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(56) References cited:
GB-A- 1 547 685
JP-A- 8 327 266
JP-A- 9 068 394
JP-A- 10 015 619
JP-A- 60 247 426

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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a V-shaped metal strip and to a formed strip such as a roll formed strip according to the preambles of claims 1 and 5 respectively, and to a bending method for bending such a strip (see for example JP-A-09068394).

[0002] In particular, the present invention relates to a stage for forming tubes in a production system for producing heat exchangers for air conditioners, including stages for producing header pipes by press working to form a flat sheet or plate to a cylindrical shape, for producing U-shaped holders by roll forming from a metal strip, for inserting, in each holder, an inner fin formed by press forming or roll forming, for forming tubes, such as heat exchanger tubes, from each holder, for forming corrugated outer fins by a corrugate cutter, and for assembling heat exchanger tubes, outer fins, and header pipes.

[0003] Tubes for conveying a fluid such as refrigerant is widely used in heat exchange devices such as a condenser of a refrigeration cycle for a motor vehicle, an evaporator and a radiator. In one production method, a refrigerant tube is formed by bending a flat metal strip.

SUMMARY OF THE INVENTION

[0004] When a metal tube is formed by applying pressure from both sides on a V-shaped metal strip until a V-shaped cross section is converted into a closed elongate cross section, the closure and joining of both edges of the open V-shaped cross section into the closed cross section is not easy because of undesired springback due to compressive stresses on the inner side of the curved portion of the metal strip and tensile stresses on the outer side. Moreover, springback tends to degrade the accuracy of the U-shaped or V-shaped cross section formed by bending operation.

[0005] It is therefore an object of the present invention to provide a V-shaped metalstrip and a formed strip which can be made securely into a tube with no or little influence of springback.

[0006] It is another object of the present invention to provide a bending method which can bend a strip accurately with no or little influence of springback

[0007] It is still another object of the present invention to provide a method for forming flanged strips of different sizes in a manner reducing the production cost.

[0008] According to a first aspect of the present invention, a V-shaped metal strip and a formed metal strip with the features of claims 1 and 5 respectively are proposed.

[0009] According to a second aspect of the present invention, a bending method of bending a metal strip from a flat shape into a folded shape having an approximately U-shaped cross section comprises a preceding bending step and a following bending step, according to claim 10 is proposed.

[0010] A bending method for forming a folded metal strip according to a preferred embodiment of the invention may comprise a sequence of bending steps, each for applying two parallel pushing forces on a metal strip at two application points toward a V-shaped groove forming an angle. The distance between the two application points and the angle of the V-shaped groove are decreased step by step in the sequence of the bending steps.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011]

Fig. 1 is an enlarged sectional view showing a part of a formed metal strip according to a first aspect of the present invention.

Figs. 2A ~ 2D are views for illustrating a sequence of steps for producing a tube from the formed metal strip of Fig. 1.

Figs. 3 ~ 9are sectional views showing seven forming roll sets used in one production method for producing the formed metal strip shown in Fig. 1.

Fig. 10 is a schematic view showing one half of a metal strip bent step by step by the roll pairs shown in Figs. 3 ~ 9.

Fig. 11 is a sectional view showing a metal strip having fold lines produced by the roll pairs shown in Figs. 3 ~ 9.

Fig. 12 is a front elevation of a roll set of a common roll 104 and a first selected roll 102 for forming flanges in a strip according to one method according to the present invention.

Fig. 13 is an enlarged view showing a part of the roll set of Fig. 12.

Fig. 14 is an enlarge view showing a roll set of the common roll 104 and a second selected roll 102'.

Fig. 15 is an enlarge view showing a roll set of the common roll 104 and a third selected roll 102".

Figs. 16A, 16B and 16C are views for showing flanged strips formed, respectively, by the roll sets of Figs. 13, 14 and 15.

DETAILED DESCRIPTION OF THE INVENTION

[0012] Fig. 1 shows a formed or folded metal strip 1 for serving as a material for forming a metal tube having an elongated cross section according to the present invention. The metal strip 1 is made of metallic material, such as aluminum or aluminum alloy, light in weight and superior in heat conductivity.

[0013] The formed metal strip 1 shown in Fig. 1 has a V-shaped cross section extending in a widthwise direction from an open lateral end 2 to a closed lateral end 6 as shown in Fig. 2A. In this example, the formed metal strip 1 has first and second (or left and right) flanges 3

terminating, respectively, at first and second (or left and right) edges 31 of the formed metal strip 1. In the state of Fig. 2A, the first and second flanges 3 are separated from each other and define a gap of the open end 2 extending in a longitudinal direction from a first longitudinal end of the formed strip 1 to a second longitudinal end.

[0014] The folded metal strip 1 has first and second (or left and right) side portions or side walls 34 and a U-shaped curved portion 4 connecting the first and second side portions 34 to form the V-shaped cross section. In this example, the first and second side portions 34 are substantially flat, and diverge, respectively, from first and second ends of the U-shaped portion 4 so as to form a V shape in cross section.

[0015] The U-shaped curved portion 4 has an outside U-shaped surface 4a and an inside U-shaped surface 4b. Only the inside U-shaped surface 4b is formed with a plurality of fold lines P which extend in the longitudinal direction of the metal strip 1 and which are arranged in a circumferential direction of the U-shaped inside surface 4b. The inside surface 4b is bent along each of the fold lines P. Along each fold line P, two surface regions meet and form an angle such as an obtuse angle.

[0016] The fold lines P are located away from an imaginary median plane O bisecting the V-shaped cross section of the V-shaped metal strip 1. In Fig. 1, the imaginary median plane appears as a center line O. Moreover, in the example of Fig. 1, there are formed three pairs of fold lines. The first pair consists of left and right (or first and second) outer fold lines P1 which are arranged substantially in a manner of bilateral symmetry with respect to the median plane O. The second pair consists of left and right (first and second) intermediate fold lines P2 arranged symmetrically in the manner of bilateral symmetry with respect to the median plane O . The third pair consists of left and right (or first and second) inner fold lines P3 arranged symmetrically in the manner of bilateral symmetry with respect to the median plane O. The distance between the left and right outer fold lines P1 is greater than the distance between the left and right intermediate fold lines P2. The height (or distance) of the outer fold lines P1 from the bottom end 6 of the formed metal strip 1 is greater than the height (or distance) of the intermediate fold lines P2. The distance between the left and right inner fold lines P3 is smaller than the distance between the left and right intermediate fold lines P2. The height (or distance) of the inner fold lines P3 from the bottom end 6 of the formed metal strip 1 is smaller than the height (or distance) of the intermediate fold lines P2.

[0017] The formed metal strip 1 can be formed into the V shape by roll forming or extrusion. In the case of roll forming, a metal strip is bent progressively by a sequence of a first step for bending the strip along each of the outer fold lines P1, a second step of further bending the strip along each of the intermediate fold lines P2 and a third step of further bending the strip along the inner fold lines P3. In the case of extrusion, the cross sectional shape of Fig. 1 is obtained by setting the shape of a die.

[0018] The formed metal strip 1 can be used as a material for forming a metal tube T for conveying a fluid such as a refrigerant for a heat transfer device such as a condenser. In this case, the metal tube T can be formed as shown in Figs. 2A ~ 2D. First, the formed metal strip 1 and an inner fin 5 are prepared as shown in Fig. 2A. Second, the inner fin 5 is inserted into the formed metal strip 1 from the gap at the open end 2 of the formed metal strip 1. The inner fin 5 of this example is a corrugated strip of the same material as the metal strip 1 and extending in a widthwise direction from a first lateral end to a second lateral end. In the inserted state, one lateral end reaches the bottom of the V-shaped inside cavity of the formed metal strip 1. Third, the V-shaped metal strip 1 is deformed with a press forming machine (not shown) by applying a predetermined pressure F from both sides in the thickness direction of the formed strip into a closed cross sectional shape, as shown in Fig. 2. In this closed state, the left and right edges 3 of the formed metal strip 1 are brought into contact with each other, and the left and right flanges 31 are superposed together. Then, the superposed flanges 31 are compressed tightly and joined together by staking or caulking, for example. The inner fin 5 is fixedly confined in the closed metal tube T, as shown in Fig. 2D.

[0019] In the operation with the press forming machine for further bending the formed metal strip 1 having the V-shaped cross section into the shape having the closed elongate cross section by applying pressure from both sides as shown in Fig. 2C, each of the fold lines P serves as an axis of bending, and promotes bending deformation of the metal strip 1. Moreover, internal stresses in the U-shaped portion 4 are distributed among the fold lines P, so that the fold lines P function to reduce springback. The reduction of springback facilitates the conversion of the metal strip from the V-shaped cross section to a desired closed elongate cross section, and further facilitates the operation of fixing the flanges 3 together by brazing or welding, for example, in the later finishing step.

[0020] The fold lines P are formed only in the inside U-shaped surface 4b, and the outside U-shaped surface 4a remains in the form of a smooth curved surface. Therefore, the outside of the U-shaped portion 4 of the metal tube T has a good appearance free of irregularities and flaws.

[0021] In the example of Fig. 1, the fold lines P1, P2 and P3 are arranged symmetrically on both sides of the imaginary median plane O. The symmetrical arrangement helps prevent stress concentration at the median plane, and prevents bending deformation along the median plane which could cause a crack. Moreover, the symmetrical arrangement of the fold lines P promotes symmetrical folding of the metal strip and secures the desirable shape free from crush, and shape errors.

[0022] The formed metal strip 1 can be used as a material for forming a refrigerant tube having an inner fin

for a condenser as mentioned before, and as a material for forming a refrigerant tube for an evaporator and a radiator with the same effects.

[0023] Figs. 3 ~ 9 shows 7 roll forming machines (or mills) 11 each having a roll set or roll pair, used in a production process according to the present invention for producing a formed metal strip as shown in Fig. 1. The production process of this example includes a sequence of seven roll bending steps or passes. Fig. 3 shows a first forming roll set 11a for the first bending step or pass. Fig. 4 shows a second forming roll set 11b for the second bending step or pass. Similarly, Figs. 5, 6, 7, 8 and 9 show, respectively, third, fourth, fifth, sixth and seventh forming roll sets 11c, 11d, 11e, 11f and 11g for the third, fourth, fifth, sixth and seventh bending steps.

[0024] Each roll set 11(11a ~ 11g) includes a concave roll 12(12a ~ 12g) with a circumferential rim formed with a V-shaped groove 13(13a ~ 13g), and a convex roll 15 (15a ~ 15g) with a circumferential rim formed with a ridge 16(16a ~ 16g) projecting radially toward the deepest middle of the V-shaped groove of the mating concave roll. In the example shown in Figs. 3 ~ 9, each roll has a shape of bilateral symmetry. An imaginary median plane divides the concave and convex rolls of each pair into left and right equal halves.

[0025] Each of the V-shaped grooves 13a ~ 13g of the concave rolls 12a ~ 12g has first and second (left and right) sloping surfaces 14(14a ~ 14g) defining a spread angle θ (θa ~ θg) of the V-shaped groove as shown in Figs. 3 ~ 9. In this example, each sloping surface is a conical surface and appears as a straight line segment in the sectional views of Figs. 1 ~ 9. The spread angle is decreased gradually step by step in the order of the seven bending steps of the sequence. The spread angle θb of the second bending step shown in Fig. 4 is smaller than the spread angle θa of the first bending step of Fig. 3. The spread angle θc of the third bending step shown in Fig. 5 is smaller than the spread angle θb of the second bending step of Fig. 4. Thus, $\theta a > \theta b > \theta c > \theta d > \theta e > \theta f > \theta g$.

[0026] Each of the ridges 16a ~ 16g of the convex rolls 15a ~ 15g has first and second (left and right) edges 17 (17a ~ 17g) confronting the first and second (left and right) sloping surfaces of the mating concave roll. In this example, the ridge 16 of each convex roll is in the form of a flange defined between first and second (left and right) flat surfaces extending radially. The first edge is formed between the first flat surface and a circumferential surface of the flange, and the second edge is formed between the second flat surface and the circumferential surface of the flange. The width of the ridge 16 measured along the axial direction defines an axial width of pressure application. The width of the ridge 16 is decreased gradually step by step in the order of the seven bending steps of the sequence. The width Lb of the second bending step shown in Fig. 4 is smaller than the width La of the first bending step of Fig. 3. The width Lc of the third bending step shown in Fig. 5 is smaller than the width Lb of the second bending step of Fig. 4. Thus, La>Lb>Lc>Ld>Le>Lf>Lg.

[0027] A strip 20 is passed through the seven roll set 11a ~ 11g successively, and thereby bent step by step from a flat form to a U-shaped form as shown in Fig. 10. In this example, the strip has flanges formed by the later-mentioned method shown in Figs. 12 ~ 16C.

[0028] As shown in Fig. 11, the inside U-shaped surface of the strip 20 bent by the sequence of the bending steps has a first pair of fold lines Pa formed by the left and right edges 17a of the first convex roll 15a shown in Fig. 3. On each of the left and right side of the median plane, the left or right edge 17a applies a pressing force on the strip 20 at an application point, and forms the fold line Pa extending, at that application point, in the longitudinal direction of the strip 20. The inside surface is folded along the fold line Pa. The left and right edges 17b of the second convex roll 15b form a second pair of fold lines Pb located between the first pair of the fold lines Pa. Similarly, the left and right edges of the subsequent bending step form a subsequent fold lines Pc ~ Pg (Pn). In Fig. 11, the shape of the formed strip 20 is simplified.

[0029] The fold lines formed by a subsequent bending step which is any of the second through last bending steps are located between the fold lines formed by a preceding bending step which is one of the first through sixth (penultimate) bending step and which is prior to the subsequent bending step in the sequence. Each fold line appears as the vertex of an obtuse angle in Fig. 10.

[0030] Bending deformation is produced along each fold line, and internal stresses are distributed widely among the fold lines. Therefore, this production process can reduce the possibility of springback and improve the accuracy of forming.

[0031] The outside U-shaped surface of the strip are formed by the smooth sloping surfaces 14a ~ 14g of the concave rolls 12a ~ 12g. Therefore, the outside U-shaped surface is free of fold lines and other irregularities.

[0032] In the illustrated example, the number of the bending steps is seven. However, the invention is not limited to this. It is possible to decrease or increase the number of the bending steps.

[0033] Fig. 12 shows a roll forming machine or roll set for forming one or more flanges in a strip, such as the flanges 3 of the metal strip 1 shown in Fig. 2A.

[0034] The flanging roll set shown in Fig. 12 includes a first roll (selective roll) 102 and a second roll (or common roll) 104.

[0035] The first roll 102 includes a center main roll section 102a having a center main roll surface for forming a flat center main section 111a in a strip 111 as shown in Fig. 16A. The first roll 102 further includes left and right side roll sections 102b each having a side roll surface for forming a flat flange 111b as shown in Fig. 16A. The center main roll section 102a is bounded axially between the left and right side roll sections 102b. The di-

ameter of each side roll section 102b is greater than the diameter of the center main section 102a. Each flange 111b is raised from the main strip section 111a, and there is formed a step between the main section 111a and the flange 111b. The first roll 2 further includes left and right roll flanges 103 each abutting and sliding on the adjacent end surface of the second roll 104. The second roll 4 is always held in a correct position relative to the first roll 2 along the axial direction by being confined between the left and right roll flanges 103 of the first roll 2.

[0036] The second roll 104 includes a center main roll section 104a for compressing the center main section 111a of the strip 111 with the center main roll section 102a of the first roll 102, and left and right side roll sections 104b each having a side roll surface for forming one of the flanges 111b of the strip 111. Each side roll surface is depressed below the center main surface. The diameter of each side roll section 104b is smaller than the diameter of the center main roll section 104a. The center main roll section 104a is located axially between the left and right side roll sections 104b.

[0037] The second roll 104 further includes a left and right pair of first annular grooves 104c and a left and right pair of second annular grooves 104d. On each of the left and right sides, the first and second annular grooves 104c and 104d are located axially between the center main section 104a and the side roll section 104b. The first annular groove 104c is located axially between the second annular groove 104d and the side roll section 104b, and the second annular groove 104d is located axially between the center main roll section 104a and the first annular groove 104c. Between the first annular groove 104c and the side roll section 104b, there is formed a first annular projection (or land) 104m. Between the first and second annular grooves 104c and 104d, there is formed a second annular projection (or land) 104n.

[0038] The left and right first annular grooves 104c are designed to form left and right flat flanges 111b' in a strip 111' shown in Fig. 16B. Each of the left and right first annular grooves 104c has predetermined axial position, width and depth corresponding to the position, axial width and the height of the flanges 111'. The left and right second annular grooves 104d are designed to form left and right flat flanges 111b" in a strip 111" shown in Fig. 16B. Each of the left and right second annular grooves 104d has predetermined axial position, width and radial depth corresponding to the position, axial width and the height of the flanges 111" shown in Fig. 16C.

[0039] When the roll forming operation is performed with the first roll 2 and the second roll 4 as shown in Fig. 13, a flanged strip 111 of a wide width is formed, as shown in Fig. 16A, from a flat strip 110 such as a flat metal strip. The center main strip section 111a is compressed between the center main roll surfaces 102a and 104a of the first and second rolls 102 and 104. The left or right flange 111b of the flanged strip 111 on each of the left and right sides is formed by compression between the side roll surfaces 102b and 104b of the first and second rolls 102 and 104.

[0040] When the roll forming operation is performed with the second roll 4 and a first roll 102' as shown in Fig. 14, a flanged strip 111' of a medium width is formed, as shown in Fig. 16B, from a flat strip 110'. The center main strip section 111a' is compressed between the center main roll surfaces 102a' and 104a of the first and second rolls 102' and 104. Unlike the first roll 102 shown in Fig. 13, the first roll 102' of Fig. 14 has left and right annular projections 102b' each having a side roll surface. The left and right annular projections 102b' are correctly fit in the left and right first annular grooves 104c of the second roll 104, respectively, with a predetermined clearance. The left or right flange 111b' of the flanged strip 111' on each of the left and right sides is formed between the left or right first annular groove 104c of the second roll 104 and the side roll surface of the annular projection 102b' of the first roll 102' fit in the first annular groove 104c. The width of the flanged strip 111' shown in Fig. 16B is smaller than that of the flanged strip 111 shown in Fig. 15A. Moreover, the width of the center main section 111a of the flanged strip 111' shown in Fig. 16B is smaller than that of the flanged strip 111 shown in Fig. 16A. In this example, the width of the left or right flange 111b' of the flanged strip 111' shown in Fig. 16B is smaller than that of the flanged strip 111 shown in Fig. 16A.

[0041] When the roll forming operation is performed with the second roll 4 and a first roll 102" as shown in Fig. 15, a flanged strip 111" of a small width is formed, as shown in Fig. 16C, from a narrow flat strip 110". The center main strip section 111a" is compressed between the center main roll surfaces 102a" and 104a of the first and second rolls 102" and 104. The first roll 102" has left and right annular projections 102b" each having a side roll surface. The left and right annular projections 102b" are correctly fit in the left and right second annular grooves 104d of the second roll 104, respectively, with a predetermined clearance. The left or right flange 111b" of the flanged strip 111" on each of the left and right sides is formed between the left or right second annular groove 104d of the second roll 104 and the side roll surface of the annular projection 102b" of the first roll 102" fit in the second annular groove 104d. The width of the flanged strip 111" shown in Fig. 16C is smaller than that of the flanged strip 111' shown in Fig. 16B. Moreover, the width of the center main section 111a" of the flanged strip 111" shown in Fig. 16C is smaller than that of the flanged strip 111' shown in Fig. 16B. In this example, the width of the left or right flange 111b" of the flanged strip 111" shown in Fig. 16C is equal to that of the flanged strip 111' shown in Fig. 16B.

[0042] The first roll 102' of Fig. 14 has left and right roll flanges 103' for positioning the second roll 4 correctly along the axial direction by limiting axial movement of the second roll 104 therebetween like the flanges 3 of

the first roll 102 of Figs. 12 and 13. Similarly, the first roll 102" of Fig. 15 has left and right roll flanges 103" for positioning the second roll 4 correctly along the axial direction by limiting axial movement of the second roll 104 therebetween.

[0043] In this way, it is possible to use the second roll 104 in common for forming flanged strips of different sizes by pairing with a selected one of the first rolls 102, 102' and 102" of different sizes, to the advantage of production cost.

[0044] Although the invention has been described above by reference to certain embodiments of the invention, the invention is not limited to the embodiments described above. Modifications and variations of the embodiments described above will occur to those skilled in the art in light of the above teachings within the scope of the following claims.

Claims

1. A V-shaped metal strip (1) having a V-shaped cross section for forming a metal tube having a closed elongated cross section, the V-shaped metal strip (1) comprising:

a U-shaped portion (4) having a U-shaped curved inside surface (4b) and a U-shaped curved outside surface (4a),

characterized in that
only the inside curved surface (4b) has a plurality of fold lines (P) formed by applying a pressing force at an application point of the strip and extending longitudinal direction of the V-shaped metal strip (1) wherein the strip is folded along said fold lines (P), and **in that** said each of the fold lines (P) is in the form of a vertex of an obtuse angle in the V-shaped cross section of said V-shaped metal strip (1), wherein said fold lines (P) are arranged away from an imaginary median plane (O) bisecting the V-shaped cross section.

2. A V-shaped metal strip (1) according to Claim 1 wherein the fold lines (P) are arranged in a manner of bilateral symmetry with respect to the imaginary median plane (O).

3. A V-shaped metal strip (1) according to Claim 1 wherein the V-shaped metal strip (1) extends in the longitudinal direction from a first end to a second end, has first and second edges (31) extending from the first end to the second end and being separated open, first and second side walls (34) extending respectively, from the first and second edges to the U-shaped portion (14) to form the V-shaped cross section with the U-shaped portion (4).

4. A V-shaped metal strip (1) according to Claim 3 wherein the V-shaped metal strip (1) has first and second flanges (3) adapted to be joined together to form the closed elongated cross section of the metal tube, the first flange (3) including the first edge (31) and being formed in the first side wall (34) and the second flange (3) including the second edge (31) and being formed in the second side wall (34).

5. A formed metal strip member for forming a fluid passage, the formed metal strip member comprising:

a folded metal strip folded in two, the metal strip comprising:

first and second edges (31) defining a first lateral end of the folded metal strip, and extending in a longitudinal direction of the metal strip from a first longitudinal end to a second longitudinal end of the metal strip (1);
first and second side walls (34) extending in a widthwise direction of the folded metal strip (1), respectively, from the first and second edges (31) toward a second lateral end of the folded metal strip; and
a U-shaped bottom (4) defining the second lateral end of the folded metal strip and connecting the first and second side walls (34) and extending from the first longitudinal end to the second longitudinal end, the U-shaped bottom (4) having an outside U-shaped surface (4a), and an inside U-shaped surface (4b),

characterized in that
said inside U-shaped surface (4b) is formed with a plurality of fold lines (P) formed by applying a pressing force at an application point of the strip and extending in the longitudinal direction, and wherein the strip is folded along said fold lines (P), and **in that** said fold lines (P) are arranged away from an imaginary median plane (O) bisecting the U-shaped bottom (4) and are in the form of a vertex of an obtuse angle in the U-shaped cross section.

6. A formed metal strip member according to Claim 5 wherein the folded metal strip is substantially in the form of bilateral symmetry with respect to said imaginary median plane (O) bisecting the U-shaped bottom (4) and the fold lines (P) are arranged in pairs each of which consists of two of the fold line (P) one being substantially an mirror image of the other with respect to the imaginary median plane (O).

7. A formed metal strip member according to Claim 5 wherein the first and second edges (31) are sepa-

rate from each other and define a gap therebetween, and the first and second side walls (34) are arranged in the form of a V shape to form a V-shaped cross section with the U-shaped bottom (4).

8. A formed metal strip member according to Claim 5 wherein the first and second edges (31) are joined together so that the folded metal strip has a closed cross section.

9. A formed metal strip member according to Claim 8 wherein the formed metal strip member further comprises an inner fin (5) confined in the folded metal strip.

10. A bending method of bending a metal strip from a flat shape into a folded shape having an approximately U-shaped cross section, the method comprising:

a preceding bending step of compressing the metal strip between a wider concave roll (12) having a circumferential rim formed with a wider V-shaped groove (13) defined by left and right sloping surfaces (14) forming a wider spread angle (θ) and a wider convex roll (15) having a circumferential rim formed with a wider ridge (16) projecting toward a middle of the V-shaped groove (13) between the left and right sloping surfaces (14) and having a left edge (17) for pressing the metal strip at a left preceding pressing point against the left sloping surface (14) and a right edge (17) for pressing the metal strip at a right preceding pressing point against the right sloping surface (14) and
a following bending step of compressing the metal strip between a narrower concave roll (12) having a circumferential rim formed with a narrower V-shaped groove (13) defined by left and right sloping surfaces (14) forming a narrower spread angle (θ) smaller than the wider spread angle (θ) of the preceding bending step and a narrower convex roll (15) having a circumferential rim formed with a narrower ridge (16) projecting toward a middle of the narrower V-shaped groove (13) between the left and right sloping surfaces (14) and having a left edge (17) for pressing the metal strip at a left following pressing point against the left sloping surface (14) and a right edge for pressing the metal strip at a following pressing point against the right sloping surface (14), the left and right following pressing points being located between the left and right preceding pressing points, whereby the strip is bent along fold lines (P) formed at said pressing points and extending in the longitudinal direction of the strip, said fold lines (P) being in the form of a vertex of an obtuse angle in the U-shaped cross section.

11. A bending method according to Claim 10 wherein the metal strip bent by the preceding bending step includes left and right sloping walls (34) extending on both sides of an imaginary median plane (O) so as to form a V-shaped cross section bisected by the imaginary median plane (O), the left and right preceding and following pressure points are arranged substantially in a manner of bilateral symmetry on both sides of the imaginary median plane (O) of the metal strip, the distance (2b) between the left and right following pressure points is smaller than the distance (2a) between the left and right preceding pressure points.

12. A bending method according to Claim 10 wherein the bending method comprises a sequence of similar bending steps inclusive of the preceding bending step and the following bending step, for decreasing the bend angle of the metal strip (1) step by step, an inserting step of inserting an inner member (5) into a cavity of the metal strip bent by the sequence of the bending steps, and a closing step of closing edges of the metal strip (1) to form a metal tube containing the inner member (5) therein.

13. A bending method according to Claim 12 wherein the bending method further comprises a flanging step of forming left and right flanges (3) in the metal strip (1) prior to the sequence of the bending steps.

Patentansprüche

1. Ein V-förmiger Metallstreifen (1) mit einem V-förmigen Querschnitt zum Formen eines Metallrohrs mit einem geschlossenen, länglichen Querschnitt, der V-förmige Metallstreifen (1) umfasst:

einen U-förmigen Abschnitt (4) mit einer U-förmig gekrümmten Innenfläche (4b) und einer U-förmig gekrümmten Außenfläche (4a),

dadurch gekennzeichnet, dass
nur die gekrümmte Innenfläche (4b) eine Vielzahl von Faltlinien (P) hat, die durch Anlegen einer Druckkraft an einem Anlagepunkt des Streifens geformt sind und sich in eine längliche Richtung des V-förmigen Metallstreifens (1) erstrecken, wobei der Streifen entlang der Faltlinien (P) gefaltet ist, und dass jede der Faltlinien (P) in Form eines Scheitels eines stumpfen Winkels in dem V-förmigen Querschnitt des V-förmigen Metallstreifens (1) ist, wobei die Faltlinien (P) von einer den V-förmigen Querschnitt halbierenden, imaginären, mittleren Ebene (O) beabstandet angeordnet sind.

2. Ein V-förmiger Metallstreifen (1) nach Anspruch 1, wobei die Faltlinien (P) nach Art von bilateraler Symmetrie in Bezug auf die imaginäre, mittlere Ebene (O) angeordnet sind.

3. Ein V-förmiger Metallstreifen (1) nach Anspruch 1, wobei
sich der V-förmige Metallstreifen (1) in Längsrichtung von einem ersten Ende zu einem zweiten Ende erstreckt, erste und zweite Kanten (31) hat, die sich von dem ersten Ende zu dem zweiten Ende erstrekken und getrennt offen sind,
sich erste und zweite Seitenwände (34) jeweils von den ersten und zweiten Kanten zu dem U-förmigen Abschnitt (4) erstrecken, um den V-förmigen Querschnitt mit dem U-förmigen Abschnitt (4) zu formen.

4. Ein V-förmiger Metallstreifen (1) nach Anspruch 3, wobei der V-förmige Metallstreifen (1) erste und zweite Wangen (3) hat, die angepasst sind, um sich zum Formen des geschlossenen, länglichen Querschnitts des Metallrohrs miteinander zu verbinden, die erste Wange (3) enthält die erste Kante (31) und ist in der ersten Seitenwand (34) ausgebildet und die zweite Wange (3) enthält die zweite Kante (31) und ist in der zweiten Seitenwand (34) ausgebildet.

5. Ein geformtes Metallstreifenelement zum Formen eines Flüssigkeitsdurchlasses, das geformte Metallstreifenelement umfasst:

einen in zwei gefalteten Metallstreifen, der Metallstreifen umfasst:

erste und zweite Kanten (31), bestimmend ein erstes seitliches Ende des gefalteten Metallstreifens und erstreckend in eine längliche Richtung des Metallstreifens von einem ersten länglichen Ende zu einem zweiten länglichen Ende des Metallstreifens (1);

erste und zweite Seitenwände (34), erstreckend in Richtung der Breite des gefalteten Metallstreifens (1), jeweils von den ersten und zweiten Kanten (31) zu einem zweiten seitlichen Ende des gefalteten Metallstreifens; und

einen U-förmigen Boden (4), der das zweite seitliche Ende des gefalteten Metallstreifens bestimmt und die ersten und zweiten Seitenwände (34) verbindet und sich von dem ersten länglichen Ende zu dem zweiten länglichen Ende erstreckt, der U-förmige Boden (4) hat eine äußere U-förmige Fläche (4a) und eine innere U-förmige Fläche (4b),

dadurch gekennzeichnet, dass
die innere U-förmige Fläche (4b) mit einer Vielzahl von Faltlinien (P) geformt ist, die durch Anlegen einer Druckkraft an einem Anlagepunkt des Streifens geformt sind und sich in die längliche Richtung erstrecken, und wobei der Streifen entlang den Faltlinien (P) gefaltet ist, und
die Faltlinien (P) von einer den U-förmigen Boden (4) halbierenden, imaginären, mittleren Ebene (O) beabstandet angeordnet sind, und in der Form eines Scheitels eines stumpfen Winkels in dem U-förmigen Querschnitt (1) sind.

6. Ein geformtes Metallstreifenelement nach Anspruch 5, wobei der gefaltete Metallstreifen im Wesentlichen in Form von bilateraler Symmetrie in Bezug auf die den U-förmigen Boden (4) halbierende, imaginäre, mittlere Ebene (O) ist und die Faltlinien (P) paarweise angeordnet sind, jedes davon aus zwei Faltlinien (4) besteht, wobei Eine im Wesentlichen ein Spiegelbild von der Anderen in Bezug auf die imaginäre, mittlere Ebene (O) ist.

7. Ein geformtes Metallstreifenelement nach Anspruch 5, wobei die ersten und zweiten Kanten (31) voneinander beabstandet sind und dazwischen eine Lücke definieren, und die ersten und zweiten Seitenwände (34) in der Form einer V-Form angeordnet sind, um einen V-förmigen Querschnitt mit dem U-förmigen Boden (4) zu formen.

8. Ein geformtes Metallstreifenelement nach Anspruch 5, wobei die ersten und zweiten Kanten (31) miteinander verbunden sind, so dass der gefaltete Metallstreifen einen geschlossenen Querschnitt hat.

9. Ein geformtes Metallstreifenelement nach Anspruch 8, wobei das geformte Metallstreifenelement ferner eine in dem gefalteten Metallstreifen eingeschlossene innere Rippe (5) umfasst.

10. Ein Biegeverfahren zum Biegen eines Metallstreifens von einer flachen Form in eine gefaltete Form mit einem ungefährlichen U-förmigen Querschnitt, das Verfahren umfasst:

einen vorangehenden Biegeschritt zum Zusammendrücken des Metallstreifens zwischen einer breiteren konkaven Walze (12) mit einem umfänglichen Rand, geformt mit einer breiteren V-förmigen Nut (13), definiert durch linke und rechte abfallenden Flächen (14), die einen breiteren Spreizwinkel (θ) bilden und einer breiteren konvexen Walze (15) mit einem umfänglichen Rand, geformt mit einer breiteren Erhöhung (16), vorspringend zu einer Mitte der V-förmigen Nut (13) zwischen den linken und

rechten abfallenden Flächen (14) und mit einer linken Kante (17) zum Pressen des Metallstreifens an einem linken vorangehenden Druckpunkt gegen die linke abfallende Fläche (14) und einer rechten Kante (17) zum Pressen des Metallstreifens an einem rechten vorangehenden Druckpunkt gegen die rechte abfallende Fläche (14), und

einen nachfolgenden Biegeschritt zum Zusammendrücken des Metallstreifens zwischen einer engeren konkaven Walze (12) mit einem umfänglichen Rand, geformt mit einer engeren V-förmigen Nut (13), definiert durch linke und rechte abfallenden Flächen (14), die einen engeren Spreizwinkel (θ) bilden, kleiner als der breitere Spreizwinkel (θ) des vorangehenden Biegeschritts, und einer engeren konvexen Walze (15) mit einem umfänglichen Rand, geformt mit einer engeren Erhöhung (16), vorspringend zu einer Mitte der engeren V-förmigen Nut (13) zwischen den linken und rechten abfallenden Flächen (14) und mit einer linken Kante (17) zum Pressen des Metallstreifens an einem linken nachfolgenden Druckpunkt gegen die linke abfallende Fläche (14) und einer rechten Kante zum Pressen des Metallstreifens an einem rechten nachfolgenden Druckpunkt gegen die rechte abfallende Fläche (14), die linken und rechten nachfolgenden Druckpunkte sind zwischen den linken und rechten vorangehenden Druckpunkten angeordnet, wobei der Streifen entlang Faltlinien (P) gebogen wird, die bei den Druckpunkten geformt sind und sich in Längsrichtung des Streifens erstrecken, die Faltlinien (P) sind in der Form eines Scheitels eines stumpfen Winkels in dem U-förmigen Querschnitt.

11. Ein Biegeverfahren nach Anspruch 10, wobei der gemäß des vorangehenden Biegeschritts gebogene Metallstreifen linke und rechte abfallende Wände (34), erstreckend an beiden Seiten einer imaginären, mittleren Ebene (O) enthält, um so einen V-förmigen Querschnitt, halbiert von der imaginären, mittleren Ebene (O) zu formen, die linken und rechten vorangehenden und nachfolgenden Druckpunkte sind im Wesentlichen nach Art von bilateraler Symmetrie an beiden Seiten der imaginären, mittleren Ebene (O) des Metallstreifens angeordnet, der Abstand (Lb) zwischen den linken und rechten nachfolgenden Druckpunkten ist geringer, als der Abstand (La) zwischen den linken und rechten vorangehenden Druckpunkten.

12. Ein Biegeverfahren nach Anspruch 10, wobei das Biegeverfahren eine Sequenz von ähnlichen Biegeschritten umfasst, inbegriffen den vorangehenden Biegeschritt und den nachfolgenden Biegeschritt zum sukzessiven Verringern des Biegewinkels des Metallstreifens (1), einen Einführungsschritt zum Einführen eines inneren Elementes (5) in einen Hohlraum des Metallstreifens, gebogen durch die Sequenz der Biegeschritte und einen Schließungsschritt zum Schließen von Kanten des Metallstreifens (1), um ein Metallrohr zu Formen, das darin das innere Element (5) enthält.

13. Ein Biegeverfahren nach Anspruch 12, wobei das Biegeverfahren ferner einen Bördelschritt zum Formen von linken und rechten Wangen (3) in dem Metallstreifen (1) vor der Sequenz der Biegeschritte umfasst.

Revendications

1. Bande de métal en forme de V (1) présentant une section transversale en forme de V destinée au formage d'un tube métallique présentant une section transversale allongée fermée, la bande de métal en forme de V (1) comprenant :

une partie en forme de U (4) comportant une surface interne incurvée en forme de U (4b) et une surface externe incurvée en forme de U (4a),

caractérisée en ce que seule la surface interne incurvée en forme de U (4b) présente une pluralité de lignes de pliage (P) formées par application d'une force de pression au niveau d'un point d'application de la bande et s'étendant en une direction longitudinale de la bande de métal en forme de V (1), dans laquelle la bande est repliée le long des dites lignes de pliage (P), et **en ce que** chacune des dites lignes de pliage (P) se trouve sous la forme d'un vertex d'angle obtus dans la section transversale en forme de V de ladite bande de métal en forme de V (1), dans laquelle lesdites lignes de pliage (P) sont disposées de part et d'autre d'un plan médian imaginaire (O) coupant en deux la section en forme de V.

2. Bande de métal en forme de V (1) selon la revendication 1, dans laquelle les lignes de pliage (P) sont disposées de manière symétrique bilatérale par rapport au plan médian imaginaire (O).

3. Bande de métal en forme de V (1) selon la revendication 1, dans laquelle la bande de métal en forme de V (1) s'étend en direction longitudinale à partir d'une première extrémité jusqu'à une seconde extrémité, comprend des premier et second bords (31) s'étendant à partir de la première extrémité jusqu'à la seconde extrémité et étant séparés ouverts,

des première et seconde parois latérales (34) s'étendant respectivement à partir des premier et second bords jusqu'à la partie en forme de U (4) afin de former la section transversale en forme de V avec la partie en forme de U (4).

4. Bande de métal en forme de V (1) selon la revendication 3, dans laquelle la bande de métal en forme de V (1) comporte des première et seconde brides (3) adaptées pour se rejoindre afin de former la section transversale allongée fermée du tube métallique, la première bride (3) comprenant le premier bord (31) et étant formée dans la première paroi latérale (34) et la seconde bride (3) comprenant le second bord (31) et étant formée dans la seconde paroi latérale (34).

5. Élément de bande de métal formée destiné au formage d'un passage de fluide, l'élément de bande de métal formée comprenant :

une bande repliée de métal pliée en deux, la bande de métal comprenant :

des premier et second bords (31) définissant une première extrémité latérale de la bande de métal repliée, et s'étendant en une direction longitudinale de la bande de métal à partir d'une première extrémité longitudinale jusqu'à une seconde extrémité longitudinale de la bande de métal (1) ;
des première et seconde parois latérales (34) s'étendant en une direction de largeur de la bande de métal repliée (1), respectivement, à partir des premier et second bords (31) vers une seconde extrémité latérale de la bande de métal repliée ; et
un fond en forme de U (4) définissant la seconde extrémité latérale de la bande de métal repliée et raccordant les première et seconde parois latérales (34) et s'étendant à partir de la première extrémité longitudinale jusqu'à la seconde extrémité longitudinale, le fond en forme de U (4) comportant une surface externe en forme de U (4a) et une surface interne en forme de U (4b),

caractérisé en ce que
ladite surface interne en forme de U (4b) est formée d'une pluralité de lignes de pliage (P) formées par application d'une force de pression au niveau d'un point d'application de la bande et s'étendant selon la direction longitudinale et où la bande est pliée le long des dites lignes de pliage (P), et **en ce que** lesdites lignes de pliage (P) sont situées de part et d'autre d'un plan médian imaginaire (O) coupant en deux le fond en forme de U (4) et se trouvent sous la forme d'un vertex d'angle obtus dans la section transversale en forme de U.

6. Élément de bande de métal formée selon la revendication 5, dans lequel la bande de métal repliée se trouve sensiblement sous la forme d'une symétrie bilatérale par rapport au dit plan médian imaginaire (O) coupant en deux le fond en forme de U (4), et les lignes de pliage (P) sont disposées en paires dont chacune est constituée de deux des lignes de pliage (P), l'une étant sensiblement une image miroir de l'autre par rapport au plan médian imaginaire (O).

7. Élément de bande de métal formée selon la revendication 5, dans lequel les premier et second bords (31) sont séparés l'un de l'autre et définissent entre eux un interstice, et les première et seconde parois latérales (34) sont agencées sous forme de V afin de former une section transversale en forme de V avec le fond en forme de U (4).

8. Élément de bande de métal formée selon la revendication 5, dans lequel les premier et second bords (31) se rejoignent de façon à ce que la bande de métal repliée présente une section transversale fermée.

9. Élément de bande de métal formée selon la revendication 8, dans lequel l'élément de bande de métal formée comprend en outre une ailette interne (5) confinée dans la bande de métal repliée.

10. Procédé de cintrage d'une bande de métal à partir d'une forme plate en une forme pliée présentant une section approximativement en forme de U, le procédé comprenant :

une étape de cintrage initial de compression de la bande de métal entre un rouleau concave plus large (12) comportant un rebord circonférentiel formé d'une rainure en forme de V plus large (13) définie par des surfaces en pente gauche et droite (14) formant un angle d'ouverture plus large (θ), et un rouleau convexe plus large (15) comportant une rebord circonférentiel formé d'une nervure plus large (16) dépassant vers le milieu de la rainure en forme de V (13) entre les surfaces en pente gauche et droite (14), et comportant un bord gauche (17) destiné à presser la bande de métal au niveau d'un point de pression initial gauche contre la surface en pente gauche (14) et un bord droit (17) destiné à presser la bande de métal au niveau d'un point de pression initial droit contre la surface en pente droite (14), et
une étape suivante, de cintrage suivant de compression de la bande de métal entre un rou-

leau concave plus étroit (12) comportant un rebord circonférentiel formé d'une rainure en forme de V plus étroite (13) définie par des surfaces en pente gauche et droite (14) formant un angle d'ouverture plus étroite (θ), plus petit que l'angle d'ouverture plus large (θ) de l'étape de cintrage initiale, et un rouleau convexe plus étroit (15) comportant une rebord circonférentiel formé d'une nervure plus étroite (16) dépassant vers le milieu de la rainure en forme de V plus étroite (13) entre les surfaces en pente gauche et droite (14), et comportant un bord gauche (17) destiné à presser la bande de métal au niveau d'un point de pression suivant gauche contre la surface en pente gauche (14) et un bord droit destiné à presser la bande de métal au niveau d'un point de pression suivant droit contre la surface en pente droite (14), les points de pression gauche et droit suivants étant situés entre les points de pression gauche et droit initiaux, moyennant quoi la bande est pliée le long de lignes de pliage (P) formées au niveau desdits points de pression et s'étendant dans la direction longitudinale de la bande, lesdites lignes de pliage (P) se trouvant sous la forme d'un vertex d'angle obtus dans la section transversale en forme de U.

11. Procédé de cintrage selon la revendication 10, dans lequel la bande de métal repliée à l'aide de l'étape de cintrage initial comprend des parois en pente gauche et droite (34) s'étendant sur les deux côtés d'un plan médian imaginaire (O) de façon à former une section en forme de V coupée en deux par le plan médian imaginaire (O), les points de pression gauche et droite initiaux et suivants sont sensiblement disposés de manière symétrique bilatérale des deux côtés du plan médian imaginaire (O) de la bande de métal, la distance (Lb) entre les points de pression gauche et droit suivants étant plus petite que la distance (La) entre les points de pression gauche et droit initiaux.

12. Procédé de cintrage selon la revendication 10, dans lequel le procédé de cintrage comprend une séquence d'étapes de cintrage similaires inclusive de l'étape de cintrage initial et de l'étape de cintrage suivant, destinée à diminuer l'angle de cintrage de la bande de métal (1) pas à pas, une étape d'insertion d'un élément interne (5) dans une cavité de la bande de métal cintrée à l'aide de la séquence d'étapes de cintrage, et une étape de fermeture des bords de fermeture de la bande de métal (1) afin de former un tube de métal contenant l'élément interne (5).

13. Procédé de cintrage selon la revendication 12, dans lequel le procédé de cintrage comprend en outre une étape de bridage par formation de brides gauche et droite (3) dans la bande de métal (1) avant la séquence d'étapes de cintrage.

FIG.1

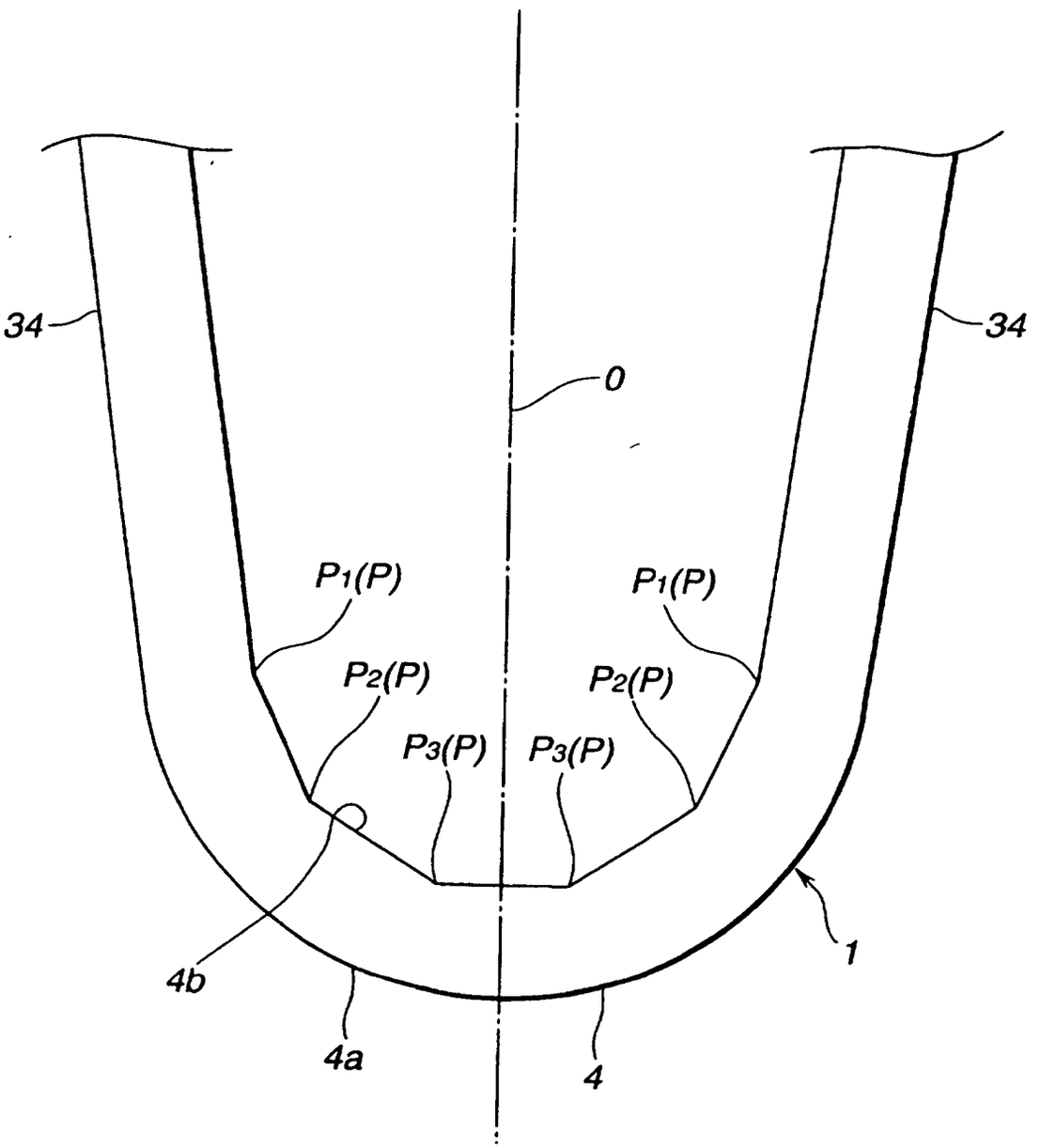


FIG.2A

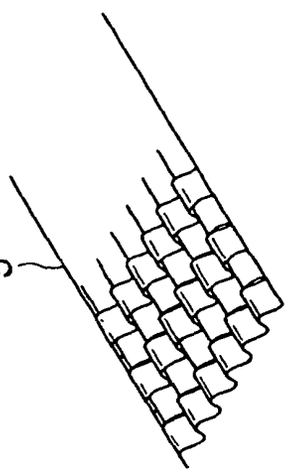


FIG.2B

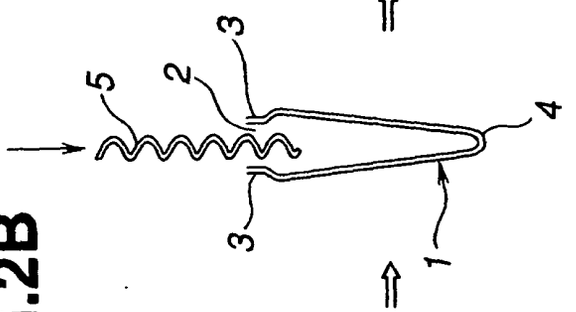


FIG.2C

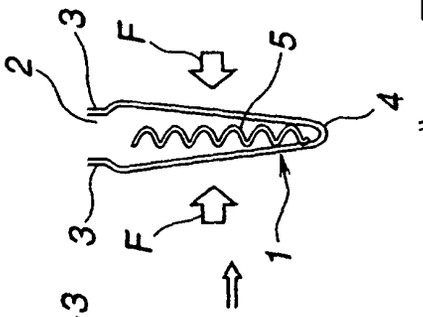
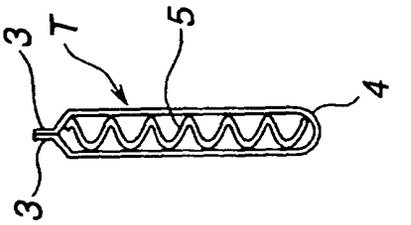


FIG.2D



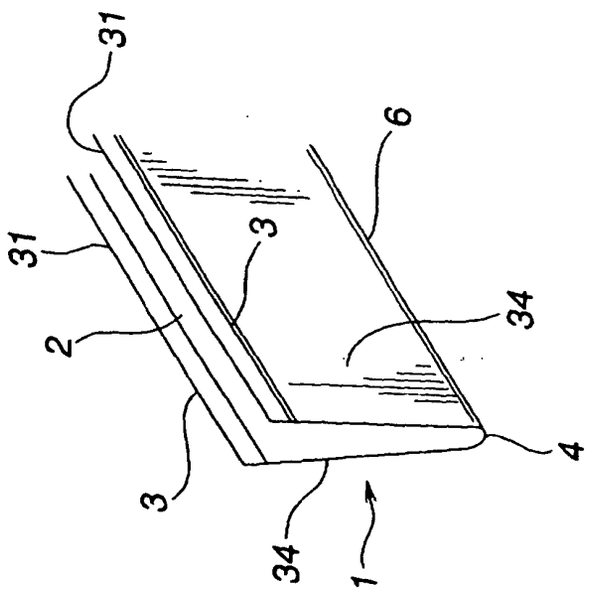


FIG.3

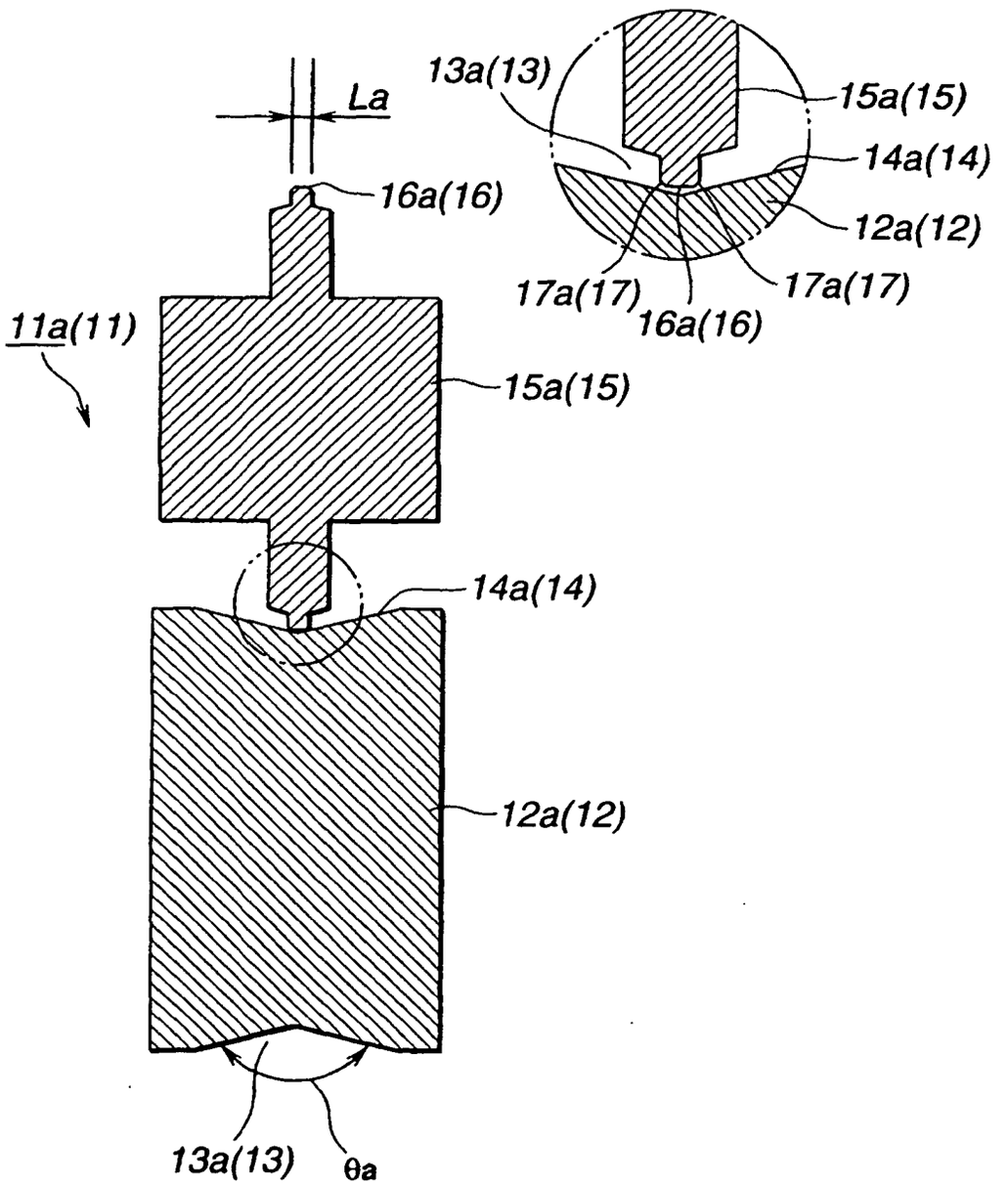

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FIG.4

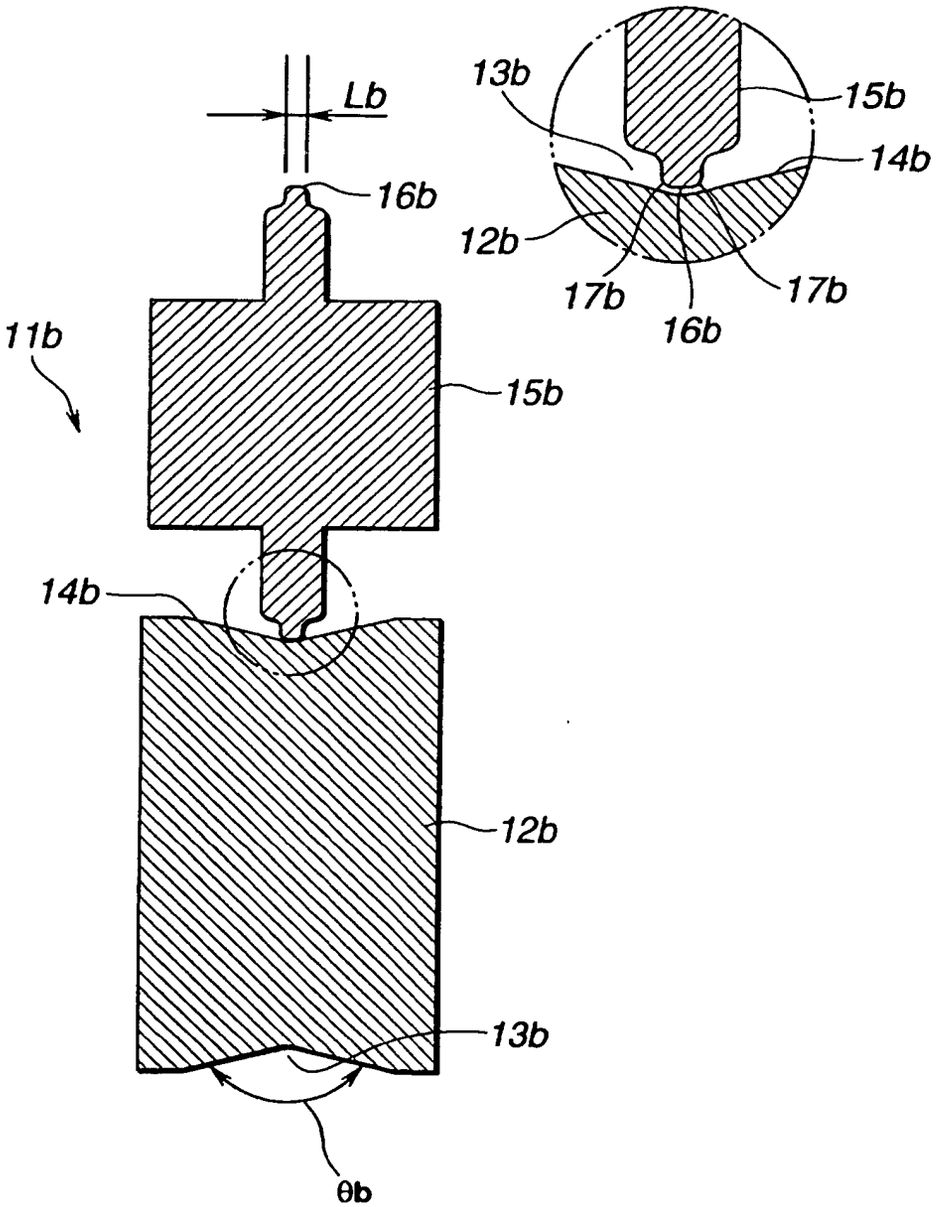


FIG.5

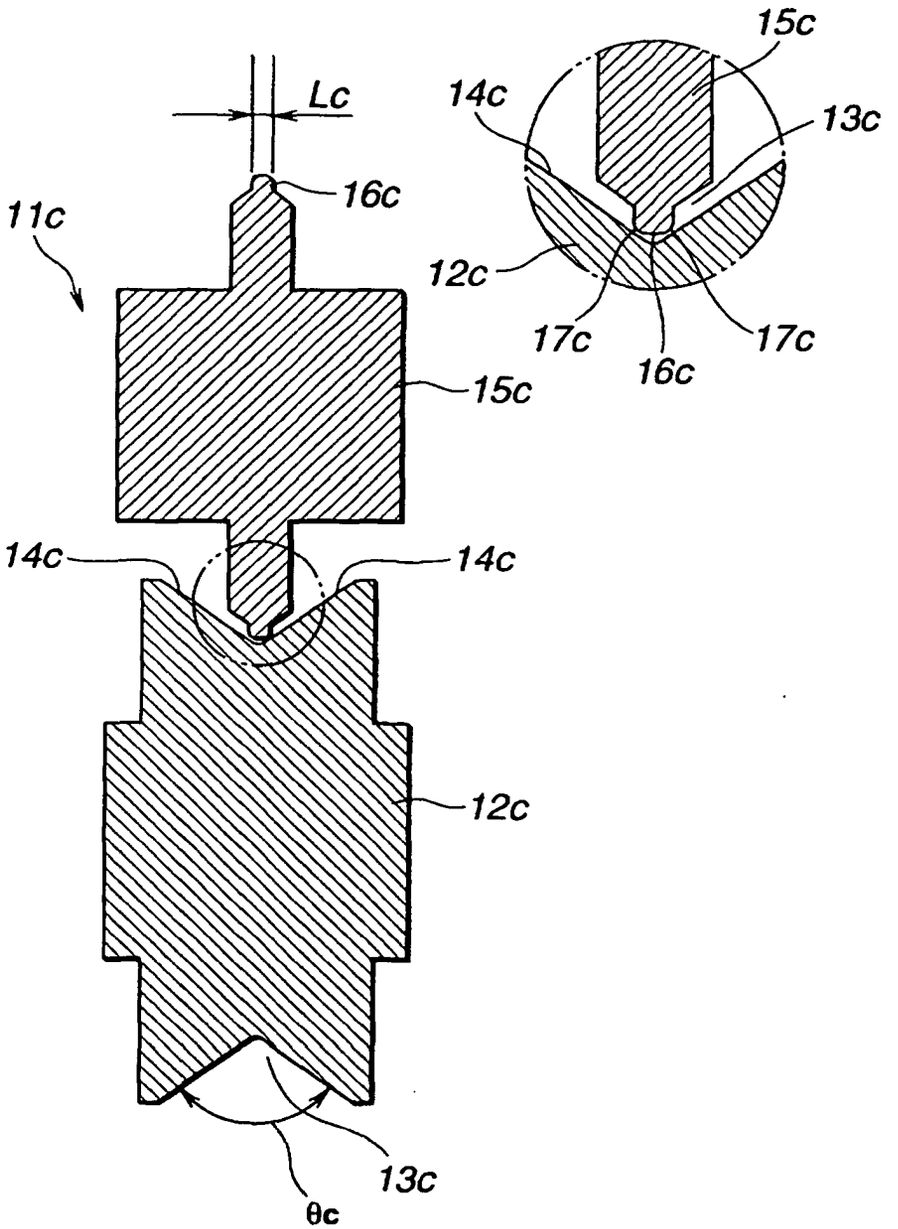


FIG.6

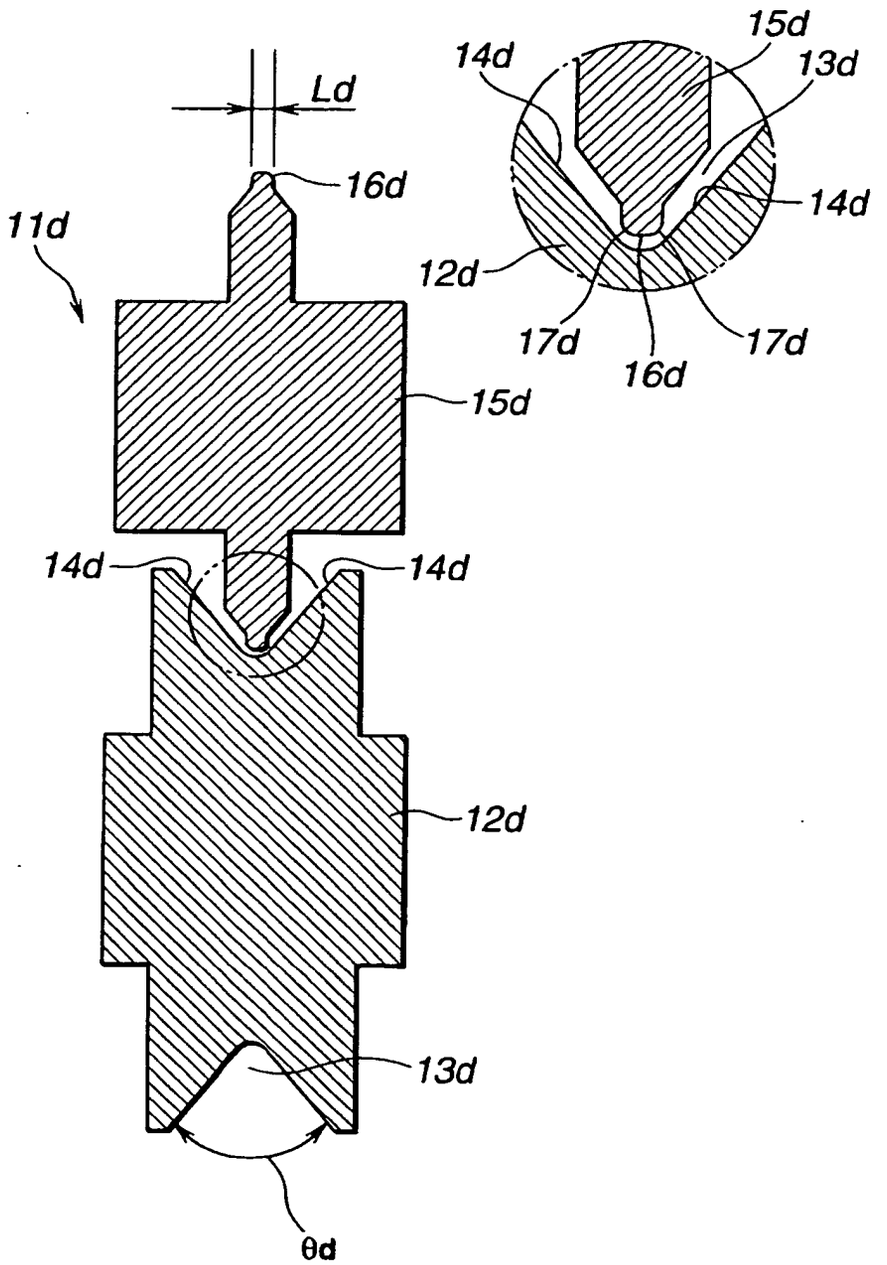


FIG.7

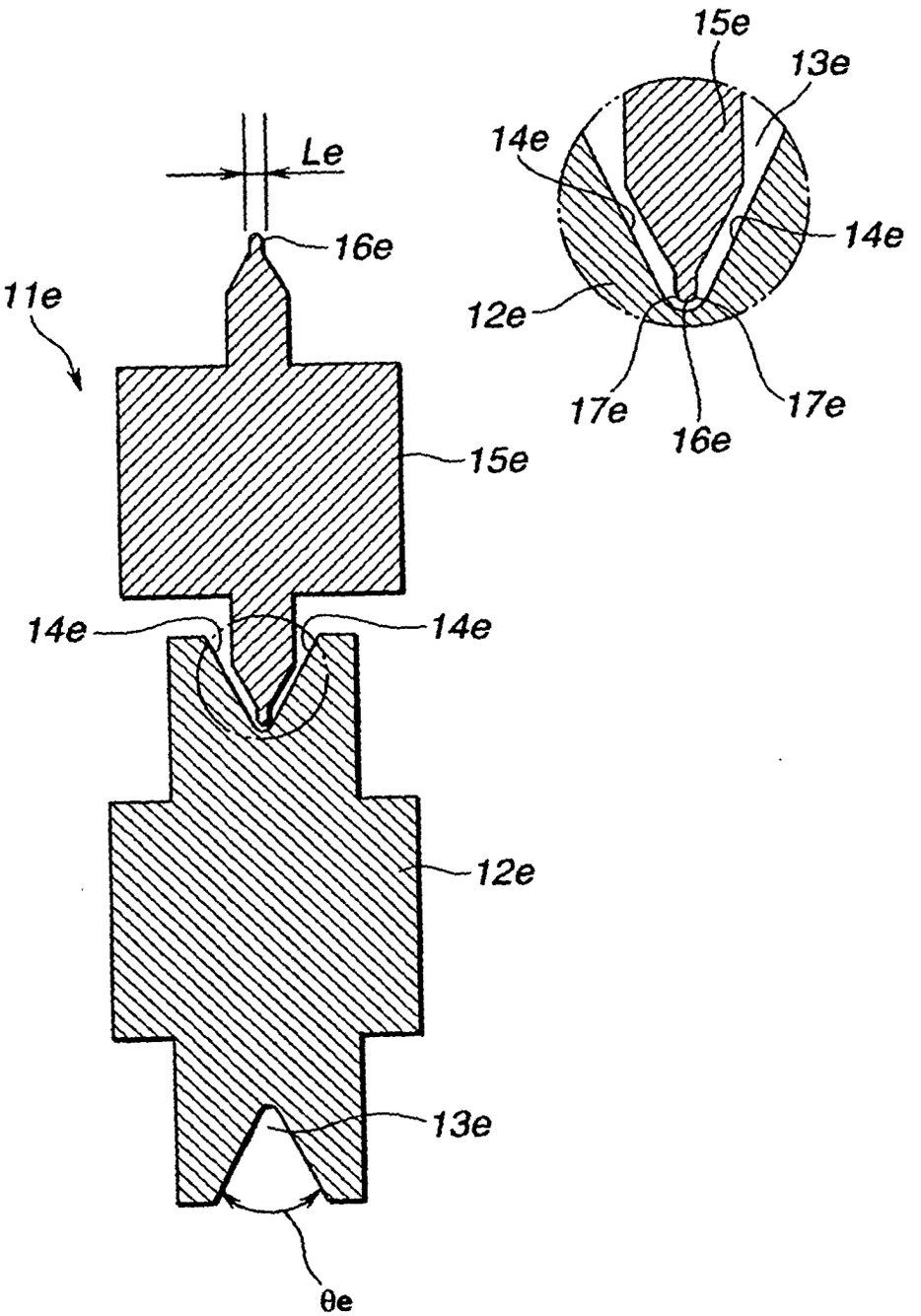


FIG.8

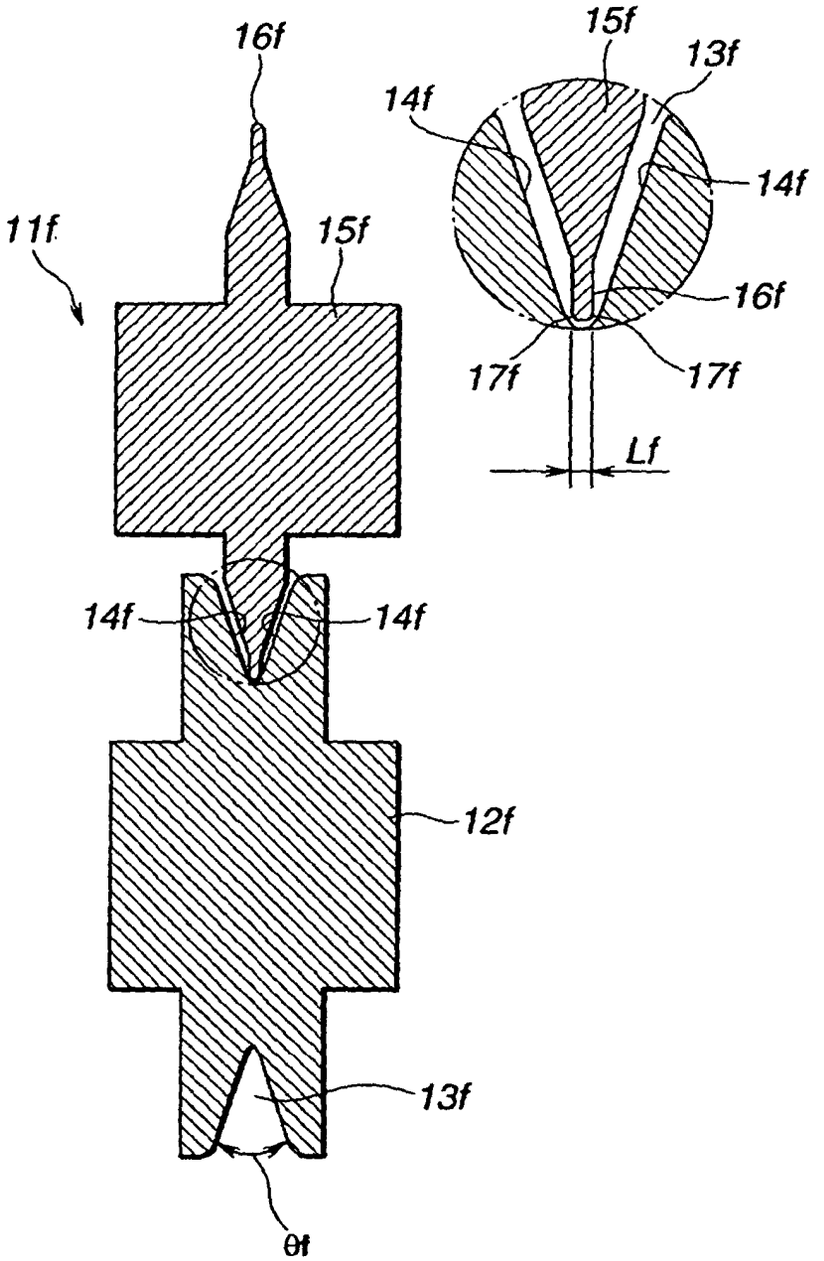


FIG.9

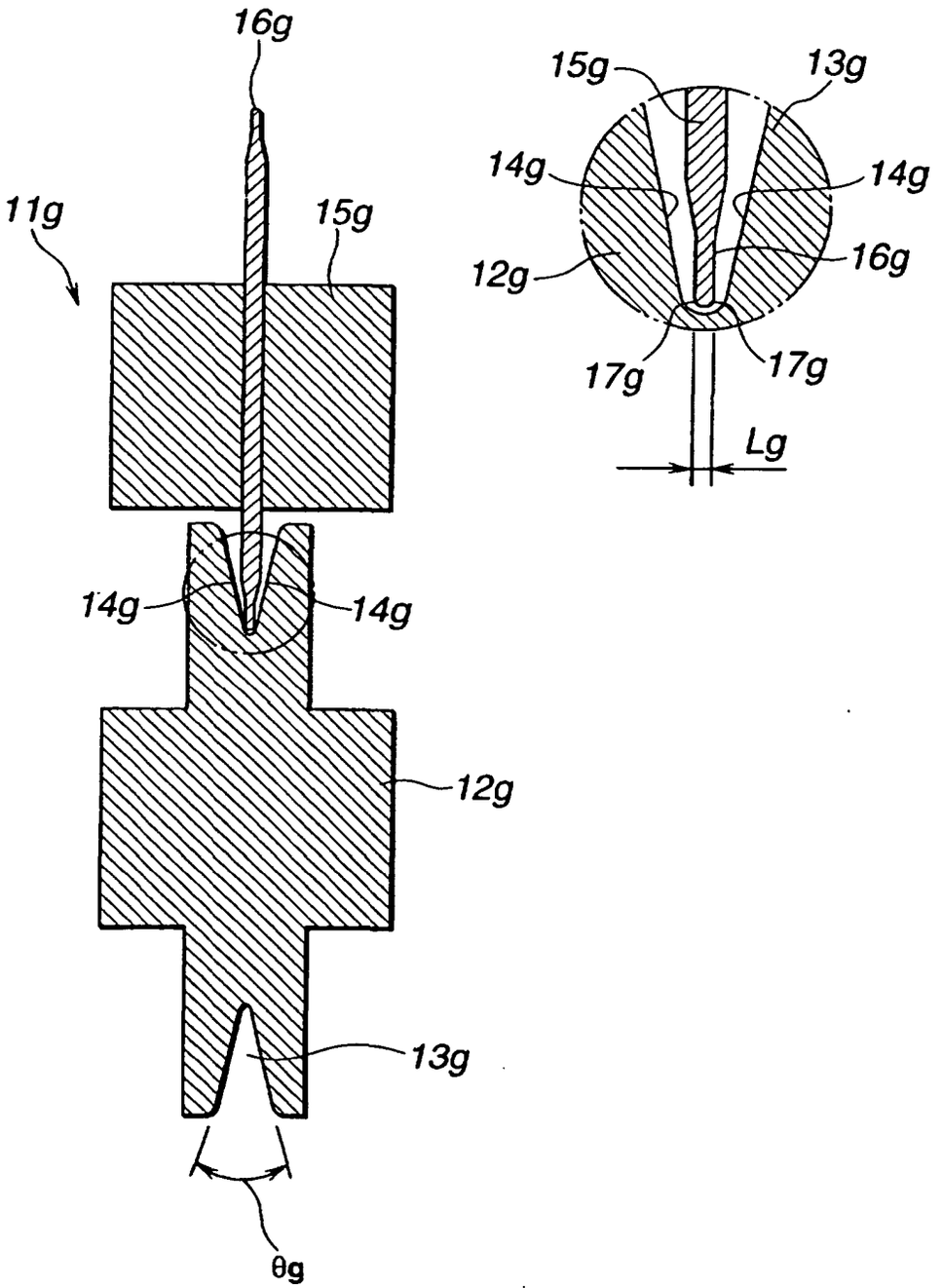


FIG.10

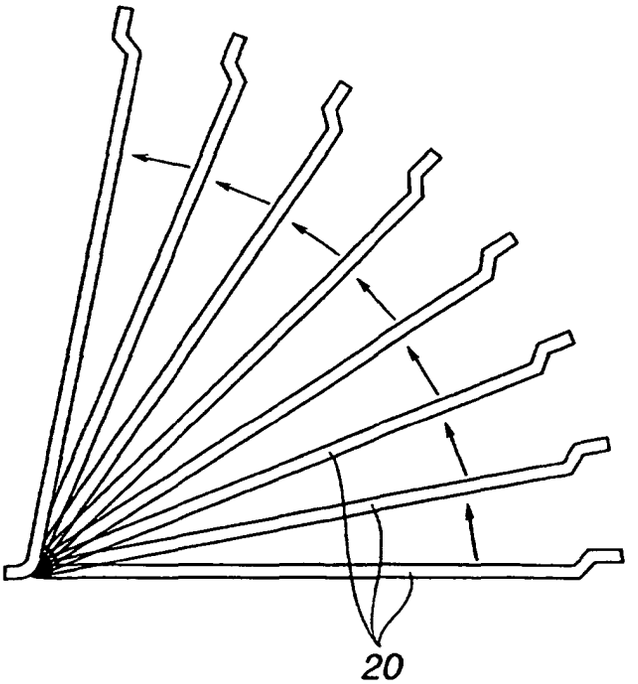


FIG.11

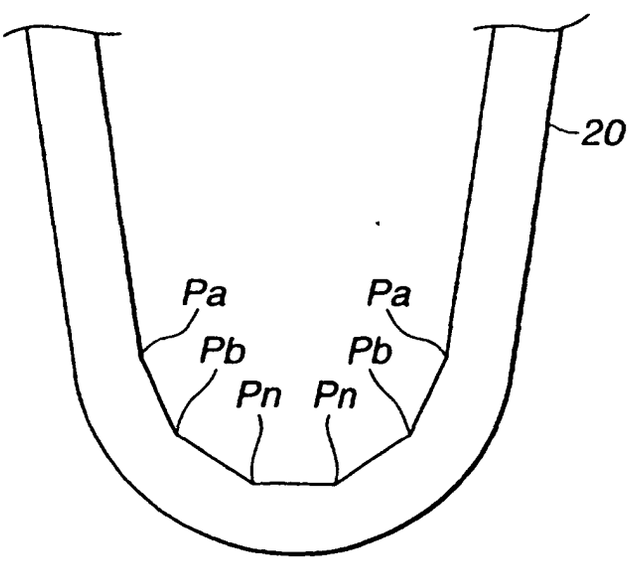
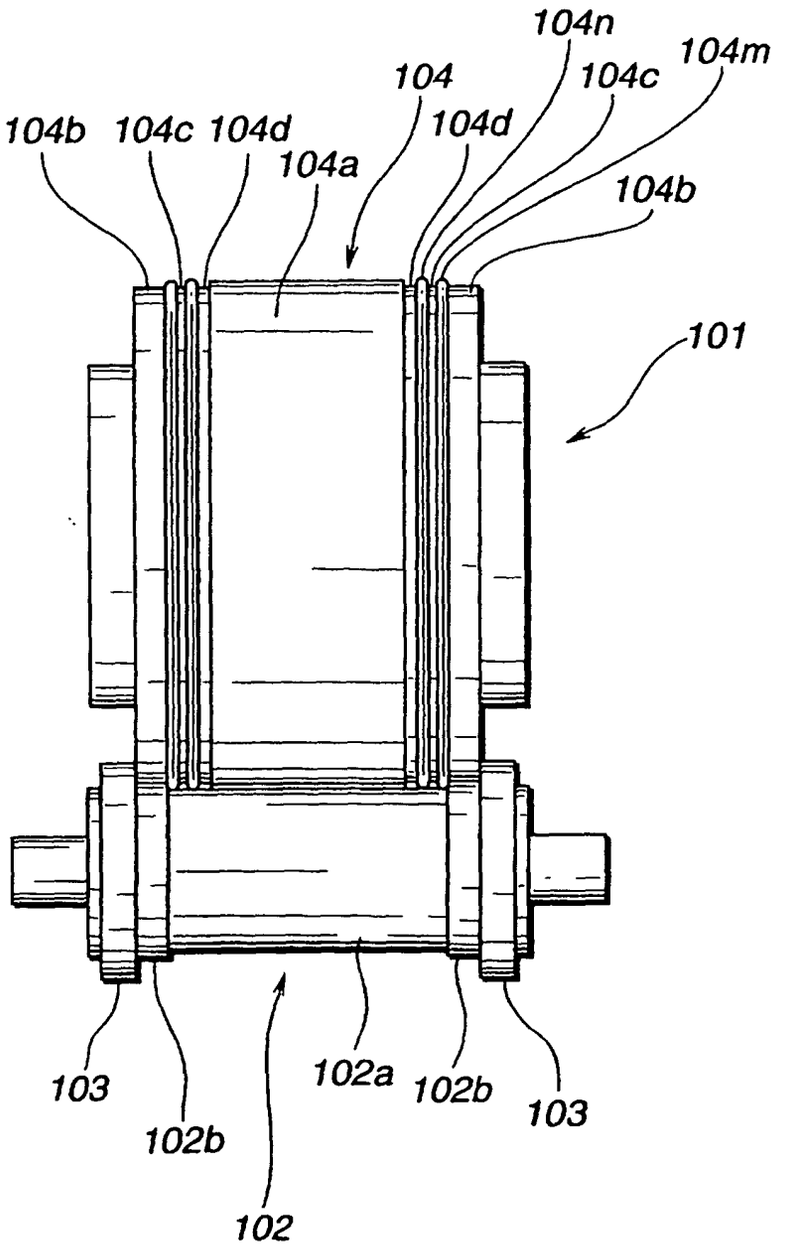


FIG.12


104n
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102a
102b
103

FIG.13

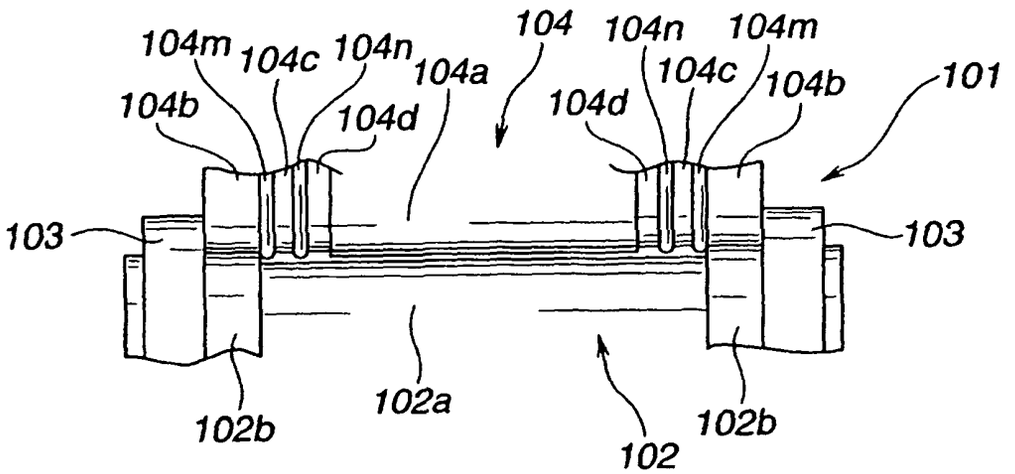

FIG.14

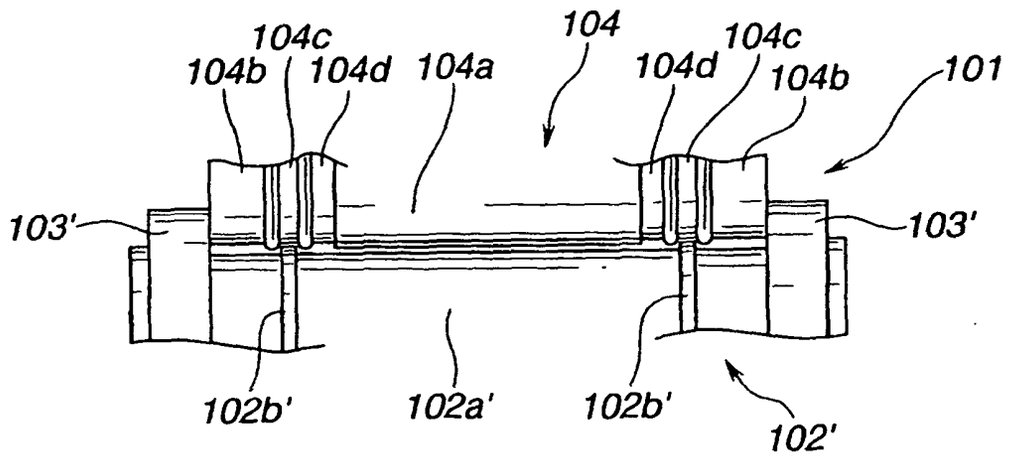

FIG.15

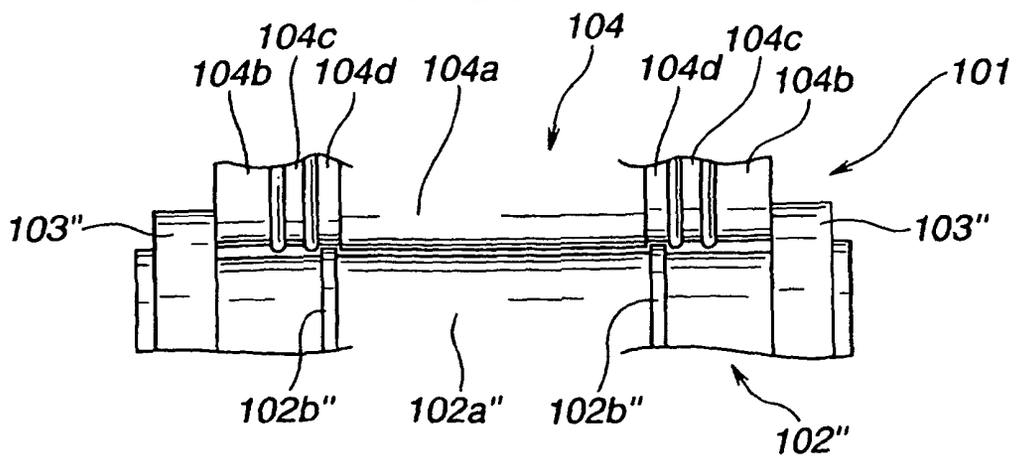

FIG.16A

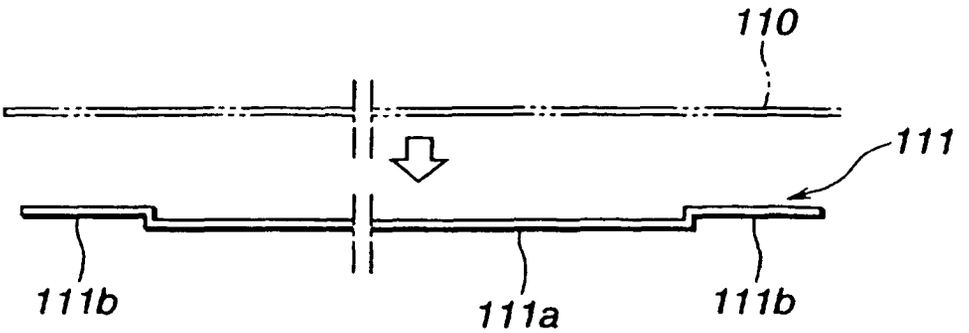

FIG.16B

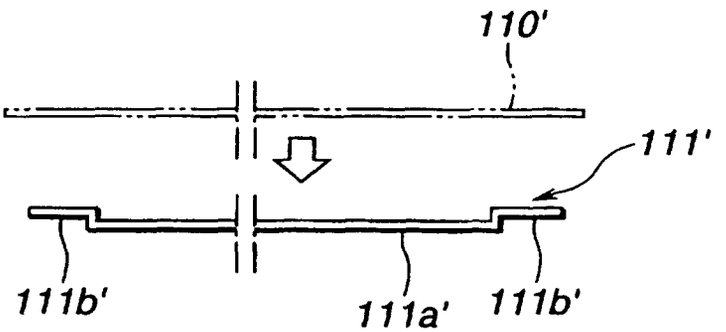

FIG.16C