 1C and 1D pressurized by the second pressuring parts. These pressuring forces F_4 include horizontal pressuring components F_{4H} toward the first parts 1A and 1B sides, and similarly to the above-described embodiment, the second parts 1C and 1D displace in the inside direction of the metal tube 1 from the first parts 1A and 1B.

[0063] Accordingly, in the present embodiment, it is possible to flatten the metal tube 1 by the pressuring components F_{4H} of the pressuring force F_4 without producing a recessed part recessed toward the inside of the metal tube 1.

[0064] Furthermore, according to the present embodiment, the pressuring surfaces 22A and 25A on the pressuring molds 22 and 25 of the cope 20 and the drag 23 can be formed by combining the first flat surfaces 26 and 28, and the second flat surfaces 27 and 29, and since the work for forming these flat surfaces 26, 27, 28 and 29 on the pressuring molds 22 and 25 is easier than the work for forming curved recessed surfaces on pressuring molds, it is possible to manufacture the pressuring molds 22 and 25 with ease.

[0065] FIG. 6 shows a third embodiment. Also in the present embodiment, the cope 40 and the drag 43 include these mold main bodies 41 and 44, and pressuring molds 42 and 45 which are buried and set in recessed parts 41A and 44A formed in these molds main bodies 41 and 44. These pressuring molds 42 and 45 include a crest part 46 and a trough part 47 for flattening a metal tube 31. Accordingly, the pressuring molds 42 and 45 include parts buried in the recessed parts 41A and 44A, and portions exposed from the recessed parts 41A and 44A.

[0066] FIG. 7 is a cross section showing the time of flattening the metal tube 31 at the position taken along the line S7-S7 in FIG. 6 which is the position corresponding to an unbent part where is not bent in the metal tube 31 and FIG. 8 is a cross section showing the time of flattening the metal tube 31 at the position taken along the line S8-S8 in FIG. 6 which is a position of bent part to be bent in the metal tube 31. As shown in FIGs. 7 and 8, pressuring surfaces 42A and 45A facing the metal tube 31 in the pressuring molds 42 and 45 of the cope 40 and the drag 43 are curved recessed surfaces similarly to the embodiments in FIGs. 2 and 3. These curved recessed surfaces are formed in a radius of curvature greater than that of a circular vertical section with respect to the tube center axis N_2 (refer to FIG. 6) of the metal tube 31 before flattening.

[0067] As clearly understood by the comparison between FIG 7 and FIG. 8, the radius of curvature of the pressuring

surfaces 42A and 45A at portions corresponding to the parts to be bent in the metal tube 31 is smaller than the radius of curvature of the pressuring surfaces 42A and 45A at portions corresponding to the parts not to be bent in the metal tube 31. Thus, the pressuring surfaces 42A and 45A in which the radius of curvature differs between a part to be bent and a part not to be bent, are formed on the pressuring molds 42 and 45 as a smoothly continuous surface.

[0068] It should be noted that though the metal tube 31 in the present embodiment is a bent-tube, the tube center axis N_2 of which is bent a little by preliminary bending conducted in advance as shown in FIG 6, the metal tube which is flattened while being bent in the present invention may be a straight tube, which is not preliminarily bent.

[0069] In the present embodiment, when the cope 40 descends toward the drag 43, at the portions where are not bent in the metal tube 31 shown in FIG. 7, first parts 31A and 31B, which are the highest part and the lowest part of the metal tube 31 in this unbent part, are pressurized toward the center of the metal tube 31 by pressuring forces F_5 from the pressuring surfaces 42A and 45A on the pressuring molds 42 and 45, and then, second parts 31C and 31D, which are the parts on both sides of the metal tube 31 in the circumferential direction with respect to the first parts 31A and 31B, are pressurized by pressuring forces F_6 from the pressuring surfaces 42A and 45A on the pressuring molds 42 and 45. Further, at the portions where are bent in the metal tube 31 shown in FIG 8, third parts 31E and 31F, which are the highest part and the lowest part of the metal tube 31 in this bent part, are pressurized toward the center of the metal tube 31 by pressuring forces F_7 from the pressuring surfaces 42A and 45A on the pressuring molds 42 and 45, and then, fourth parts 31G and 31H, which are the parts on both sides of the metal tube 31 in the circumferential direction with respect to the third parts 31E and 31F are pressurized by pressuring forces F_8 from the pressuring surfaces 42A and 45A on the pressuring molds 42 and 45.

[0070] Accordingly, in the portions of the pressuring surfaces 42A and 45A corresponding to the unbent parts of the metal tube 31, a first pressuring part to apply pressure to the metal tube 31 by the pressuring force F_5 and a second pressuring part to apply pressure by the pressuring force F_6 exist, and in the portions of the pressuring surfaces 42A and 45A corresponding to the bent parts of the metal tube 31, a third pressuring part to apply pressure to the metal tube 31 by the pressuring force F_7 and a fourth pressuring part to apply pressure by the pressuring force F_8 exist.

[0071] The second portions 31C and 31D are displaced from the first parts 31A and 31B in the inside direction of the metal tube 1, while the fourth parts 31G and 31H are displaced from the third parts 31E and 31F in the inside direction of the metal tube 1.

[0072] In the present embodiment, since the pressuring force F_6 of the second pressuring part, and the pressuring force F_8 of the fourth pressuring part are slant pressuring forces in response to the radius of curvature of the pressuring surfaces 42A and 45A, the pressuring force F_6 include pressuring components F_{6H} toward the first portions 31A and 31B sides, and the pressuring force F_8 include pressuring components F_{8H} toward the third portions 31E and 31F sides. As described above, since the radius of curvature of the pressuring surfaces 42A and 45A at the portions corresponding to the bent parts of the metal tube 31 is smaller than the radius of curvature of the pressuring surfaces 42A and 45A at the portions corresponding to the unbent parts of the metal tube 31, the pressuring components F_{8H} of the pressuring force F_8 is greater than the pressuring components F_{6H} of the pressuring force F_6 .

[0073] In FIG 6, since the metal tube 31 is bent by the pressuring molds 42 and 45 of the cope 40 and the drag 43 so as to be protruding downward, an upper side portion 49 at a bent part of the metal tube 31 facing the pressuring mold 42 of the cope 40 is a compressed part compressed in the direction of the tube center axis N_2 as a result of the bending process.

[0074] Since the compressed portion 49 is also a portion to be flattened similarly to the unbent part, a compressive force in the circumferential direction of the metal tube 31 due to the flattening and a compressive force in the direction of the tube center axis N_2 due to the bending are generated. Accordingly, the compressed portion 49 becomes more likely to produce a recessed part recessed toward the inside of the metal tube 31 than the unbent portion.

[0075] However, in the present embodiment, since the pressuring components F_{8H} of the pressuring force F_8 generated by the pressuring molds 42 of the cope 40 are greater than the pressuring components F_{6H} of the pressuring force F_6 , it becomes possible to flatten the metal tube 31 while preventing production of a recessed part owing to the pressuring components F_{8H} established to be so great.

[0076] Furthermore, in the present embodiment, since the pressuring surfaces 42A and 45A on the pressuring molds 42 and 45 of the cope 40 and the drag 43 are curved recessed surfaces with the same radius of curvature in the bent part of the metal tube 31, it is possible to flatten the part to be bent of the metal tube 31 in a manner that the vertical portion with respect to the tube center axis N_2 is made symmetrical. In addition, since the radius of curvature of the pressuring surfaces 41A and 45A are the same, it is possible to flatten even the unbent part of the metal tube 31 in a manner that the vertical portion with respect to the tube center axis N_2 is made symmetrical.

[0077] FIGs. 9 and 10 show a fourth embodiment of flattening the metal tube 31 while bending a portion of the metal tube 31, similarly to the embodiment in FIGs. 6, 7 and 8, in which FIG 9 is a view corresponding to FIG 7, and FIG 10 is a view corresponding to FIG 8. In this embodiment, pressuring surfaces 52A and 55A on the pressuring molds 52 and 55 set in mold main bodies 51 and 54 of a cope 50 and a drag 53 are formed in a combination of a plurality of flat surfaces.

[0078] In other words, the pressuring surfaces 52A and 55A in portions corresponding to the unbent parts of the metal

tube 31 shown in FIG. 9 are formed from first flat surfaces 56 and 58 at the center in the horizontal radial direction of the metal tube 31 and second flat surfaces 57 and 59 arranged on both sides of the metal tube 31 in the horizontal radial direction with respect to these first flat surfaces 56 and 58. The second flat surface 57 on the pressuring mold 52 of the cope 50 is a surface slanting in a downward direction to the horizontal radial direction of the metal tube 31 from the first flat surface 56, and the second flat surface 59 on the pressuring mold 55 of the drag 53 is a slant surface slanting in an upward direction to the horizontal radial direction of the metal tube 31 from the first flat surface 58.

[0079] The pressuring surfaces 52A and 55A at the portion corresponding to a bent part of the metal tube 31 shown in FIG 10 are formed from a third flat surfaces 60 and 62 at the center in the horizontal radial direction of the metal tube 31, and a fourth flat surfaces 61 and 63 arranged on both sides of the metal tube 31 in the horizontal radial direction with respect to these third flat surfaces 60 and 62. The fourth flat surface 61 on the pressuring mold 52 of the cope 50 is a slant surface slanting in a downward direction to the horizontal radial direction of the metal tube 31 from the third flat surface 60, and the fourth flat surface 63 on the pressuring mold 55 of the drag 53 is a slant surface slanting in an upward direction to the horizontal radial direction of the metal tube 31 from the third flat surface 62. The first flat surfaces 56 and 58, and the third flat surfaces 60 and 62 continue smoothly, and the second flat surfaces 57 and 59, and the fourth flat surfaces 61 and 63 continue smoothly.

[0080] The tilt angle of the fourth flat surfaces 61 and 63 to the third flat surfaces 60 and 62 becomes greater than that of the second surfaces 57 and 59 to the first flat surfaces 56 and 58.

[0081] In the present embodiment, when the cope 50 descends toward the drag 53, in the portion not to be bent in the metal tube 31 shown in FIG 9, first portions 31A and 31B, that is the highest part and the lowest part of the metal tube 31, are pressurized toward the center of the metal tube 31 by pressuring forces F_9 from the first pressuring surfaces 56 and 58 on the pressuring molds 52 and 55, and then, second portions 31C and 31D, being the parts on both sides of the metal tube 31 in the circumferential direction with respect to the first portions 31A and 31B, are pressurized by pressuring forces F_{10} from the second flat surfaces 57 and 59 on the pressuring molds 52 and 55. Further, in the portion to be bent in the metal tube 31 shown in FIG 10, third portions 31E and 31F, that is the highest part and the lowest part of the metal tube 31, are pressurized toward the center of the metal tube 31 by pressuring forces F_{11} from the third flat surfaces 60 and 62 on the pressuring molds 52 and 55, and then, fourth portions 31G and 31H being the portions on both sides of the metal tube 31 in the circumferential direction with respect to the third portions 31E and 31F are pressurized by pressuring forces F_{12} from the fourth flat surfaces 61 and 63 on the pressuring molds 52 and 55.

[0082] Accordingly, in the portions of the first flat surfaces 56 and 58 corresponding to the unbent parts of the metal tube 31, a first pressuring part to apply pressure to the metal tube 31 by the pressuring force F_9 exists; in the portions of the second flat surfaces 57 and 59, a second pressuring part to apply pressure by the pressuring force F_{10} exists respectively; in the portions of the third flat surfaces 60 and 62 corresponding to the bent parts of the metal tube 31, a third pressuring part to apply pressure to the metal tube 31 by the pressuring force F_{11} exists; and in the fourth flat surfaces 61 and 63, a fourth pressuring part to apply pressure to the metal tube 31 by the pressuring force F_{12} exists respectively. The pressuring force F_{10} generated at the second pressuring part includes pressuring force F_{10H} toward the first portions 31A and 31B, and the pressuring force F_{12} generated at the fourth pressuring part includes a pressuring force F_{12H} toward the third portions 31E and 31F.

[0083] Since the tilt angle of the fourth flat surfaces 61 and 63 to the third flat surfaces 60 and 62 becomes greater than that of the second surfaces 57 and 59 to the first flat surfaces 56 and 58, the pressuring component F_{12H} of the pressuring force F_{12} is greater than the pressuring component F_{10H} of the pressuring force F_{10} . In addition, the second portions 31C and 31D are displaced from the first portions 31A and 31B in the inside direction of the metal tube 1, while the fourth parts 31G and 31H are displaced from the third parts 31E and 31F in the inside direction of the metal tube 1.

[0084] Accordingly, also in the present embodiment, it becomes possible to flatten the metal tube 31 while preventing production of a recessed part similarly to the embodiment shown in FIGs. 6, 7 and 8.

[0085] A fifth embodiment will be explained next. FIG 11 shows a metal tube 71 before flattening in the present embodiment, and FIG 12 shows a metal tube 71' after the flattening, in other words, a metal tube product manufactured by a device and a method for elliptically processing a metal tube capable of flattening the metal tube 71 relating to the present embodiment. The flattened metal tube 71' is for the use of a brake pedal arm for a four wheeled vehicle.

[0086] As shown in FIG 11, the metal tube 71 before flattening includes a large diameter part 72 having an enlarged diameter by diameter enlarging, and a small diameter part 73 which is not subject to diameter enlarging and smoothly connecting with the large diameter part 72. The large diameter part 72 is bent at an angle of θ_1 with respect to the small diameter part 73, and an end part 73A of the small diameter part 73 on the opposite side of the large diameter 72 is bent in a direction different from the angle θ_1 . These diameter enlarging and bending are conducted before flattening as a preliminary processing. A vertical section with respect to the tube center axis N_3 of the metal tube 71 at an arbitrary position in the direction of the tube center axis N_3 of the metal tube 71 before flattening is circular, similarly to the hitherto embodiments.

[0087] As shown in FIG. 12, the metal tube 71' after flattening is flattened at the large diameter part 72 and most of the small diameter part 73 except the end part 73A have been flattened, and a portion between the large diameter part

72 and the small diameter part 73 is bent at an angle θ_2 larger than the angle θ_1 . The reason that the end part 73A of the small diameter part 73 is not flattened is that if the end part 73A is flattened at the time of cutting the end part 73A of the metal tube 71' with a cutter 74 moving in the direction orthogonal to the tube center axis N_3 in order to set the full length of the metal tube 71' after flattening to be predetermined, the execution of the cutting processing becomes difficult, and if a vertical section with respect to the tube center axis N_3 of the end part 73A is maintained to be circular, it is possible to cut it easily without crushing and deforming the end part 73A with the cutter 74.

[0088] FIG. 13 is a cross section showing the principal portions of the parts of a cope 80 and a drag 83 of a press device serving as a flattening device for the metal tube 71 relating to the present embodiment, and FIG. 14 is an arrow diagram taken along the line S14-S14 in FIG. 13, and FIG. 15 is a cross section of the principal portions of the parts of the cope 80 and the drag 83 after flattening the metal tube 71. As shown in FIG. 13, the cope 80 and the drag 83 being press molds include mold main bodies 81 and 84, and pressuring molds 82 and 85 which are buried and set in recessed parts 81A and 84A formed in these molds main bodies 81 and 84. The surfaces of these pressuring molds 82 and 85 facing the metal tube 71 are pressuring surfaces 82A and 85A to pressurize the metal tube 71 for the purpose of flattening the metal tube 71, excepting portions 82B and 85B facing the end part 73A of the small diameter part 73 of the metal tube 71.

[0089] Among the surfaces facing the metal tube 71 of the pressuring molds 82 and 85, the portions 82B and 85B facing the end part 73A of the small diameter part 73 are curved recessed surfaces having the same radius of curvature as that of the cross section of the end part 73A before flattening. Therefore, as shown in FIG. 15, the mold main body 81 of the descended cope 80 abuts on the mold main body 84 of the drag 83 to perform closing of the molds, and when flattening of the metal tube 71 is completed by this closing, the peripheral surface of the end part 73A is in a state of merely surrounded by these curved recessed surfaces 82B and 85B, so that the end part 73A is not flattened by the pressuring molds 82 and 85.

[0090] The pressuring molds 82 and 85 include first parts 86 and 88 for flattening the large diameter part 72 of the metal tube 71 and second parts 87 and 89 for flattening the small diameter part 73 excepting the end part 73A, and the second parts 87 and 89 are slanting parts slanted in an upward direction from the horizontal first parts 86 and 88. Thereby, the metal tube 71 is flattened, and at the same time, it is bent at the angle of θ_2 between the large diameter part 72 and the small diameter part 73.

[0091] In addition, in the present embodiment, since the thickness of the large diameter part 72 after flattening is sufficiently small compared with the diameter of the large diameter part 72 before flattening, a core member 90 is installed in the press device in the present embodiment in such a manner that the core member 90 is structured to be inserted in the inside of the large diameter part 72 of the metal tube 71 set on the pressuring mold 85 of the drag 80 when the cope 80 descends toward the drag 83 by a predetermined distance, and the flattening of the large diameter part 72 is progressed to a predetermined extent. The core member 90 is devised to move back and forth toward the metal tube 71 by a driving means, such as a slide cam means driven by a vertical movement of the cope 80, or a hydraulic cylinder, and as shown in FIG. 13, a guide bush 91 for guiding the core member 90 back and forth is installed in a rising wall 84B of the above-described recessed part 84A formed in the mold main body 84 of the drag 83 on the core member 90 side, and in the inside of a portion corresponding to the thickness of the rising wall 84B for the purpose of burying and setting the pressuring mold 85.

[0092] As shown in FIG. 13, flattening of the metal tube 71 by the cope 80 and the drag 83 is initiated after setting the metal tube 71 on the pressuring mold 85 of the drag 83 by abutting an end face 72A of the large diameter part 72 which is the end face in the direction of the tube center axis N_3 of the metal tube 71 on the above-described rising wall 84B. Upon descent of the cope 80, the large diameter part 72 and the small diameter part 73 excepting the end part 73A of the metal tube 71 are flattened by the pressuring surfaces 82A and 85A of the pressuring molds 82 and 85. The flattening of the large diameter part 72 is conducted while the core member 90 is inserted in the inside of the metal tube 1.

[0093] After the cope 80 starts descending and flattening of the metal tube 71 is initiated, insertion of the core member 90 is started by inserting it into the inside of the metal tube 71 from the end face 72A. Then, the core member 90 is inserted into the length extent of the large diameter part 72 which is at the midpoint of the full length of the metal tube 71 before the large diameter part 72 is molded to a predetermined cross sectional shape by the pressuring molds 82 and 85.

[0094] Flattening of the metal tube 71 is conducted while the metal tube 71 is bent at an angle of θ_2 between the large diameter part 72 and the small diameter part 73, and a third pressuring part and a fourth pressuring part are provided in portions of the pressuring surfaces 82A and 85A on the pressuring molds 82 and 85, which correspond to the bent parts of the metal tube 71, similarly to the embodiment shown in FIGs. 7 and 8, and the embodiment shown in FIGs. 9 and 10. Furthermore, a first pressuring part and a second pressuring part are provided in the portions of the pressuring surfaces 82A and 85A on the pressuring molds 82 and 85, which correspond to the small diameter part 73 being an unbent part of the metal tube 71, similarly to the embodiment shown in FIGs. 7 and 8, and the embodiment shown in FIGs. 9 and 10. The pressuring force generated in the fourth pressuring part includes a pressuring component toward the pressurized side by the pressuring force of the third pressuring part, and the pressuring force generated in the second

pressuring part includes a pressuring component toward the pressurized side by the pressuring force of the first pressuring part. Since the pressuring component of the pressuring force of the fourth pressuring part is greater than the pressuring component of the pressuring force of the second pressuring part, the bent part of the metal tube 71 can be flattened and bent without producing a recessed part recessed in the inside of the metal tube 71.

[0095] A portion corresponding to the large diameter part 72 between the pressuring surfaces 82A and 85A of the pressuring molds 82 and 85 is a portion for flattening the large diameter part 72 until the inside surface of the metal tube 71 comes into contact with the core member 90.

[0096] Since the flattening and the bending of the metal tube 71 described above is performed while the whole of the metal tube 71 except the end part 73A of the small diameter part 73 is compressed, the full length of the metal tube 71' after flattening increases in the direction of the tube center axis N_3 by displacement of material pads of the metal tube 71 due to the compression. Since the flattening and the bending of the metal tube 71 in the present embodiment is conducted by abutting an end face 72A in the direction of the tube center axis N_3 of the metal tube 71 on the rising wall 84B, the increase in the full length of the metal tube 71 is achieved while blocking displacement of the end face 72A in the outside direction of the tube center axis N_3 .

[0097] That is, in the present invention, the rising wall 84B serves as an end face displacement controlling part to restrict displacement of the end face 72A in the outside direction of the tube center axis N_3 , and therefore, an increase in the full length of the metal tube 71 appears as an extension toward the other side in the direction of the tube center axis N_3 . When the full length of the metal tube 71 is increased toward the other side in the direction of the tube center axis N_3 as above, the peripheral surface of the end part 73A of the small diameter part 73 on the extension side is surrounded by the above-described curved recessed surfaces 82B and 85B of the pressuring molds 82 and 85 when the flattening is completed as shown in FIG. 15, and since the radius of curvature of these curved recessed 82B and 85B are the same as the radius of curvature of the cross section of the small diameter part 73 of the metal tube 71 before flattening, the end part 73A can maintain a circular cross section similar to that of the tube not to be flattened.

[0098] Accordingly, the work to cut the end part 73A with the cutter 74 in FIG. 12 for the purpose of suitably making the metal tube 71' after the flattening, which is taken out from after opening of the cope 80 and the drag 83 suitable full length can be easily performed as determined.

[0099] It should be noted that the flattening of the metal tube 71 by descending of the cope 80 and the cutting of the end part 73A may be performed simultaneously by installing the cutter 74 on the cope 80.

[0100] FIG 16 shows a sixth embodiment in which drilling of three holes is conducted in the large diameter part 72 of the metal tube 71 when flattening and bending of the metal tube 71 is performed. On the cope 80 in the present embodiment, three punching members 92, 93 and 94 are installed in the downward direction and guide holes 90A, 90B and 90C to guide the punch members 92, 93 and 94 are formed in the core member 90. Accordingly, holes 95, 96 and 97 are formed in the large diameter part 72 by the punch members 92, 93 and 94 descending while guided by these guide holes 90A, 90B and 90C in the metal tube 71' which is manufactured from the metal tube 1 by flattening and bending.

[0101] By this structure, processing of the holes 95, 96 and 97 required when the metal tube 71' is used as the above-described brake pedal arm can be performed at the same time when the metal tube 71' is manufactured from the metal tube 71.

[0102] It should be noted that although the punch members 92, 93 and 94 in FIG. 16 are arranged in the mold main body 81 and the pressuring mold 82 of the cope 80, it is possible to form the holes 95, 96 and 97 in the large diameter part with the three punch members by a descent of the above-described separating mold just after forming the large diameter part 72 into a predetermined cross section with the pressuring molds 82 and 85, and the core member 90, by, for instance, installing a separate type mold which is separated from the mold main body 81 and descends with delay from descending of the mold main body 81 in the cope 80, and by disposing three punch members on the separate type mold.

[0103] FIG. 17 is a plan view showing a brake pedal arm 100 for a four-wheeled vehicle, which is prepared from the metal tube 71' manufactured in the embodiment in FIG. 16, and a brake pedal 110 attached to the arm 100, and FIG 18 is a side view of the arm 100 and brake pedal 110. The arm 100 is prepared by cutting the end part 73A of the small diameter part 73 of the metal tube 71' with the above-described cutter 74, and the brake pedal 110 is attached to the cut end part. The arm 100 is bent at the angle of θ_2 shown in FIG. 12 by bending with the pressuring molds 82 and 85 in FIG. 16, as shown in FIG 17. Making use of this angle of θ_2 , it is possible to ensure the space to arrange crucial members such as a steering shaft in a four-wheeled vehicle to be close to the arm 100.

[0104] As shown in FIG 18, the arm 100 includes a large dimensional part 101 which has a large vertical dimension, and a small dimensional part 102 which is smaller in the vertical dimension than the large dimensional part 101, and by the above-described flattening, the large dimensional part 101 is formed from the above-described large diameter part 72, while the small dimensional part 102 is formed from the small diameter part 73. The flattening is conducted leaving a hollow in the inside of the arm 100, and the hollow portion is continuous over the full length of the arm 100. The above-described holes 95, 96 and 97 are provided in the large dimensional part 101, in which the hole 95 is used to connect a link member 111 for connecting a toggle of brake master cylinder and the arm 100 with the arm 100, the hole 96 is

used to insert a horizontal pivot center axis 112 of the arm 100, and the hole 97 is used to connect a return spring 113 for imparting a return force to the arm 100 when it pivots downward around the pivot center axis 112 with the arm 100.

[0105] FIG. 19 is a cross section taken along the line S19-S19 at a small dimensional part 102 of the arm 100 shown in FIG. 18, and FIG 20 is a cross section taken along the line S20-S20 at a large dimensional part 101 of the arm 100 shown in FIG 18. As shown in FIG. 19, two surfaces 102A facing each other in the lateral direction of the small dimensional part 102 are convex surfaces protruding by curving outward due to the flattening explained in the description of the small dimensional part 102, while two surfaces 101A facing each other in the lateral direction of the large dimensional part 101 are, as shown in FIG 20, flat surfaces parallel to each other, because the flattening explained in the description of the large dimensional part 101 is conducted till the inner surface of the large dimensional part 101 comes into contact with the above-described core member 90.

[0106] The vertical dimension of the small dimensional part 102 is H_1 , while the vertical dimension of the large dimensional part 101 is H_2 , in which H_2 is larger than H_1 . A great load generated upon depressing a brake pedal 110 downward to brake a four wheeled vehicle is acted on the arm 100, and the bending moment generated in the arm 100 by this load is the greatest at the portion where the hole 96 which the pivot center axis 112 of the arm 100 is horizontally inserted through is formed. In the present embodiment, this part corresponds to the large dimensional part 101 having the vertical dimension greater than that of the small dimensional part 102. Since the section modulus of a horizontal neutral axis of the large dimensional part 101 is made larger than the section modulus of a horizontal neutral axis of the small dimensional part 102 owing to the above structure, it is possible to make the strength of the arm 100 with respect to the bending moment sufficiently great.

[0107] FIG 21 shows a large dimensional part 101' of another embodiment. In the present embodiment, two surfaces 101'A facing each other in the lateral direction of the large dimensional part 101' are convex surfaces similar to the two surfaces 102A of the small dimensional part 102 in FIG. 19. According to the present embodiment, although the vertical dimension H_3 of the large dimensional part 101 is smaller than H_2 , it becomes possible to mold the large dimensional part 101' without using the above-described core member 90 to be inserted until it reaches the midpoint of the full length of the metal tube.

[0108] Note that work to form the above-described holes 95, 96 and 97 in the large dimensional part 101' is to be conducted after conducting the above-described flattening and bending as an after processing.

Industrial Availability

[0109] The present invention can be used for manufacturing a member to be used as, for instance, a brake pedal arm of a four wheeled vehicle or the like by flattening of a metal tube.

Claims

1. A device for elliptically processing a metal tube capable of flattening the metal tube having two press molds facing each other, and flattening said metal tube having a circular vertical section to the center axis of the tube by pressurizing with said two press molds, wherein
at least one press mold out of said two press molds comprises:

a first pressuring part pressurizing a first portion being a part of the surface of said metal tube toward the center of the metal tube; and

a second pressuring part being a pressuring part existing on both sides of said metal tube in the circumferential direction, sandwiching the first pressuring part, pressurizing second parts on the metal tube surface, which are displaced in the inside direction of said metal tube from the first part while generating a pressuring component toward the first portion side.

2. The device for elliptically processing a metal tube capable of flattening the metal tube according to claim 1, wherein a surface on said one press mold facing said metal tube is a surface including a curved recessed surface having a radius of curvature greater than said vertical section of said metal tube, and said first pressuring part and said second pressuring part are arranged on the curved recessed surface.

3. The device for elliptically processing a metal tube capable of flattening the metal tube according to claim 1, wherein a surface on said one press mold facing said metal tube is a surface including at least one flat surface, and one pressuring part out of said first pressuring part and said second pressuring part is provided on the one flat surface.

4. The device for elliptically processing a metal tube capable of flattening the metal tube according to claim 1, wherein

said first and second pressuring parts are provided on both of said two press molds.

5 5. The device for elliptically processing a metal tube capable of flattening the metal tube according to claim 4, wherein the magnitude of said pressuring components generated by said second pressuring parts on both of said two press molds are the same.

6. The device for elliptically processing a metal tube capable of flattening the metal tube according to claim 1, wherein said two press molds are molds for bending a part of the metal tube while flattening said metal tube.

10 7. The device for elliptically processing a metal tube capable of flattening the metal tube according to claim 6, wherein said first pressuring part and said second pressuring part are pressuring parts for pressurizing an unbent part where said metal tube is not bent; wherein a press mold facing a compressed side of said metal tube compressed by at least said bending, out of said two press molds, comprises: a third pressuring part for pressurizing a third part to be a portion on the surface of
15 said metal tube toward the center of the metal tube; and fourth pressuring parts being pressuring parts existing on both sides of said metal tube in the circumferential direction, sandwiching the third pressuring part, pressurizing the fourth parts on the surface of the metal tube which are displaced in the inside direction of said metal tube from said third part while generating a pressuring component toward said third part side; and wherein said pressuring components of the pressuring force of the fourth pressuring parts are made greater than
20 said pressuring component of pressuring force of said second pressuring part.

8. The device for elliptically processing a metal tube capable of flattening the metal tube according to claim 7, wherein a surface facing said metal tube on said press mold provided with said third pressuring part and said fourth pressuring part is a surface including a curved recessed surface having a radius of curvature greater than said vertical section
25 of said metal tube, and said third pressuring part and said fourth pressuring part are provided on the curved recessed surface.

9. The device for elliptically processing a metal tube capable of flattening the metal tube according to claim 7, wherein a surface facing said metal tube on said press mold provided with said third pressuring part and said fourth pressuring part is a surface including at least one flat surface, and one pressuring part out of said third pressuring part and said
30 fourth pressuring part is provided on the one flat surface.

10. The device for elliptically processing a metal tube capable of flattening the metal tube according to claim 7, wherein said third pressuring part and said fourth pressuring part are provided to both of said two press molds.
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11. The device for elliptically processing a metal tube capable of flattening the metal tube according to claim 10, wherein the magnitude of said pressuring components of the pressuring force of said fourth pressuring parts on both of said two press molds are the same.

40 12. The device for elliptically processing a metal tube capable of flattening the metal tube according to claim 1, further comprising:

an end face displacement controlling part for restricting outward displacement of one end face of the metal tube in the direction of said tube center axis by abutment of one end face of the metal tube in the direction of said
45 tube center axis on said controlling part,

wherein respective surfaces on said two press molds facing the peripheral surface of the other end part of the metal tube in the direction of the tube center axis are formed in a curved recessed surface having the same radius of curvature as that of said other end part having a circular vertical section with respect to said tube center axis; and
50 wherein the peripheral surface of said other end part at the time of completion of the flattening of said metal tube by said two press molds is surrounded by these curved recessed surfaces, and said other end part is cut by a cutter transferring in the direction perpendicular to said tube center axis after completion of the flattening.

13. The device for elliptically processing a metal tube capable of flattening the metal tube according to claim 12, wherein at least one press mold out of said two press molds comprises a mold main body and a pressuring mold having at least one portion buried in the mold main body; and
55 wherein said end face displacement controlling part is served as a rising wall formed in said mold main body for the purpose of burying at least one portion of said pressuring mold.

14. The device for elliptically processing a metal tube capable of flattening the metal tube according to claim 1, further comprising:

5 a core member inserted until it reaches the midpoint of the full length of the metal tube from one end part of the metal tube in the direction of the tube center axis toward the inside of said metal tube, when said metal tube is flattened with said two press molds.

15. The device for elliptically processing a metal tube capable of flattening the metal tube according to claim 14, wherein one press mold out of said two press molds is provided with at least one punch member for performing drilling in said metal tube; and
10 a guide hole for guiding said punch member is formed in said core member.

16. A metal tube product manufactured by the device for elliptically processing a metal tube capable of flattening the metal tube according to claim 1.
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17. The metal tube product according to claim 16, wherein said metal tube product is used as a brake pedal arm for vehicles.

18. A method for elliptically processing a metal tube capable of flattening the metal tube for flattening said metal tube by pressurizing the metal tube having a circular vertical section with respect to the tube center axis by two press molds facing each other, comprising:
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25 a first pressurizing step for pressurizing a first part being a portion of the surface of said metal tube toward the center of the metal tube by said two press molds, and

a second pressurizing step for pressurizing second parts which are on both sides of said metal tube in the circumferential direction with respect to said first part, and on the surface of the metal tube displaced in the inside direction of said metal tube from said first part, while generating pressuring components toward said first part side by at least one press mold out of said two press molds.

19. The method for elliptically processing a metal tube capable of flattening the metal tube according to claim 18, further comprising a step of:
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35 inserting a core member until it reaches the midpoint of the full length of the metal tube from one end part of the metal tube in the direction of the tube center axis toward the inside of said metal tube.

20. The method for elliptically processing a metal tube capable of flattening the metal tube according to claim 19, further comprising a step of:

40 drilling a hole in said metal tube with a punch member installed at least one in one press mold out of said two press molds and guided by a guide hole formed in said core member.

21. A metal tube product manufactured according to the method for elliptically processing a metal tube capable of flattening the metal tube according to claim 18.

22. The metal tube product according to claim 21, wherein said metal tube product is used as a brake pedal arm for vehicles.
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23. A metal tube product formed from a flattened metal tube still keeping a hollow part in the inside thereof, and used as a brake pedal arm for vehicles.
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24. The metal tube product according to claim 23, wherein said hollow part is continuous over the full length of said metal tube.

25. The metal tube product according to claim 23, comprising:
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a large dimensional part having a large vertical dimension; and
a small dimensional part having a vertical dimension smaller than said large dimensional part,

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wherein said large dimensional part is provided with a hole, which the pivot center axis of said brake pedal arm is horizontally inserted through.

5 **26.** The metal tube product according to claim 25, wherein two surfaces facing each other in the lateral direction of said large dimensional part are flat surfaces parallel to each other.

27. The metal tube product according to claim 25, wherein the two surfaces facing each other in the lateral direction of said large dimensional part are convex surfaces protruding by curving outward.

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FIG.1

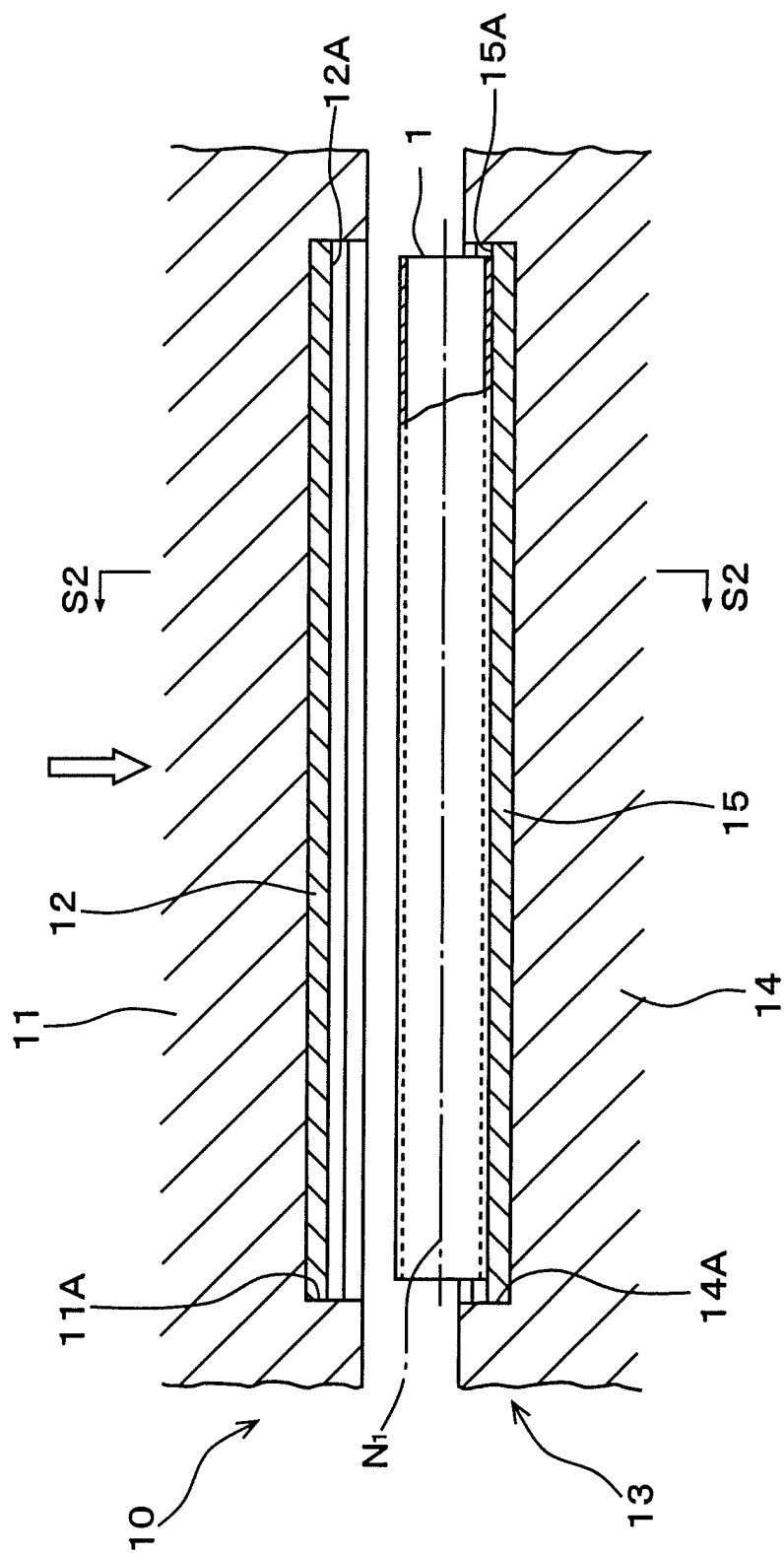


FIG.2

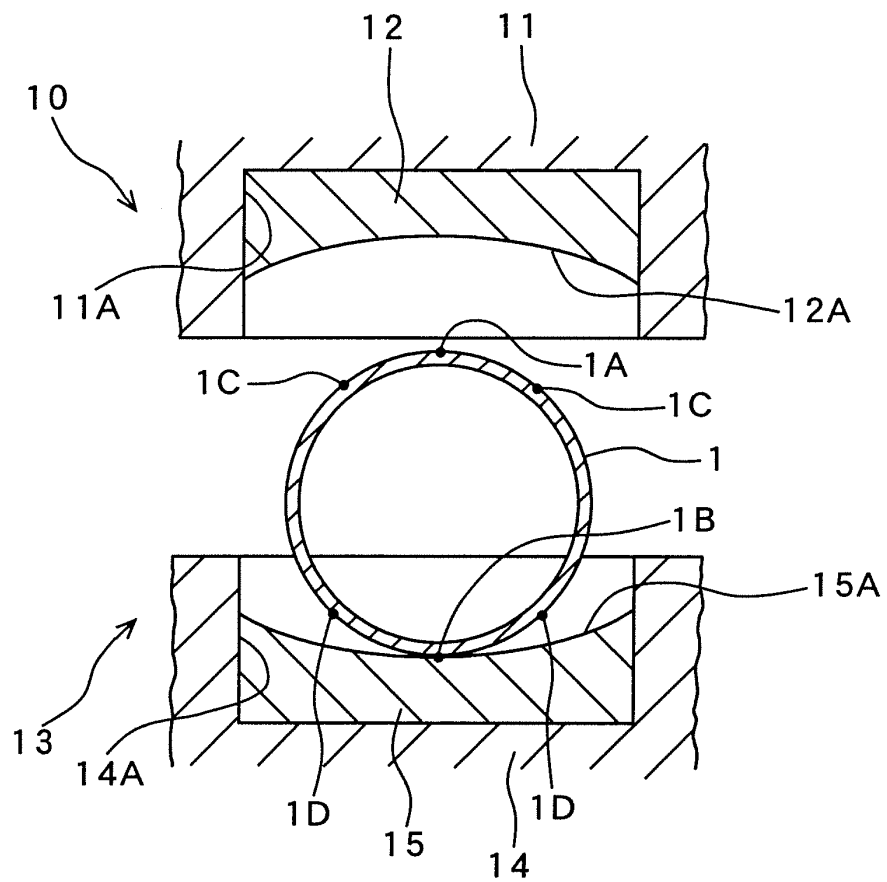


FIG. 3

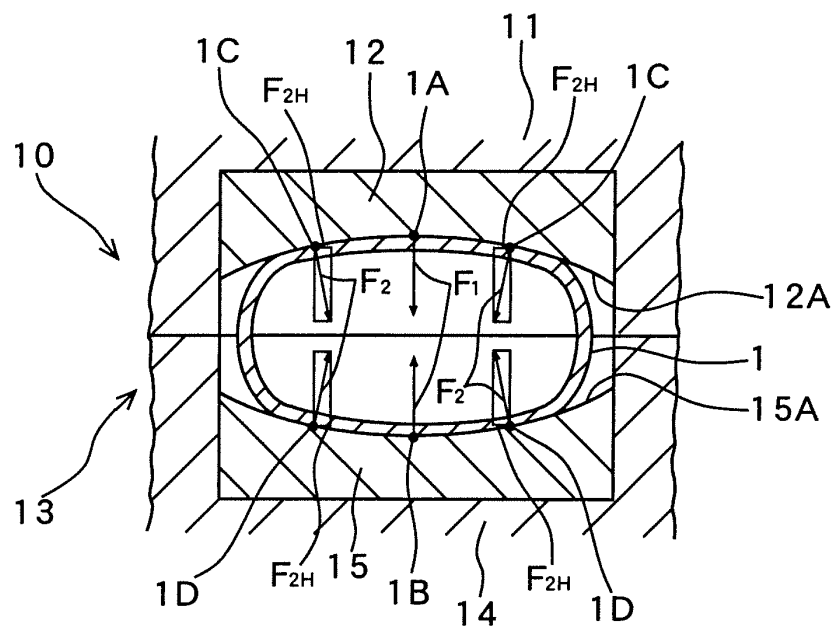


FIG.4

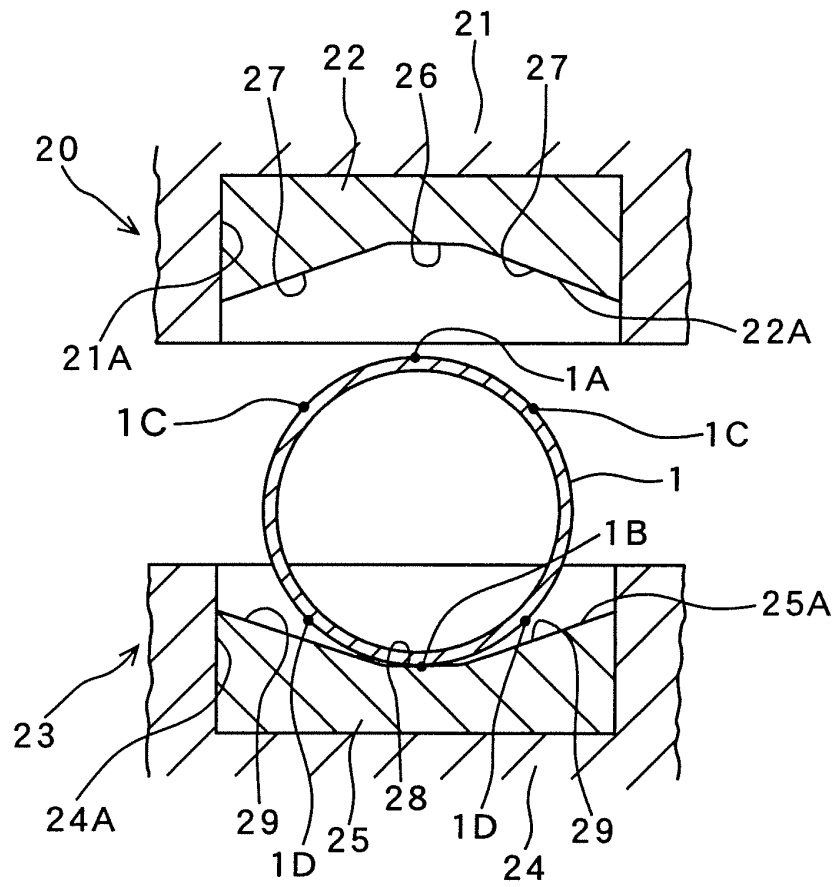


FIG.5

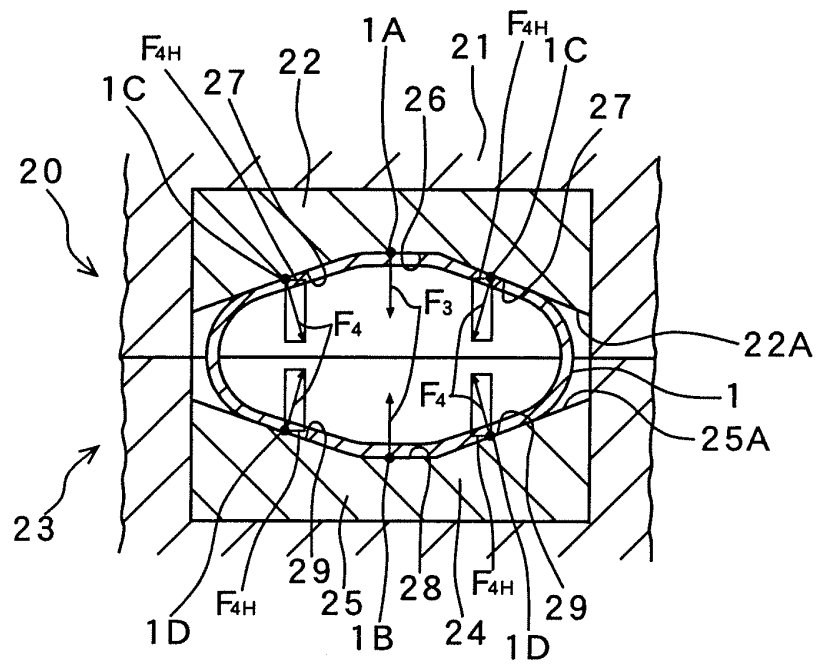


FIG. 6

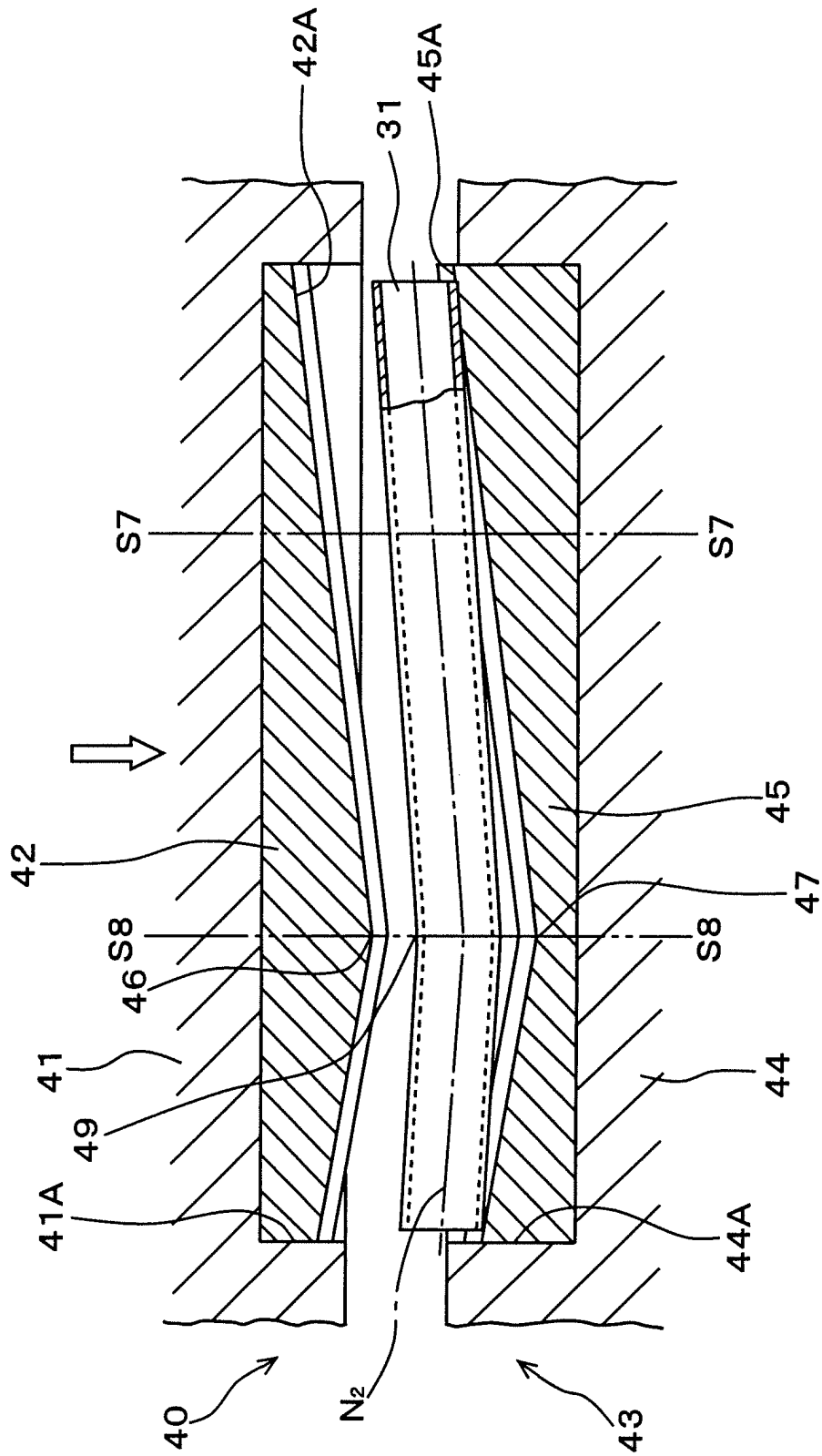


FIG.7

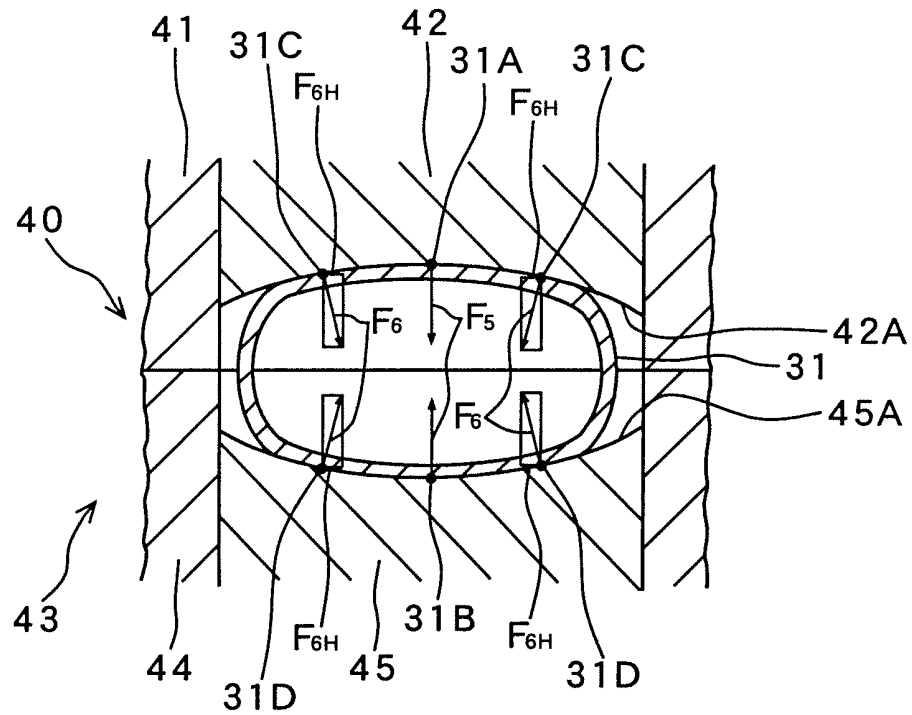


FIG.8

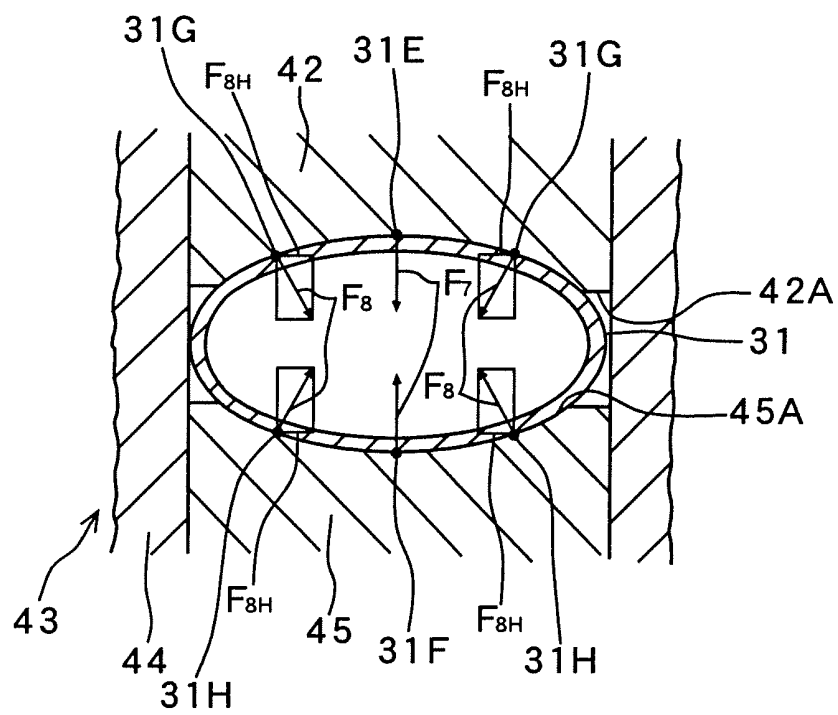


FIG.9

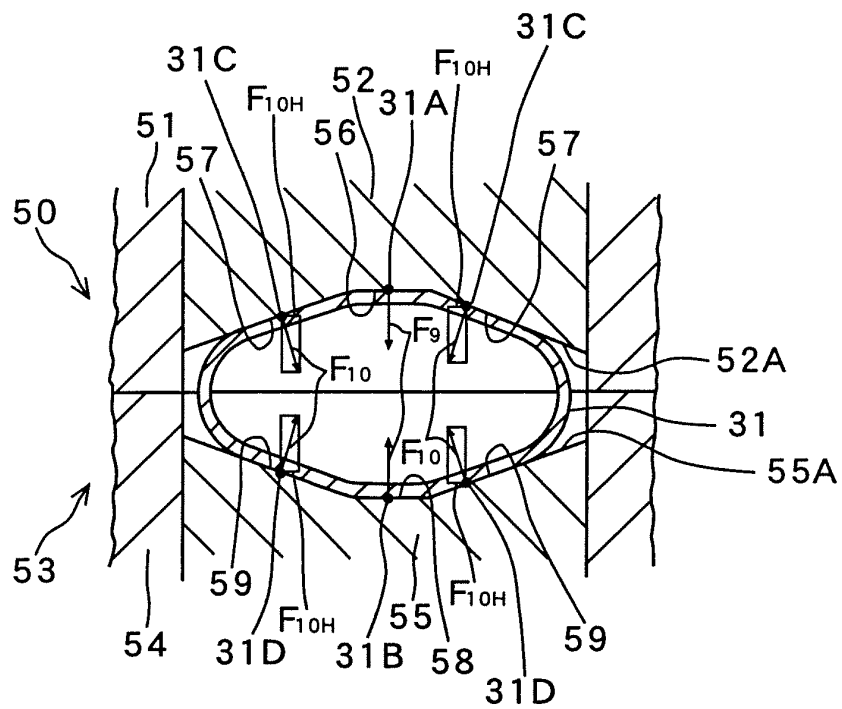


FIG. 10

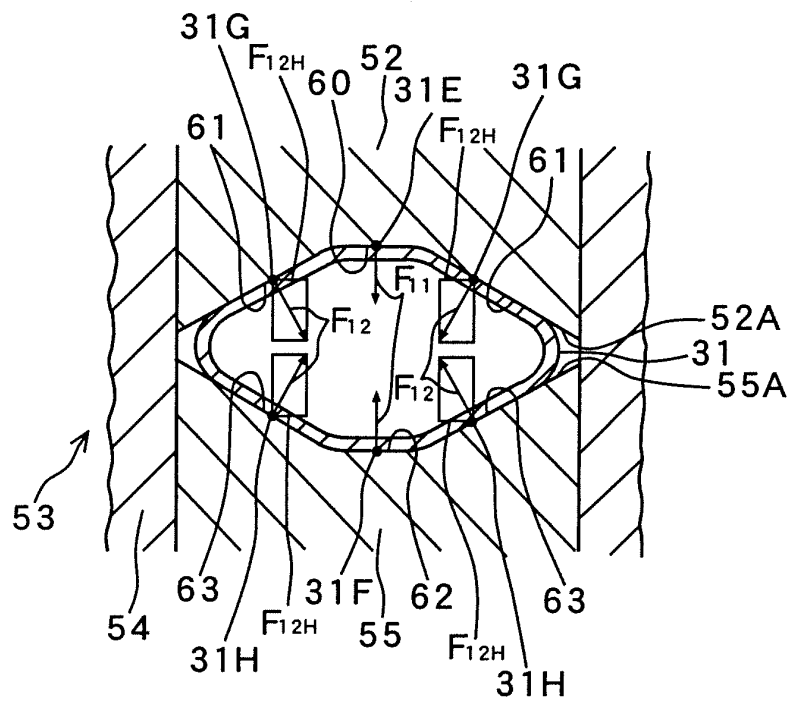


FIG.11

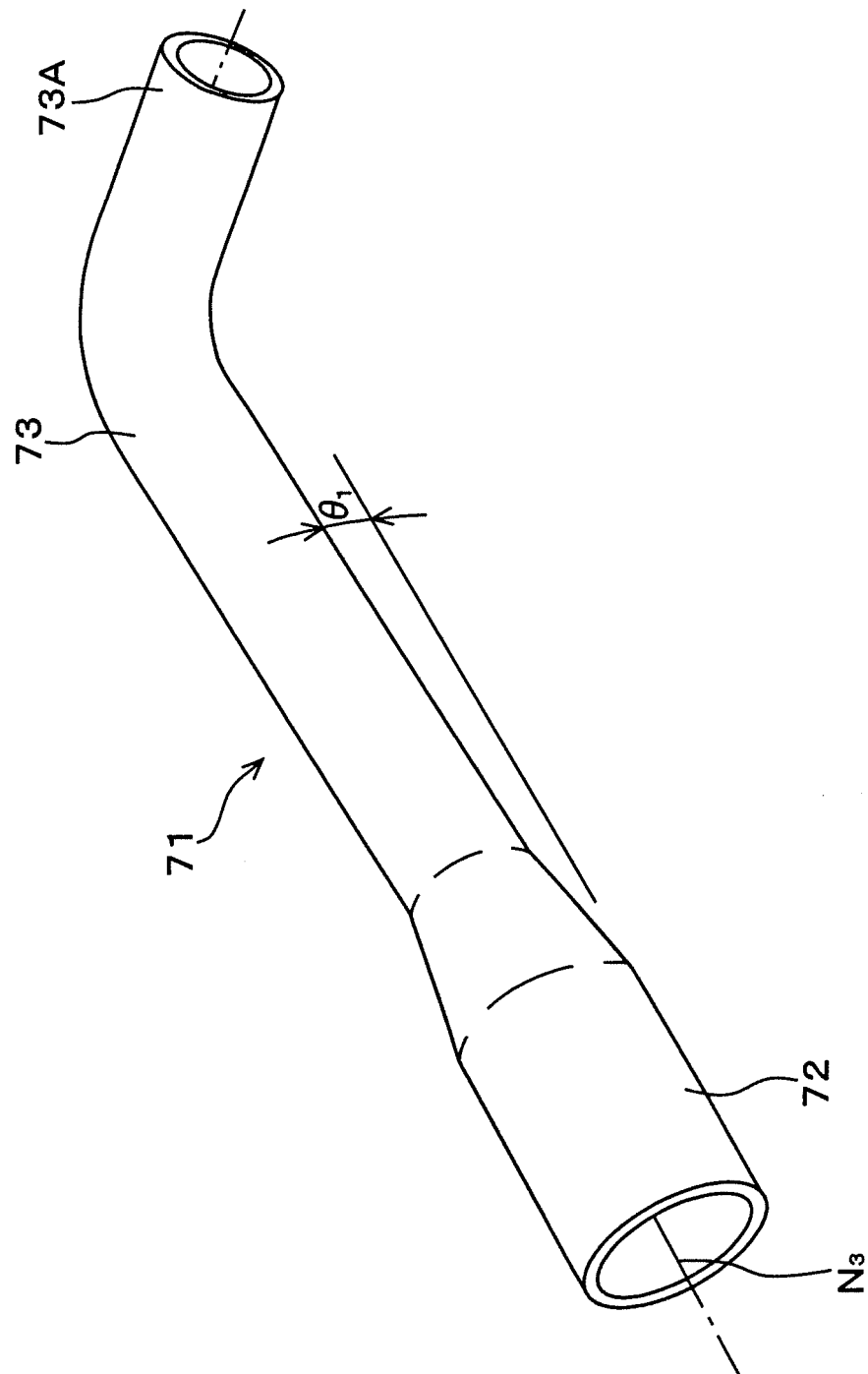


FIG.12

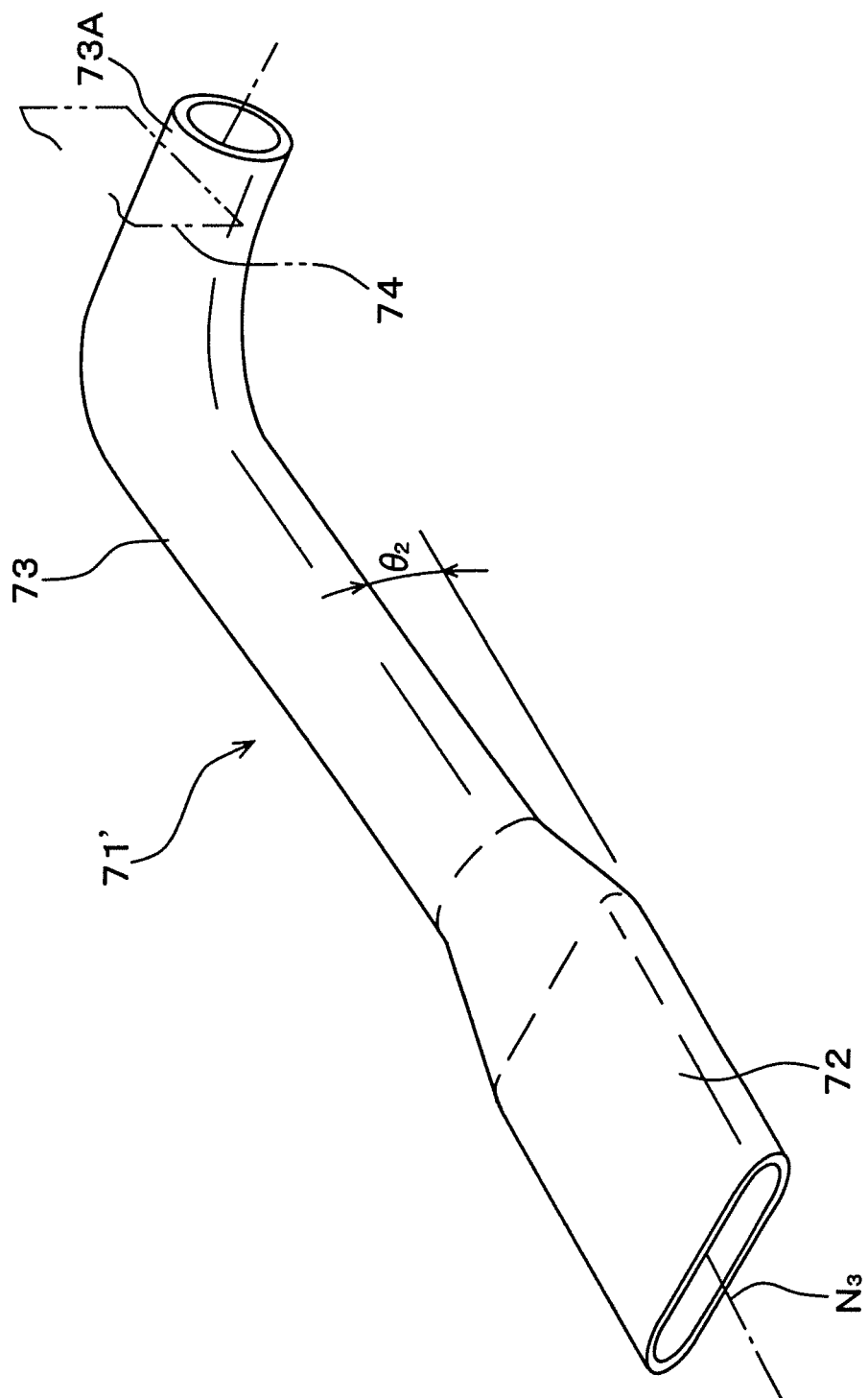


FIG.13

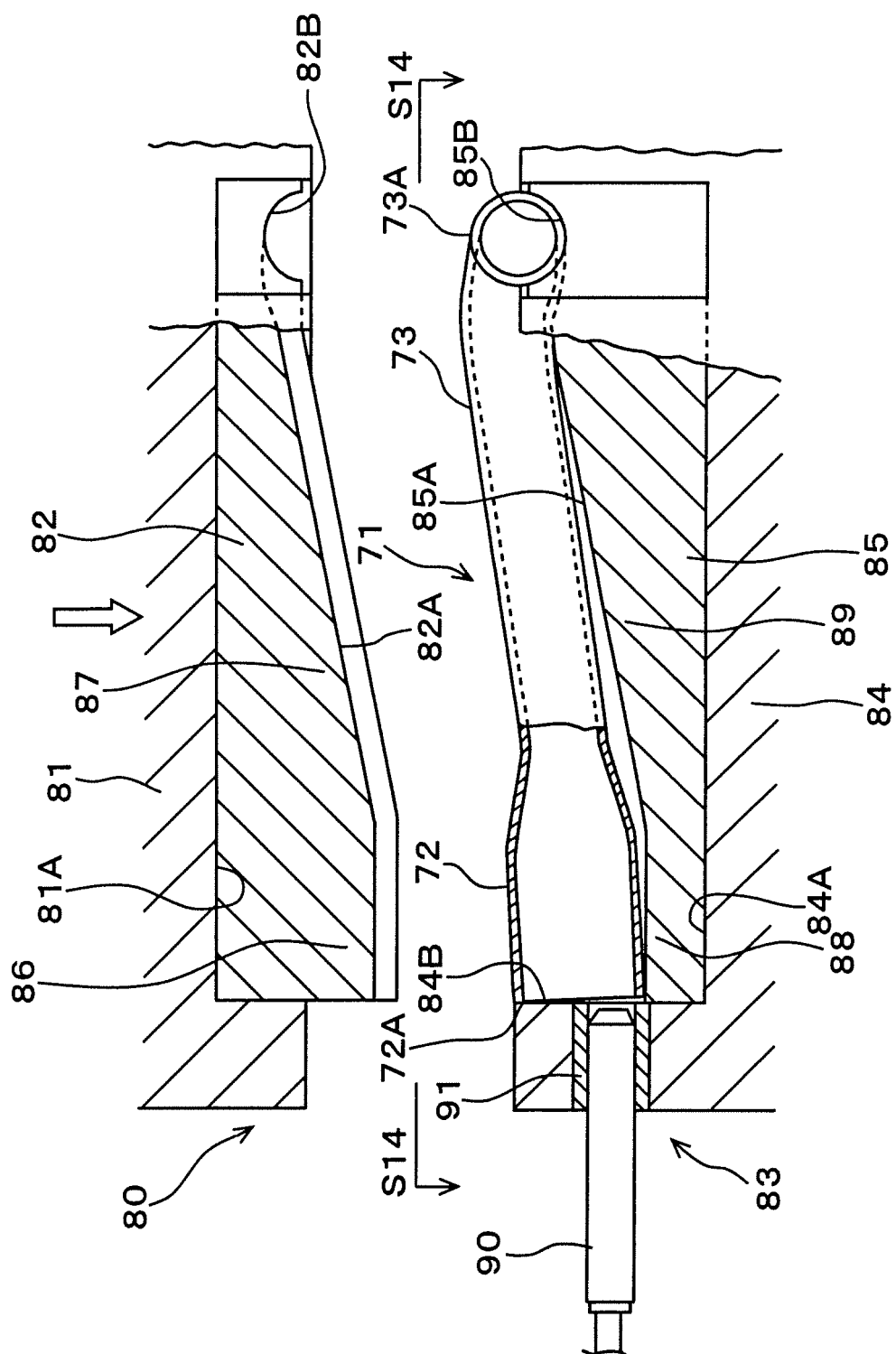


FIG.14

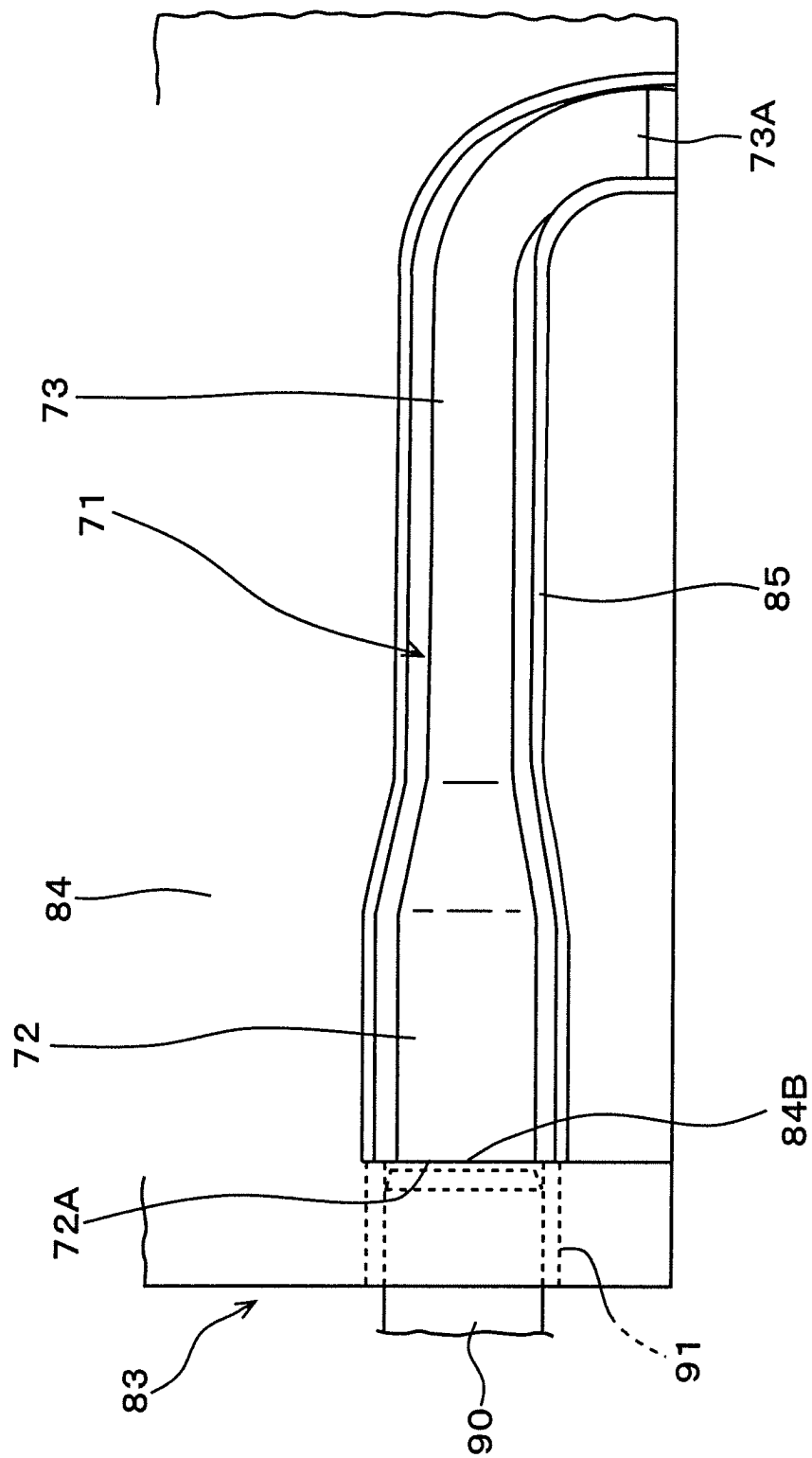


FIG.15

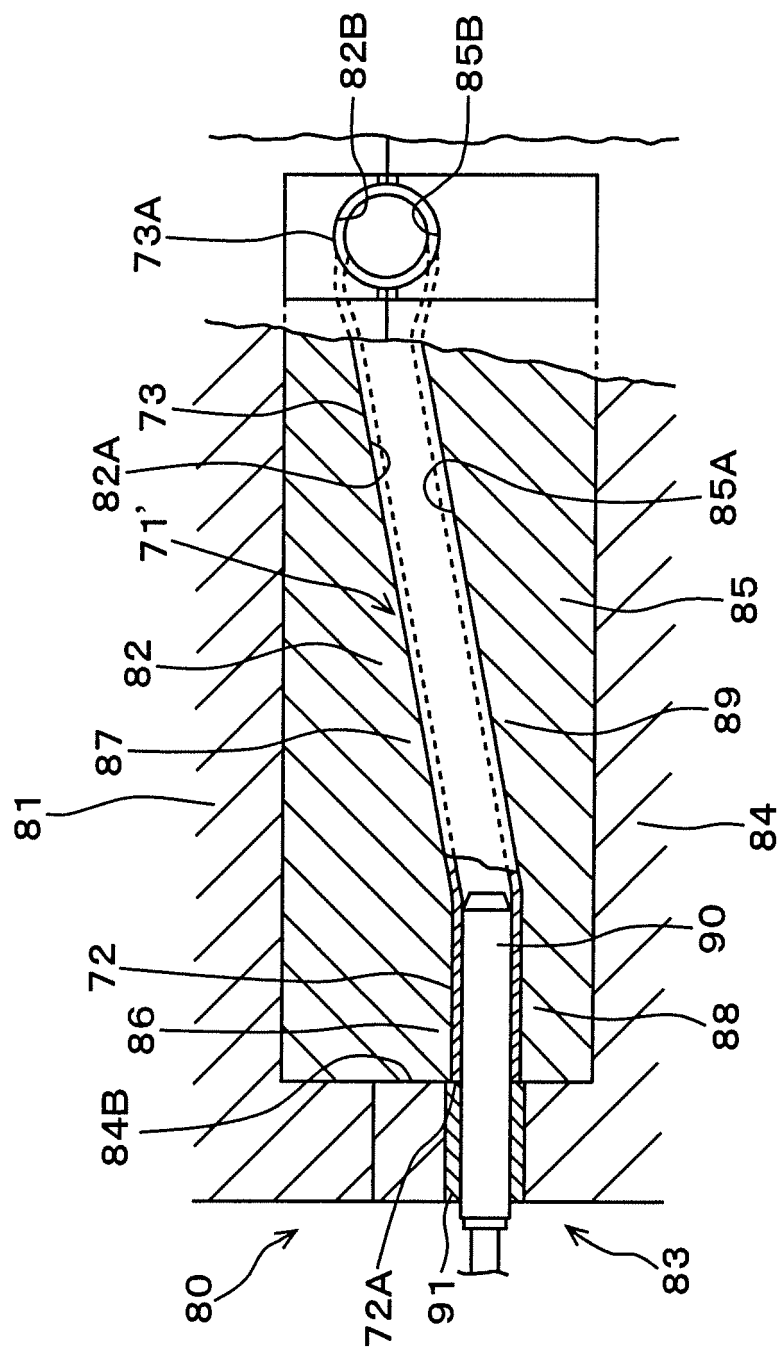


FIG.16

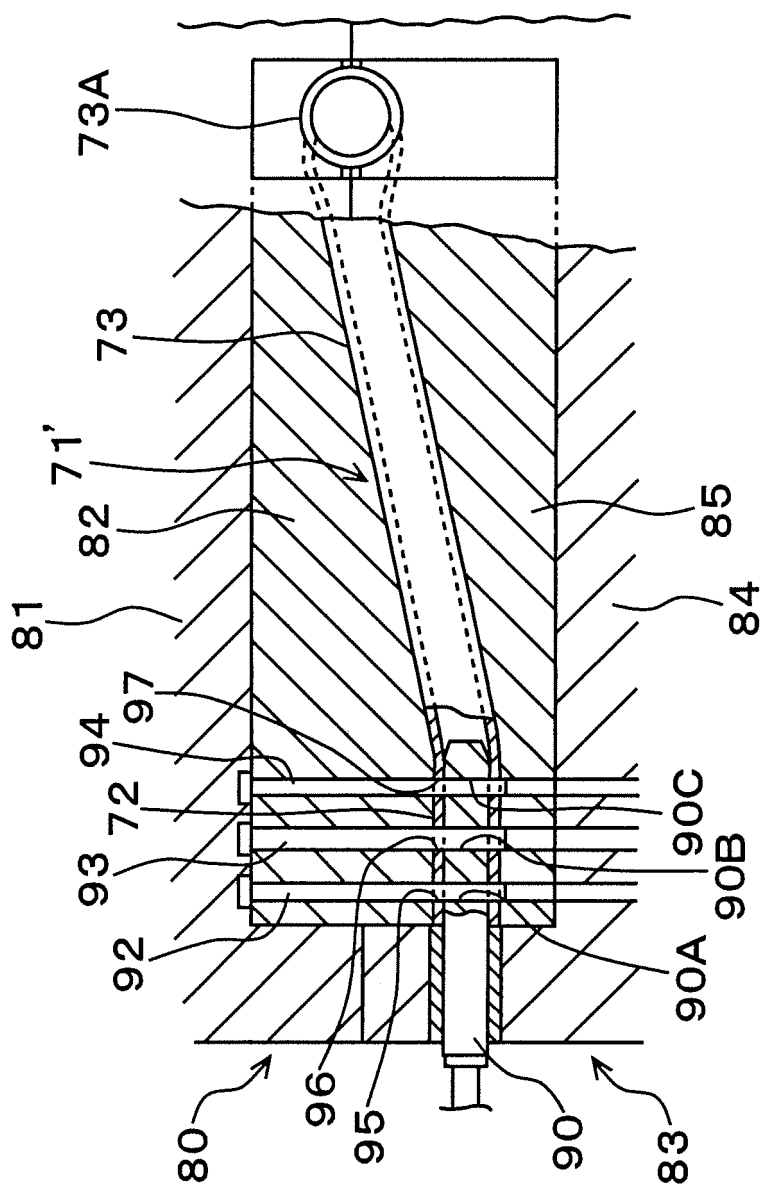


FIG.17

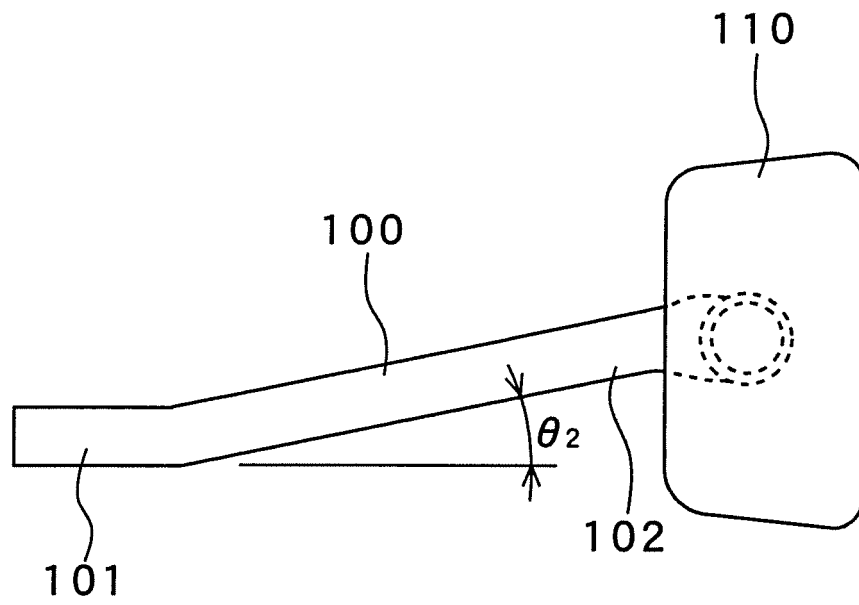


FIG.18

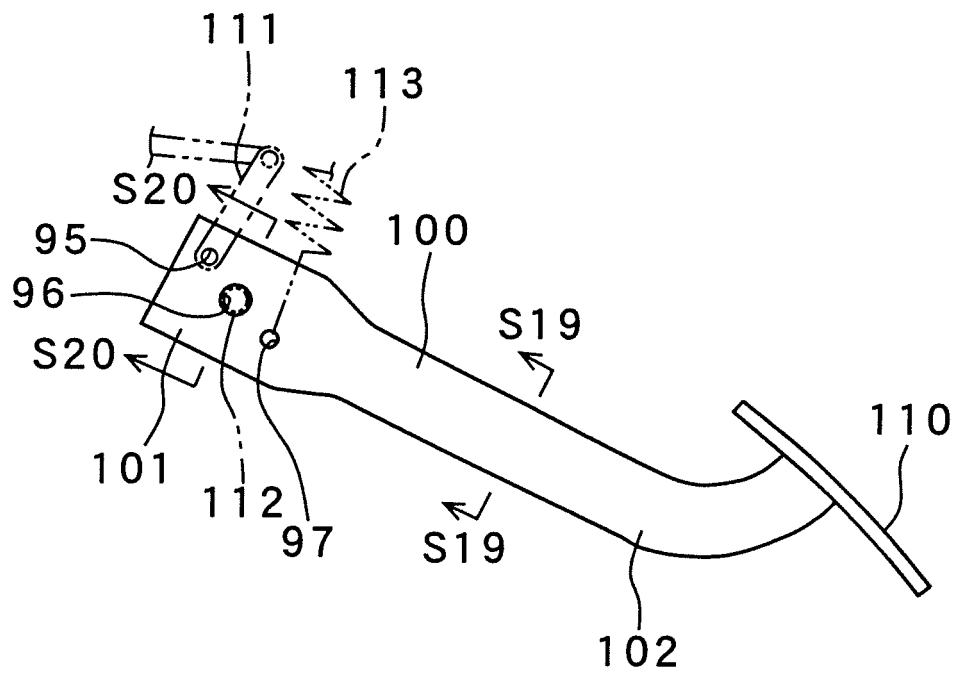


FIG.19

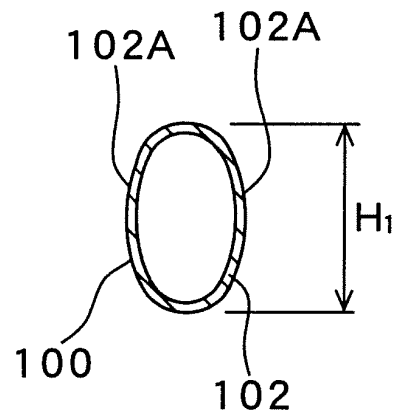


FIG.20

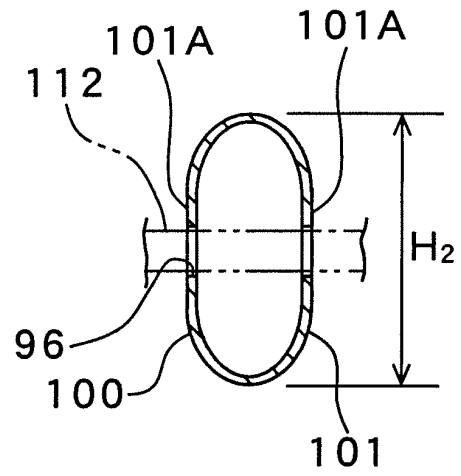


FIG.21

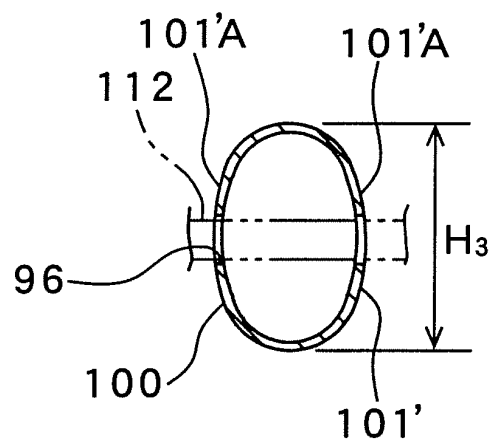


FIG.22

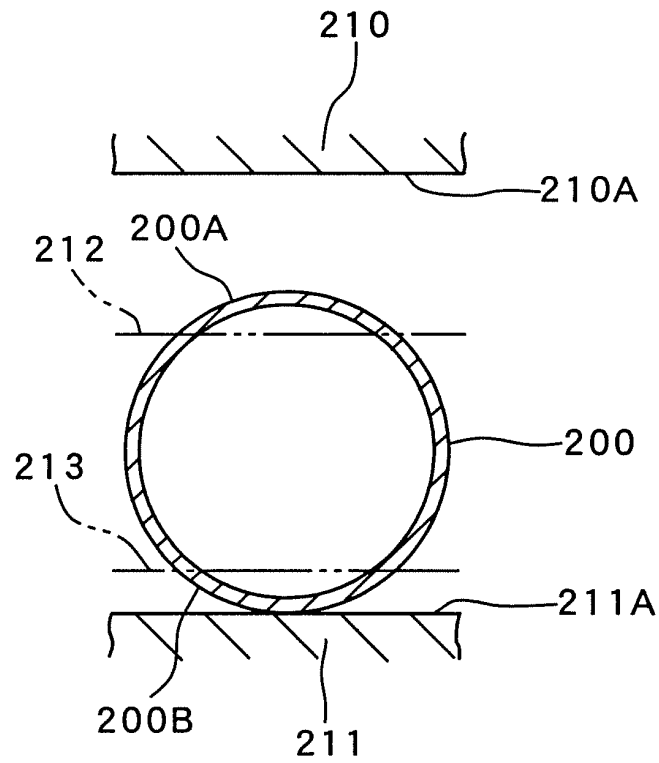
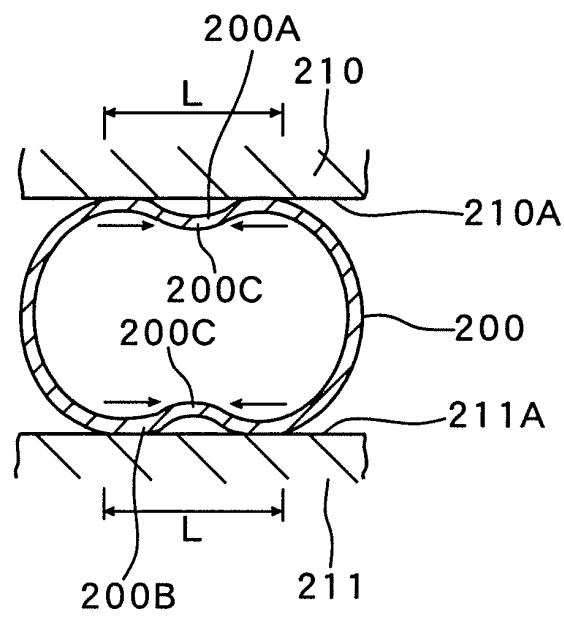


FIG.23



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2006/306136

A. CLASSIFICATION OF SUBJECT MATTER

B21D51/16(2006.01), B21D53/88(2006.01)

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B21D51/16, B21D53/88

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

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2006

Kokai Jitsuyo Shinan Koho 1971-2006 Toroku Jitsuyo Shinan Koho 1994-2006

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2001-208490 A (Hitachi Cable, Ltd.), 03 August, 2001 (03.08.01), Par. No. [0016]; Fig. 4(A)	1-2, 4-5, 16, 18, 21
Y		6, 14, 19
A	(Family: none)	3, 7-13, 15, 20
Y	JP 49-40272 A (Sanyo Kinzoku Kabushiki Kaisha), 15 April, 1974 (15.04.74), Full text; Figs. 2 to 3 (Family: none)	6
Y	JP 7-178470 A (Kabushiki Kaisha Yutaka Giken), 18 July, 1995 (18.07.95), Full text; Figs. 2 to 7 (Family: none)	14, 19

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

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Date of the actual completion of the international search
06 June, 2006 (06.06.06)Date of mailing of the international search report
13 June, 2006 (13.06.06)Name and mailing address of the ISA/
Japanese Patent Office

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2006/306136

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 10-264784 A (Mitsubishi Agricultural Machinery Co., Ltd.), 06 October, 1998 (06.10.98), Par. No. [0019]; Figs. 3 to 10 (Family: none)	17, 22-24
Y	JP 2000-35029 A (Tokai Rubber Industries, Ltd.), 02 February, 2000 (02.02.00), Par. Nos. [0045] to [0049]; Figs. 10, 11 & GB 2358001 A & WO 2000/004296 A1 & DE 19983388 A1	17, 22-24
A	JP 11-78817 A (Futaba Sangyo Co., Ltd.), 23 March, 1999 (23.03.99), Full text; Fig. 8 (Family: none)	17, 22-27

Form PCT/ISA/210 (continuation of second sheet) (April 2005)

REFERENCES CITED IN THE DESCRIPTION

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