(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 4 527 518 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
26.03.2025 Bulletin 2025/13

(21) Application number: **23807415.7**

(22) Date of filing: **27.04.2023**

(51) International Patent Classification (IPC):
B21D 28/16 *(2006.01)* ***B21D 28/14*** *(2006.01)*

(52) Cooperative Patent Classification (CPC):
B21D 28/14; B21D 28/16

(86) International application number:
PCT/JP2023/016706

(87) International publication number:
WO 2023/223805 (23.11.2023 Gazette 2023/47)

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

(30) Priority: **17.05.2022 JP 2022080776**

(71) Applicant: **NIPPON STEEL CORPORATION**
Chiyoda-ku
Tokyo 100-8071 (JP)

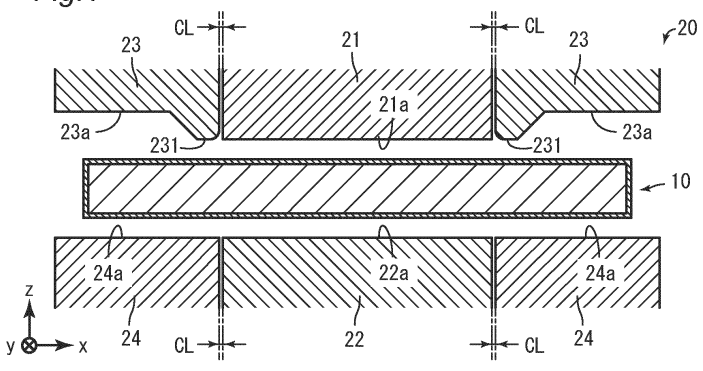
(72) Inventors:
- **NORITA, Katsunari**
  Tokyo 100-8071 (JP)
- **SASAKI, Hirokazu**
  Tokyo 100-8071 (JP)
- **ISSAKA, Hameed**
  Tokyo 100-8071 (JP)

(74) Representative: **Zimmermann & Partner**
Patentanwälte mbB
Postfach 330 920
80069 München (DE)

(54) METHOD FOR MANUFACTURING METALLIC MEMBER, MOLD, AND METALLIC MEMBER

(57) A method of manufacturing a metallic member having a cut edge surface with improved corrosion resistance is provided. The method of manufacturing a metallic member uses a press tool (20) to stamp a metal sheet (10) having front and back faces covered with a coating layer, thus producing a metallic member. The press tool (20) includes a punch (21), a counter-pad (22), a sheet holder (23), and a die (24). The sheet holder (23) includes a projecting portion (231) at an inner circumferential edge of the face facing the metal sheet (10), the projecting portion (231) of the sheet holder (23) including a corner at its inner circumference, the corner having a radius of curvature *R1,* the radius of curvature *R1* being not smaller than 0.10 times the thickness of the metal sheet (10). The manufacturing method includes: pushing the projecting portion (231) of the sheet holder (23) into the metal sheet (10); and moving the punch (21) and the die (24) closer to each other to stamp the metal sheet (10).

Fig.1



EP 4 527 518 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to a method of manufacturing a metallic member, a press tool, and a metallic member.

BACKGROUND ART

[0002] Steel members of automobiles and buildings are usually produced through press working. When a corrosion-resistant steel member needs to be produced, a material in the form of cold-rolled steel sheet or hot-rolled steel sheet is pressed and then provided with paint and/or plating. Providing painting and/or plating steps after pressing increases work time and/or costs.

[0003] To solve this problem, a material in the form of plated steel sheet may be pressed. However, if a plated steel sheet is subjected to a press-working process that involves cutting, such as stamping, the plating layer is severed at the cut edge surface, exposing base steel. If the base steel at the cut edge surface remains exposed, corrosion initiates at the cut edge surface. Addressing this requires an additional step for plating the cut edge surface at which base steel is exposed, which increases work time and costs.

[0004] JP 2021-133391 A discloses a cutting tool including a fixed tool portion and a movable tool portion. The movable tool portion is constructed to cut a metal sheet by performing a first cutting step, where the clearance between the fixed and movable tool portions is $c+\Delta c$ ($\Delta c>0$), and a subsequent second cutting step, where the clearance between the fixed and movable tool portions is c.

[0005] JP 2017-87294 A discloses a method of cutting a surface-treated steel sheet using a tool including a die and a punch that provide a clearance of 1 to 20 % of the sheet thickness, where the corner of at least one of the die or punch is provided with a radius of curvature that is not smaller than 0.12 times the sheet thickness of the surface-treated steel sheet.

[0006] JP 2009-287082 A discloses a method of cutting a zinc-based plated steel sheet using a tool including a die, a punch and a die holder, wherein, to cut a zinc-based plated steel sheet with an amount of Zn adhering to each surface not smaller than 10g/m^2 and with a sheet thickness not larger than 2.0 mm, that one of the die and punch which corresponds to the product steel sheet has a rounded corner with a radius of curvature that is 0.10 to 0.50 times the sheet thickness of the steel sheet, whereas the corner of the other one and the corner of the die holder each form a right angle, and wherein the cutting is performed with the side surfaces of the die and die holder of the tool being aligned and with a clearance between the die and punch not larger than 1.0 % of the sheet thickness of the steel sheet.

[0007] JP 2020-32437 A discloses a cut product produced by coating surfaces of a base material with a coating material to produce a multi-layer material and then cutting it. The cut edge surface of this cut product includes a first inclined surface inclined from a first surface toward the middle as determined along the sheet-thickness direction, a second inclined surface inclined from a second surface toward the middle as determined along the sheet-thickness direction, and a fracture surface formed between the first and second inclined surfaces. At least some portions of the first and second inclined surfaces remain coated with the coating material that covers the surfaces of the base material.

[0008] One known precision shearing process that provides a smooth cut edge surface is the "opposite-die shearing method" (see, for example, JP H6-182461 A, JP 2000-210731 A, and JP 2005-14062 A).

PRIOR ART DOCUMENTS

PATENT DOCUMENTS

[0009]

Patent Document 1: JP 2021-133391 A
Patent Document 2: JP 2017-87294 A
Patent Document 3: JP 2009-287082 A
Patent Document 4: JP 2020-32437 A
Patent Document 5: JP H6-182461 A
Patent Document 6: JP 2000-210731 A
Patent Document 7: JP 2005-14062 A

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0010] JP 2021-133391 A, JP 2017-87294 A, and JP 2009-287082 A each discloses a particular tool construction specifically created to leave a section of the material's plating layer that goes around onto the cut edge surface. However, these methods leave such a go-around section of the plating layer from one direction, which means that the amount of the plating component that can be supplied onto the cut edge surface is limited.

[0011] A problem to be solved by the present invention is to provide a method of manufacturing a metallic member having a cut edge surface with improved corrosion resistance, a press tool capable of manufacturing a metallic member having a cut edge surface with improved corrosion resistance, and a metallic member having a cut edge surface with improved corrosion resistance.

MEANS FOR SOLVING THE PROBLEMS

[0012] A method of manufacturing a metallic member according to one embodiment of the present invention is a method of manufacturing a metallic member by using a press tool to stamp a metal sheet having front and back faces covered with a coating layer, the press tool includ-

ing: a punch; a counter-pad located opposite to the punch, the metal sheet being positioned between the punch and the counter-pad; a sheet holder located adjacent to the same side of the metal sheet as the punch as determined along a thickness direction of the sheet and positioned to surround the punch along in-plane directions of the metal sheet; and a die located adjacent to the same side of the metal sheet as the counter-pad as determined along the thickness direction of the sheet and positioned to surround the counter-pad along in-plane directions of the metal sheet, the sheet holder including a projecting portion at an inner circumferential edge of a face facing the metal sheet, the projecting portion of the sheet holder including a corner at an inner circumference, the corner having a radius of curvature *R1,* the radius of curvature *R1* being not smaller than 0.10 times a thickness of the metal sheet, the manufacturing method including: pushing the projecting portion of the sheet holder into the metal sheet; and moving the punch and the die closer to each other to stamp the metal sheet.

[0013] A method of manufacturing a metallic member according to one embodiment of the present invention is a method of manufacturing a metallic member by using a press tool to stamp a metal sheet having front and back faces covered with a coating layer, the press tool including: a punch; a counter-pad located opposite to the punch, the metal sheet being positioned between the punch and the counter-pad; a sheet holder located adjacent to the same side of the metal sheet as the punch as determined along a thickness direction of the sheet and positioned to surround the punch along in-plane directions of the metal sheet; and a die located adjacent to the same side of the metal sheet as the counter-pad as determined along the thickness direction of the sheet and positioned to surround the counter-pad along in-plane directions of the metal sheet, the punch including a projecting portion at a circumferential edge of a face facing the metal sheet, the projecting portion of the punch including a corner at an outer circumference, the corner having a radius of curvature *R3,* the radius of curvature *R3* being not smaller than 0.10 times a thickness of the metal sheet, the manufacturing method including: pushing the projecting portion of the punch into the metal sheet; and moving the counter-pad and the sheet holder closer to each other to stamp the metal sheet.

[0014] A press tool according to one embodiment of the present invention includes: a punch; a counter-pad located opposite to the punch, a metal sheet representing a workpiece being positioned between the punch and the counter-pad; a sheet holder located adjacent to the same side of the metal sheet as the punch as determined along a thickness direction of the sheet and positioned to surround the punch along in-plane directions of the metal sheet; and a die located adjacent to the same side of the metal sheet as the counter-pad as determined along the thickness direction of the sheet and positioned to surround the counter-pad along in-plane directions of the metal sheet, the sheet holder including a projecting portion at an inner circumferential edge of a face facing the metal sheet, the projecting portion of the sheet holder including a corner at an inner circumference, the corner having a radius of curvature *R1,* the radius of curvature *R1* being not smaller than 0.2 mm.

[0015] A press tool according to one embodiment of the present invention includes: a punch; a counter-pad located opposite to the punch, a metal sheet representing a workpiece being positioned between the punch and the counter-pad; a sheet holder located adjacent to the same side of the metal sheet as the punch as determined along a thickness direction of the sheet and positioned to surround the punch along in-plane directions of the metal sheet; and a die located adjacent to the same side of the metal sheet as the counter-pad as determined along the thickness direction of the sheet and positioned to surround the counter-pad along in-plane directions of the metal sheet, the punch including a projecting portion at a circumferential edge of a face facing the metal sheet, the projecting portion of the punch including a corner at an outer circumference, the corner having a radius of curvature *R3,* the radius of curvature *R3* being not smaller than 0.2 mm.

[0016] A metallic member according to one embodiment of the present invention is a metallic member formed by stamping a metal sheet having front and back faces covered with a coating layer, including a cut edge surface formed by the stamping, the cut edge surface including: a sheared surface; and a recessed surface represented by a curved surface having a shape protruding inwardly with respect to the member, at least a portion of the recessed surface being covered with the coating layer.

[0017] A method of manufacturing a metallic member according to one embodiment of the present invention is a method of manufacturing a metallic member by using a press tool to stamp a metal sheet having front and back faces covered with a coating layer,
the press tool including:

a punch;
a counter-pad located opposite to the punch, the metal sheet being positioned between the punch and the counter-pad;
a sheet holder located adjacent to the same side of the metal sheet as the punch as determined along a thickness direction of the sheet and positioned to surround the punch along in-plane directions of the metal sheet; and
a die located adjacent to the same side of the metal sheet as the counter-pad as determined along the thickness direction of the sheet and positioned to surround the counter-pad along in-plane directions of the metal sheet,
the press tool further including the following construction A) or B):

A) the sheet holder including a projecting portion

at an inner circumferential edge of a face facing the metal sheet, the projecting portion of the sheet holder including a corner at an inner circumference, the corner having a radius of curvature *R1,* the radius of curvature *R1* being not smaller than 0.10 times a thickness of the metal sheet, or

B) the punch including a projecting portion at a circumferential edge of a face facing the metal sheet, the projecting portion of the punch including a corner at an outer circumference, the corner having a radius of curvature *R3,* the radius of curvature *R3* being not smaller than 0.10 times a thickness of the metal sheet,

the manufacturing method including:

pushing the projecting portion of the sheet holder into the metal sheet; and
stamping the metal sheet.

[0018] A press tool according to one embodiment of the present invention includes:

a punch;
a counter-pad located opposite to the punch, a metal sheet representing a workpiece being positioned between the punch and the counter-pad;
a sheet holder located adjacent to the same side of the metal sheet as the punch as determined along a thickness direction of the sheet and positioned to surround the punch along in-plane directions of the metal sheet; and
a die located adjacent to the same side of the metal sheet as the counter-pad as determined along the thickness direction of the sheet and positioned to surround the counter-pad along in-plane directions of the metal sheet,
the press tool further including the following construction A) or B):

A) the sheet holder including a projecting portion at an inner circumferential edge of a face facing the metal sheet, the projecting portion of the sheet holder including a corner at an inner circumference, the corner having a radius of curvature *R1,* the radius of curvature *R1* being not smaller than 0.2 mm, or

B) the punch including a projecting portion at a circumferential edge of a face facing the metal sheet, the projecting portion of the punch including a corner at an outer circumference, the corner having a radius of curvature *R3,* the radius of curvature *R3* being not smaller than 0.2 mm.

EFFECTS OF THE INVENTION

[0019] The present invention provides a metallic member having a cut edge surface with improved corrosion resistance.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020]

[FIG. 1] FIG. 1 is a cross-sectional view of a press tool according to a first embodiment of the present invention, schematically illustrating its construction.
[FIG. 2] FIG. 2 is a cross-sectional view of a portion of the sheet holder of the press tool of FIG. 1.
[FIG. 3] FIG. 3 is a cross-sectional view of a variation of the sheet holder of the press tool of FIG. 1.
[FIG. 4] FIG. 4 is a flow chart of a method of manufacturing a metallic member according to one embodiment of the present invention.
[FIG. 5] FIG. 5 is a cross-sectional view schematically illustrating a moment during the manufacture of a metallic member.
[FIG. 6] FIG. 6 is a cross-sectional view schematically illustrating a moment during the manufacture of a metallic member.
[FIG. 7] FIG. 7 is an enlarged schematic cross-sectional view of the projecting portion and nearby portions.
[FIG. 8] FIG. 8 is a cross-sectional view schematically illustrating a moment during the manufacture of a metallic member.
[FIG. 9] FIG. 9 is a cross-sectional view of a metallic member according to one embodiment of the present invention, schematically illustrating its construction.
[FIG. 10] FIG. 10 is a cross-sectional view of a press tool according to a second embodiment of the present invention, schematically illustrating its construction.
[FIG. 11] FIG. 11 is a cross-sectional view of a portion of the die of the press tool of FIG. 10.
[FIG. 12] FIG. 12 is a cross-sectional view schematically illustrating a moment during the manufacture of a metallic member.
[FIG. 13] FIG. 13 is a cross-sectional view schematically illustrating a moment during the manufacture of a metallic member.
[FIG. 14] FIG. 14 is a cross-sectional view schematically illustrating a moment during the manufacture of a metallic member.
[FIG. 15] FIG. 15 is a cross-sectional view of a metallic member according to one embodiment of the present invention, schematically illustrating its construction.
[FIG. 16] FIG. 16 is a cross-sectional view of a press tool according to a third embodiment of the present invention, schematically illustrating its construction.
[FIG. 17] FIG. 17 is a cross-sectional view of a portion of the die of the press tool of FIG. 16.
[FIG. 18] FIG. 18 is a cross-sectional view schema-

tically illustrating a moment during the manufacture of a metallic member.

[FIG. 19] FIG. 19 is a cross-sectional view schematically illustrating a moment during the manufacture of a metallic member.

[FIG. 20] FIG. 20 is a cross-sectional view schematically illustrating a moment during the manufacture of a metallic member.

[FIG. 21] FIG. 21 is a cross-sectional view of a metallic member according to one embodiment of the present invention, schematically illustrating its construction.

[FIG. 22] FIG. 22 is a cross-sectional view of a press tool according to a fourth embodiment of the present invention, schematically illustrating its construction.

[FIG. 23] FIG. 23 is a cross-sectional view of a portion of the punch of the press tool of FIG. 22.

[FIG. 24] FIG. 24 is a cross-sectional view schematically illustrating a moment during the manufacture of a metallic member.

[FIG. 25] FIG. 25 is a cross-sectional view schematically illustrating a moment during the manufacture of a metallic member.

[FIG. 26] FIG. 26 is a cross-sectional view schematically illustrating a moment during the manufacture of a metallic member.

[FIG. 27] FIG. 27 is a cross-sectional view of a press tool according to a fifth embodiment of the present invention, schematically illustrating its construction.

[FIG. 28] FIG. 28 is a cross-sectional view of a portion of the counter-pad of the press tool of FIG. 27.

[FIG. 29] FIG. 29 is a cross-sectional view schematically illustrating a moment during the manufacture of a metallic member.

[FIG. 30] FIG. 30 is a cross-sectional view schematically illustrating a moment during the manufacture of a metallic member.

[FIG. 31] FIG. 31 is a cross-sectional view schematically illustrating a moment during the manufacture of a metallic member.

[FIG. 32] FIG. 32 is a cross-sectional view of a press tool according to a sixth embodiment of the present invention, schematically illustrating its construction.

[FIG. 33] FIG. 33 is a cross-sectional view of a portion of the counter-pad of the press tool of FIG. 32.

[FIG. 34] FIG. 34 is a cross-sectional view schematically illustrating a moment during the manufacture of a metallic member.

[FIG. 35] FIG. 35 is a cross-sectional view schematically illustrating a moment during the manufacture of a metallic member.

[FIG. 36] FIG. 36 is a cross-sectional view schematically illustrating a moment during the manufacture of a metallic member.

[FIG. 37] FIG. 37 schematically illustrates the distribution of the plating layer found when the projecting portion of the sheet holder has been pushed into the metal sheet, calculated by CAE.

[FIG. 38] FIG. 38 is a graph showing the relationship between the radius of curvature *R1* and the distance of coating with plating, *d*.

[FIG. 39] FIG. 39 illustrates plating coverage.

[FIG. 40] FIG. 40 shows plating coverage obtained by CAE.

EMBODIMENTS FOR CARRYING OUT THE INVENTION

[0021] Now, embodiments of the present invention will be described in detail with reference to the drawings. The same or corresponding components in the drawings are labeled with the same reference numerals, and their description will not be repeated. The size ratios between the components shown in the drawings do not necessary represent the actual size ratios.

[First Embodiment]

[Press tool]

[0022] FIG. 1 is a cross-sectional view of a press tool 20 according to a first embodiment of the present invention, schematically illustrating its construction. The press tool 20 is used for stamping a metal sheet. The press tool 20 includes a punch 21, a counter-pad 22, a sheet holder (i.e., upper die part) 23, and a die (i.e., lower die part) 24. The counter-pad 22 is located opposite to the punch 21, a metal sheet 10 representing a workpiece being positioned between the punch and counter-pad. The sheet holder 23 is located adjacent to the same side of the metal sheet 10 as the punch 21 as determined along the thickness direction of the sheet (i.e., z-direction of FIG. 1), and positioned to surround the punch 21 along in-plane directions of the metal sheet 10 (i.e., xy-in-plane directions of FIG. 1). The die 24 is located adjacent to the same side of the metal sheet 10 as the counter-pad 22 as determined along the thickness direction of the sheet and is positioned to surround the counter-pad 22 along in-plane directions of the metal sheet 10.

[0023] The punch 21 and counter-pad 22 include faces 21a and 22a, respectively, that face the metal sheet 10. Both the face 21a and the face 22a are flat surfaces parallel to the metal sheet 10. The faces 21a and 22a have the same planar shape (shape in an xy-plane). The faces 21a and 22a may have any planar shape, and may be circular, elliptical or rectangular, for example.

[0024] A clearance CL of a predetermined size is provided between the punch 21 and sheet holder 23. Similarly, a clearance CL of a predetermined size is provided between the counter-pad 22 and die 24. Preferably, the clearance CL has a generally constant size across the entire outer circumference of the punch 21 or counter-pad 22.

[0025] The sheet holder 23 includes a projecting portion 231 at an inner circumferential edge of the face 23a facing the metal sheet 10. As used herein, the inner

circumferential edge of the face 23a means its circumferential edge adjacent to the punch 21.

[0026] The face 24a of the die 24 that faces the metal sheet 10 is a flat surface parallel to the metal sheet 10.

[0027] FIG. 2 is a cross-sectional view of a portion of the sheet holder 23. The projecting portion 231 includes a corner 231a at its inner circumference, the corner having a radius of curvature *R1.* As used herein, the inner circumference of the projecting portion 231 means the side of the projecting portion 231 that is adjacent to the punch 21.

[0028] The radius of curvature *R1* of the corner 231a is preferably not smaller than 0.2 mm. The radius of curvature *R1* is more preferably not smaller than 0.3 mm, yet more preferably not smaller than 0.5 mm, still more preferably not smaller than 0.8 mm, and yet more preferably not smaller than 1.0 mm. Further, the radius of curvature *R1* of the corner 231a is preferably not smaller than 0.10 times the thickness of the metal sheet 10, i.e., workpiece. A lower limit of the radius of curvature *R1* is more preferably 0.20 times the thickness of the metal sheet 10, and yet more preferably 0.30 times the thickness of the metal sheet 10. An upper limit of the radius of curvature *R1* is preferably 0.40 times the thickness of the metal sheet 10.

[0029] The height of the projecting portion 231, *h1,* is preferably not smaller than 0.25 times the thickness of the metal sheet 10, i.e., workpiece. A lower limit of the height *h1* is more preferably 0.30 times the thickness of the metal sheet 10, and yet more preferably 0.50 times the thickness of the metal sheet 10. An upper limit of the height *h1* is preferably 1.00 times the thickness of the metal sheet 10.

[0030] The side of the projecting portion 231 opposite to the corner 231a may have any shape. In the implementation of FIG. 2, the projecting portion 231 has an inclined portion 231b constituting its side opposite to the corner 231a. The inclined portion 231b is shaped so as to expand toward the outer circumference (i.e., in directions away from the punch 21) as it goes closer to the face 23a. As the projecting portion 231 includes such an inclined portion 231b, the durability of the projecting portion 231 is improved. It will be understood that the inclined portion 231b may have a shape represented by a straight line, as shown in FIG. 2, or may have a shape represented by a curved line, such as the inclined portion 231Ab shown in FIG. 3.

[Method of Manufacturing Metallic Member]

[0031] Next, a method of manufacturing a metallic member according to one embodiment of the present invention will be described. The method of manufacturing a metallic member according to the present embodiment uses the above-described press tool 20 to stamp a metal sheet having front and back faces covered with a coating layer (hereinafter referred to as "surface-coated metal sheet") to produce a metallic member.

[0032] Although not limiting, the base material of the surface-coated metal sheet may be steel, copper, a copper alloy, aluminum, or an aluminum alloy, for example. The manufacturing method according to the present embodiment is particularly suitable for implementations where the base material of the surface-coated metal sheet is steel. This is because steel is prone to rust and, as such, providing corrosion resistance to steel has a significant advantage. The coating layer may be a plating layer, a paint layer, or a resin layer, for example. The coated metal sheet is typically a plated steel sheet. The plated steel sheet may be a Zn-based plated steel sheet or an Al-based plated steel sheet, for example. The following description discusses a plating layer as an example of a coating layer and a surface-plated metal sheet as an example of a surface-coated metal sheet.

[0033] More preferably, the surface-plated metal sheet is a Zn-based plated steel sheet. A Zn-based plating acts as a sacrificial corrosion protection for the steel sheet, i.e., base material. This prevents corrosion initiating at exposed base material at the cut edge surface resulting from the shearing, thereby further increasing the corrosion resistance of the produced metallic member. Although not limiting, the Zn-based plating may be hot-dip galvanizing, galvannealing, Zn-Ni-based plating, Zn-Al-based plating, Zn-Mg-based plating, or Zn-Al-Mg-based plating, for example.

[0034] Although not limiting, the sheet thickness of the surface-plated metal sheet is 1.0 to 6.0 mm, for example.

[0035] The thickness of the plating layer of the surface-plated metal sheet (i.e., thickness as measured at one face of the sheet; the same applies hereinafter) is preferably not smaller than 15 μm. If the thickness of the plating layer is too small, the plating layer may be insufficient for covering the cut edge surface, in which case corrosion resistance may not be provided to the cut edge surface. A lower limit of the thickness of the plating layer of the surface-plated metal sheet is more preferably 30 μm. Although not limiting, an upper limit of the thickness of the plating layer of the surface-plated metal sheet is 150 μm, for example.

[0036] FIG. 4 is a flow chart of a method of manufacturing a metallic member according to one embodiment of the present invention. The manufacturing method includes: a step in which a surface-plated metal sheet (hereinafter simply referred to as "metal sheet 10") is placed on the counter-pad 22 and die 24 (step S1); a step in which the projecting portion 231 of the sheet holder 23 is pushed into the metal sheet 10 (step S2); and a step in which the punch 21 and die 24 are moved closer to each other to stamp the metal sheet 10 (step S3).

[0037] The various steps will be described below with reference to FIGS. 5 to 8. All of these drawings are schematic views. As stated above, the size ratios between the components shown in the drawings do not necessary represent the actual size ratios (the same applies to FIGS. 1 to 3 and FIGS. 9 sqq.).

[0038] The metal sheet 10 is placed on the counter-pad

22 and die 24 (step S1; see FIG. 5). The metal sheet 10 has front and back faces covered with a plating layer 10a. FIG. 5 and other drawings show implementations where the edge surfaces of the metal sheet 10 are also covered with the plating layer 10a; in other implementations, the edge surfaces of the metal sheet 10 may not be covered with the plating layer 10a.

[0039] The projecting portion 231 of the sheet holder 23 is pushed into the metal sheet 10 (step S2; see FIG. 6). For example, a press, not shown, may be used to apply pressures of the same magnitude to the punch 21 and counter-pad 22 to sandwich the metal sheet 10 and thus hold the metal sheet 10. With the sheet kept in this state, the die 24 is fixed in position and the sheet holder 23 is moved closer to the die 24 to push the projecting portion 231 of the sheet holder 23 into the metal sheet 10. In other implementations, instead of applying pressures of the same magnitude to the punch 21 and counter-pad 22, one of the punch 21 and counter-pad 22 may be fixed in position and, with this one kept in this state, pressure may be applied to the other one to sandwich the metal sheet 10.

[0040] FIG. 7 is an enlarged schematic cross-sectional view of the projecting portion 231 and nearby portions. As the projecting portion 231 is pushed in, a recess 10b is formed in the metal sheet 10 and, at the same time, a go-around section of the plating layer 10a is left on a wall of the recess 10b. At this time, as the corner 231a of the projecting portion 231 has a predetermined radius of curvature *R1,* a go-around section of the plating layer 10a will be left on that one of the two walls 10b1 and 10b2 of the recess 10b which is adjacent to the corner 231a, i.e., wall 10b1.

[0041] This wall 10b1 is located inward of (i.e., further toward the center of the punch 21 than) the surface of the projecting portion 231 as determined along in-plane directions of the metal sheet 10 (i.e., xy-in-plane directions). In other words, a small gap is formed between the wall 10b1 and projecting portion 231. This is because portions of the material pushed in by the projecting portion 231 move toward the center of the punch 21 due to plastic flow.

[0042] FIG. 7 shows an implementation where a go-around section of the plating layer 10a is also left on the wall 10b2 adjacent to the inclined portion 231b; in other implementations, no go-around section of the plating layer 10a may be left on the wall 10b2.

[0043] The punch 21 and die 24 are moved closer to each other to stamp the metal sheet 10 (step S3; see FIG. 8). For example, with the die 24 fixed in position, pressure is applied to the sheet holder 23 such that the sheet holder 23 and die 24 sandwich the metal sheet 10 and thus hold the metal sheet 10. With the sheet kept in this state, the punch 21 is moved closer to the die 24 to stamp the metal sheet 10. At this time, a pressure may be applied to the counter-pad 22 that is lower than the pressure applied to the punch 21 to support the metal sheet 10 from below.

[0044] Alternatively, in lieu of fixing the die 24 in position and applying pressure to the sheet holder 23, the metal sheet 10 may be sandwiched by fixing the sheet holder 23 in position and, with the sheet holder kept in this state, applying pressure to the die 24, or by applying pressures of the same magnitude to the sheet holder 23 and die 24.

[0045] Alternatively, in lieu of moving the punch 21, the die 24 may be moved to stamp the metal sheet 10. Specifically, with the metal sheet 10 sandwiched between the punch 21 and counter-pad 22, the die 24 may be moved closer to the punch 21 to stamp the metal sheet 10. Alternatively, both the punch 21 and die 24 may be moved to stamp the metal sheet 10.

[0046] As a result, the metal sheet 10 is separated into a metallic member 11 and remainder 119. According to the present embodiment, the portion of the sheet sandwiched between the punch 21 and counter-pad 22 provides the metallic member 11. At this time, a go-around section of the plating layer 10a from one surface of the metal sheet 10 (i.e., surface in contact with the counter-pad 22) is left on the cut edge surface 111 of the metallic member 11.

[0047] It will be understood that steps S2 and S3 may be performed as a single step by employing a double-action press or equipment capable of independently driving the punch 21 and sheet holder 23. Nevertheless, it is preferable that step S2 and step S3 are performed separately because this will allow the use of equipment with a simpler construction. For example, simple construction may be provided where, at step S2, the press is lowered to perform recess formation using the sheet holder 23 alone and, at step S3, pressure is applied to the sheet holder 23 using a spring, for example, and the punch 21 is lowered to perform stamping.

[0048] The above description relates to an implementation where the metal sheet 10 is placed on the counter-pad 22 and die 24 before working the metal sheet 10. In other implementations, the top and bottom of the press tool 20 (i.e., the arrangement in the z-direction) may be reversed, where the metal sheet 10 is placed on the punch 21 and sheet holder 23 before being worked. In such implementations, too, the step of pushing the projecting portion 231 of the sheet holder 23 into the metal sheet 10 (step S2) and the step of moving the punch 21 and die 24 closer to each other to stamp the metal sheet 10 (step S3) may be performed in the same manner.

[Metallic Member]

[0049] FIG. 9 is a cross-sectional view of a metallic member 11 according to one embodiment of the present invention, schematically illustrating its construction. The metallic member 11 is formed by stamping a surface-plated metal sheet. The metallic member 11 includes a cut edge surface 111 formed through the stamping.

[0050] In addition to the cut edge surface 111, the metallic member 11 includes a first surface 112 and a

second surface 113 opposite to the first surface 112. The first and second surfaces 112 and 113 may have any planar shape (shape in an xy-plane). The first and second surfaces 112 and 113 are covered with a plating layer 10a. The plating layer 10a is derived from the plating layer of the material, i.e., surface-plated metal sheet.

[0051] The cut edge surface 111 includes a sheared surface 111a, a recessed surface 111b, and an undercut contiguous to the recessed surface 111b, 111e.

[0052] The cut edge surface 111 further includes a fracture surface 111c and an undercut contiguous to the sheared surface 111a (i.e., second undercut), 111d. As determined along the thickness direction of the metallic member 11 (i.e., z-direction), the fracture surface 111c is located between the sheared surface 111a and recessed surface 111b. As determined along the thickness direction of the metallic member 11 (i.e., z-direction), the undercut 111d is located contiguous to the side of the sheared surface 111a opposite to that adjacent to the recessed surface 111b. In other words, as determined along the thickness direction of the metallic member 11 (i.e., z-direction), the sheared surface 111a is located between the recessed surface 111b and undercut 111d.

[0053] Depending on the working conditions and other factors, the cut edge surface 111 may not include a fracture surface 111c.

[0054] The recessed surface 111b is formed by the step of pushing the projecting portion 231 into the metal sheet 10 (i.e. step S2 in FIG. 4). Each of the undercut 111d and undercut 111e is a curved surface that protrudes outwardly with respect to the member, whereas the recessed surface 111b is a curved surface of a shape that protrudes inwardly with respect to the member.

[0055] The recessed surface 111b is recessed by an amount of sinking *W1* with respect to the sheared surface 111a. The amount of sinking *W1* is defined as, in a cross section of the metallic member 11, the distance between the tangent to the sheared surface 111a and the inward-most point on the recessed surface 111b. The amount of sinking *W1* may be, for example, 0.01 to 0.15 times the thickness of the metallic member 11. A lower limit of the amount of sinking *W1* is preferably 0.02 times the thickness of the metallic member 11. An upper limit of the amount of sinking *W1* is preferably 0.10 times the thickness of the metallic member 11.

[0056] According to the present embodiment, at least a portion of the recessed surface 111b is covered with the plating layer 10a. This improves the corrosion resistance of the cut edge surface 111.

[0057] In addition to at least a portion of the recessed surface 111b being covered with the plating layer 10a, it is preferable that not less than 50 % of the total area of the recessed surface 111b and the undercut 111e contiguous to the recessed surface 111b is covered with the plating layer 10a. In more detail, it is preferable that $d/(t1+t2)$ is not less than 0.5 (i.e., not less than 50 %), where *t1* and *t2* are the dimensions of the recessed surface 111b and undercut 111e, respectively, as measured in the thickness direction of the metal sheet 10, and dis the dimension of that portion of the total area of the recessed surface 111b and undercut 111e which is covered with the plating layer 10a as measured in the thickness direction of the metal sheet 10. The determination as to whether a given portion is covered with the plating layer 10a may be based on measurements on the cut edge surface 111 using an energy dispersive X-ray analyzer (EDX), for example.

[0058] More preferably, $d/(t1+t2)$ is not less than 75 %. Most preferably, the entire recessed surface 111b is covered with the plating layer 10a.

[0059] Typically, the undercut 111d contiguous to the sheared surface 111a is entirely covered with the plating layer 10a. At least a portion of the sheared surface 111a is covered with the plating layer 10a. Typically, the fracture surface 111c is not covered with the plating layer 10a.

[0060] As is the case with the plating layer 10a covering the first and second surfaces 112 and 113, the plating layer 10a covering the sheared surface 111a, recessed surface 111b and undercuts 111d and 111e is derived from the plating layer of the material, i.e., surface-plated metal sheet. Thus, the plating layer 10a covering the sheared surface 111a, recessed surface 111b and undercut 111d and the plating layer 10a covering the first and second surfaces 112 and 113 are one and the same plating layer.

[Effects of Present Embodiment]

[0061] The press tool 20, the method of the manufacturing a metallic member, and the metallic member 11 according to the first embodiment of the present invention have been described. The sheet holder 23 of the press tool 20 includes a projecting portion 231 at the inner circumferential edge of the face 23a facing the metal sheet 10. The projecting portion 231 includes a corner 231a at its inner circumference, the corner having a radius of curvature *R1* (FIG. 2). As this projecting portion 231 is pushed into the metal sheet 10, a recess 10b (FIG. 7) is formed in the metal sheet 10 and, at the same time, a go-around section of the plating layer 10a is left on a wall of the recess 10b. As the corner 231a of the projecting portion 231 has a predetermined radius of curvature *R1,* a go-around section of the plating layer 10a is left on that one of the two walls 10b1 and 10b2 of the recess 10b which is adjacent to the corner 231a, i.e., wall 10b1. The wall 10b1 corresponds to the recessed surface 111b (FIG. 9) of the metallic member 11. At least a portion of the recessed surface 111b is covered with the plating layer 10a.

[0062] The press tool 20 according to the present embodiment and the method of manufacturing a metallic member according to the present embodiment are capable of supplying the plating layer 10a from both sides of the cut edge surface 111 arranged in the thickness direction (i.e., z-direction). In other words, the plate layer 10a may be supplied not only from the second surface 113,

but also from the first surface 112. Specifically, in addition to the undercut 111d and sheared surface 111a, at least a portion of the recessed surface 111b may be covered with the plating layer 10a. This provides a metallic member 11 with a cut edge surface 111 with improved corrosion resistance.

[0063] Now, second to sixth embodiments of the present embodiment will be described. Features in which these embodiments are different from the first embodiment will be mainly described below, and common features may not be described again.

[Second Embodiment]

[Press tool]

[0064] FIG. 10 is a cross-sectional view of a press tool 30 according to a second embodiment of the present invention, schematically illustrating its construction. The press tool 30 includes a die 34, which replaces the die 24 (FIG. 1) of the press tool 20 of the first embodiment.

[0065] The die 34 includes a projecting portion 341 at an inner circumferential edge of the of the face 34a facing the metal sheet 10. As used herein, the inner circumferential edge of the face 34a means its circumferential edge adjacent to the counter-pad 22.

[0066] FIG. 11 is a cross-sectional view of a portion of the die 34. The die 34 includes a corner 341a at its inner circumference, the corner having a radius of curvature *R2*. As used herein, the inner circumference of the projecting portion 341 means the side of the projecting portion 341 that is adjacent to the counter-pad 22.

[0067] The radius of curvature *R2* of the corner 341a has the same preferable ranges as the radius of curvature *R1* (FIG. 2) of the corner 231a of the projecting portion 231 of the sheet holder 23. The radii of curvature *R1* and *R2* may be equal, or may be different.

[0068] The height *h2* of the projecting portion 341 has the same preferable ranges as the height *h1* (FIG. 2) of the projecting portion 231 of the sheet holder 23. The heights *h1* and *h2* may be equal, or may be different.

[Method of Manufacturing Metallic Member]

[0069] A method of manufacturing a metallic member according to the present embodiment uses the above-described press tool 30 to stamp a surface-plated metal sheet to produce a metallic member. The manufacturing method includes the step of placing a metal sheet 10 on the counter-pad 22 and die 34, the step of pushing the projecting portion 231 of the sheet holder 23 and the projecting portion 341 of the die 34 into the metal sheet 10, and the step of moving the punch 21 and die 34 closer to each other to stamp the metal sheet 10. The various steps will be described below with reference to FIGS. 12 to 14.

[0070] A metal sheet 10 is placed on the counter-pad 22 and die 34 (see FIG. 12). In the present embodiment, too, in some implementations the top and bottom of the press tool 30 (i.e., the arrangement in the z-direction) may be reversed, where the metal sheet 10 is placed on the punch 21 and sheet holder 23 before being worked.

[0071] The projecting portion 231 of the sheet holder 23 and the projecting portion 341 of the die 34 are pushed into the metal sheet 10 (see FIG. 13). For example, the punch 21 and counter-pad 22 are caused to sandwich the metal sheet 10 to hold the metal sheet 10. With the sheet kept in this state, the sheet holder 23 and die 34 are moved closer to each other to push the projecting portion 231 of the sheet holder 23 and the projecting portion 341 of the die 34 into the metal sheet 10. In lieu of moving both the sheet holder 23 and die 34, one of the sheet holder 23 and die 34 may be fixed and only the other one may be moved. In such implementations, too, the pressures applied to the punch 21 and counter-pad 22 may be controlled appropriately to enable the projecting portion 231 of the sheet holder 23 and the projecting portion 341 of the die 34 to be pushed into the metal sheet 10.

[0072] The punch 21 and die 34 are moved closer to each other to stamp the metal sheet 10 (see FIG. 14). Thus, the metal sheet 10 is separated into a metallic member 12 and remainder 129. In the present embodiment, the portion of the sheet sandwiched between the punch 21 and counter-pad 22 provides the metallic member 12.

[Metallic Member]

[0073] FIG. 15 is a cross-sectional view of a metallic member 12 according to one embodiment of the present invention, schematically illustrating its construction. The metallic member 12 is formed by stamping a surface-plated metal sheet. The metallic member 12 includes a cut edge surface 121 formed through stamping. In addition to the cut edge surface 121, the metallic member 12 includes a first surface 122 and a second surface 123. The first and second surfaces 122 and 123 are covered with a plating layer 10a.

[0074] The cut edge surface 121 includes a sheared surface 121a, a recessed surface 121b, and an undercut contiguous to the recessed surface 121b, 121e.

[0075] The cut edge surface 121 further includes a fracture surface 121c, a second recessed surface 121d, and an undercut contiguous to the second recessed surface 121d, 121f. As determined along the thickness direction of the metallic member 12 (i.e., z-direction), the fracture surface 121c is located between the sheared surface 121a and recessed surface 121b. As determined along the thickness direction of the metallic member 12 (i.e., z-direction), the second recessed surface 121d is located contiguous to the side of the sheared surface 121a opposite to that adjacent to the recessed surface 121b. In other words, as determined along the thickness direction of the metallic member 12 (i.e., z-direction), the sheared surface 121a is located between the recessed surface 121b and the second recessed

surface 121d.

[0076] In the present embodiment, too, depending on the working conditions and other features, the cut edge surface 121 may not include a fracture surface 121c.

[0077] Each of the recessed surface 121b and second recessed surface 121d is a curved surface of a shape that protrudes inwardly with respect to the member. The amount of sinking *W2* of the recessed surface 121b and the amount of sinking *W3* of the second recessed surface 121d have the same ranges as the amount of sinking *W1* (FIG. 9) of the recessed surface 111b of the metallic member 11. It is to be noted that the amount of sinking *W3* of the second recessed surface 121d tends to be smaller than the amount of sinking *W2* of the recessed surface 121b.

[0078] In the present embodiment, too, at least a portion of the recessed surface 121b is covered with the plating layer 10a. This improves the corrosion resistance of the cut edge surface 121. In the present embodiment, too, in addition to at least a portion of the recessed surface 121b being covered with the plating layer 10a, it is more preferable that not less than 50 % of the total area of the recessed surface 121b and the undercut 121e contiguous to the recessed surface 121b is covered with the plating layer 10a. The preferable proportions of the total area of the recessed surface 121b and undercut 121e covered with the plating layer 10a and other associated features are the same as for the metallic member 11.

[0079] Typically, the undercut 121f contiguous to the second recessed surface 121d is entirely covered with the plating layer 10a. At least a portion of the second recessed surface 121d is covered with the plating layer 10a. The sheared surface 121a may be entirely covered, partially covered, or not covered at all, with the plating layer 10a. Typically, the fracture surface 121c is not covered with the plating layer 10a.

[Effects of Present Embodiment]

[0080] The press tool 30, the method of the manufacturing a metallic member, and the metallic member 12 according to the second embodiment of the present invention have been described. According to the present embodiment, the projecting portions 231 and 341 are pushed into the metal sheet 10 to supply the plating layer 10a from both sides of the metal sheet 10 arranged in the thickness direction. Further, when the remaining middle portion is stamped through, the predetermined radius of curvature *R2* of the corner 341a of the projecting portion 341 allows a larger amount of the plating layer 10a to provide a go-around section on the cut edge surface 121. This provides a metallic member 12 having a cut edge surface 121 with improved corrosion resistance.

[Third Embodiment]

[Press tool]

[0081] FIG. 16 is a cross-sectional view of a press tool 40 according to a third embodiment of the present invention, schematically illustrating its construction. The press tool 40 includes a die 44, which replaces the die 24 (FIG. 1) of the press tool 20 of the first embodiment.

[0082] FIG. 17 is a cross-sectional view of a portion of the die 44. The face 44a of the die 44 that faces the metal sheet 10 is a flat surface parallel to the metal sheet 10. The die 44 includes a double corner at its inner circumference. A used herein, the inner circumference of the die 44 means the side of the die adjacent to the counter-pad 22. The double corner includes a first sub-corner 441 and a second sub-corner 442. The second sub-corner 442 is located farther from the metal sheet 10 than the first sub-corner 441 is as measured in the thickness direction of the metal sheet 10 (i.e., z-direction), and located closer to the counter-pad 22 than the first sub-corner 441 is as measured in in-plane directions of the metal sheet 10 (i.e., xy-in-plane directions).

[0083] The step height *sh1* of the double corner is preferably larger than zero times and not larger than 0.50 times the thickness of the metal sheet 10, i.e., workpiece. The step height *sh1* is defined as the distance from the face 44a to the topmost point of the second sub-corner 442 (i.e., point closest to the face 44a) as measured in the z-direction. A lower limit of the step height *sh1* is preferably 0.10 times the thickness of the metal sheet 10, and more preferably 0.20 times.

[0084] The width *w1* of the double corner is preferably 0.10 to 0.70 times the thickness of the metal sheet 10, i.e., workpiece. The width *w1* is defined as the distance from the side of the first sub-corner 441 to the side of the second sub-corner 442 (i.e., inner circumferential surface of the die 44) as measured in xy-in-plane directions. A lower limit of the width *w1* is preferably 0.10 times the thickness of the metal sheet 10, and more preferably 0.20 times.

[0085] The radius of curvature *Rp2* of the second sub-corner 442 is preferably not smaller than 0.1 mm. The radius of curvature *Rp2* is more preferably not smaller than 0.2 mm, and yet more preferably not smaller than 0.3 mm. Further, the radius of curvature *Rp2* of the second sub-corner 442 is preferably not smaller than 0.10 times the thickness of the metal sheet 10, i.e., workpiece. A lower limit of the radius of curvature *Rp2* is more preferably 0.20 times the thickness of the metal sheet 10. An upper limit of the radius of curvature *Rp2* is preferably 0.70 times the thickness of the metal sheet 10.

[0086] The radius of curvature *Rp1* of the first sub-corner 441 is not limited to any particular value. For example, the radius of curvature *Rp1* is 0 to 0.50 times the radius of curvature *Rp2*. The radius of curvature *Rp1* may be zero.

[Method of Manufacturing Metallic Member]

[0087] A method of manufacturing a metallic member according to the present embodiment uses the above-described press tool 40 to stamp a surface-plated metal sheet to produce a metallic member. The manufacturing method includes the step of placing a metal sheet 10 on the counter-pad 22 and die 44, the step of pushing the projecting portion 231 of the sheet holder 23 into the metal sheet 10, and the step of moving the punch 21 and die 44 closer to each other to stamp the metal sheet 10. The various steps will be described below with reference to FIGS. 18 to 20.

[0088] A metal sheet 10 is placed on the counter-pad 22 and die 44 (see FIG. 18). In the present embodiment, too, in some implementations the top and bottom of the press tool 40 (i.e., the arrangement in the z-direction) may be reversed, where the metal sheet 10 is placed on the punch 21 and sheet holder 23 before being worked.

[0089] The projecting portion 231 of the sheet holder 23 is pushed into the metal sheet 10 (see FIG. 19). For example, the punch 21 and counter-pad 22 are caused to sandwich the metal sheet 10 to hold the metal sheet 10. With the sheet kept in this state, the sheet holder 23 is moved closer to the die 44 to push the projecting portion 231 of the sheet holder 23 into the metal sheet 10.

[0090] The punch 21 and die 44 are moved closer to each other to stamp the metal sheet 10 (see FIG. 20). Thus, the metal sheet 10 is separated into a metallic member 13 and remainder 139. According to the present embodiment, the portion of the sheet sandwiched between the punch 21 and counter-pad 22 provides the metallic member 13.

[Metallic Member]

[0091] FIG. 21 is a cross-sectional view of a metallic member 13 according to one embodiment of the present invention, schematically illustrating its construction. The metallic member 13 is formed by stamping a surface-plated metal sheet. The metallic member 13 includes a cut edge surface 131 formed through stamping. In addition to the cut edge surface 131, the metallic member 13 includes a first surface 132 and a second surface 133. The first and second surfaces 132 and 133 are covered with the plating layer 10a.

[0092] The cut edge surface 131 includes a sheared surface 131a, a recessed surface 131b, a fracture surface 131c, an undercut 131d, and an undercut 131e. The cut edge surface 131 generally has the same construction as the cut edge surface 111 (FIG. 9) of the metallic member 11. In more detail, in the cut edge surface 131, the undercut 131d is larger in size than the undercut 111d (FIG. 9) and, as a result, the proportions of the sheared surface 131a and fracture surface 131c are different from those in the metallic member 11.

[Effects of Present Embodiment]

[0093] According to the present embodiment, during the step of stamping the metal sheet 10, the width *w1* (FIG. 17) of the double corner increases the clearance between the punch 21 and die 44, thus increasing the size of a roll-over adjacent to the cut edge surface. As a result, the portion of the sheet that is in contact with the second sub-corner 442 is inclined appropriately and, during formation using the second sub-corner 442, the plating layer 10a can be moved more easily onto the cut edge surface. This provides a metallic member 13 having a cut edge surface 131 with improved corrosion resistance.

[Fourth Embodiment]

[Press tool]

[0094] FIG. 22 is a cross-sectional view of a press tool 50 according to a fourth embodiment of the present invention, schematically illustrating its construction. The press tool 50 includes a punch 51, which replaces the punch 21 (FIG. 1) of the press tool 20 of the first embodiment, and a sheet holder 53, which replaces the sheet holder 23.

[0095] The punch 51 includes a projecting portion 511 at a circumferential edge of the face 51a that faces the metal sheet 10.

[0096] The face 53a of the sheet holder 53 that faces the metal sheet 10 is a flat surface parallel to the metal sheet 10.

[0097] FIG. 23 is a cross-sectional view of a portion of the punch 51. The projecting portion 511 includes a corner 511a at its outer circumference, the corner having a radius of curvature *R3.* As used herein, the outer circumference of the projecting portion 511 means the side of the projecting portion 511 adjacent to the sheet holder 53.

[0098] The radius of curvature *R3* of the corner 511a has the same preferable ranges as the radius of curvature *R1* (FIG. 2) of the corner 231a of the projecting portion 231 of the sheet holder 23. The height *h3* of the projecting portion 511 has the same preferable ranges as the height *h1* (FIG. 2) of the projecting portion 231 of the sheet holder 23.

[Method of Manufacturing Metallic Member]

[0099] A method of manufacturing a metallic member according to the present embodiment uses the above-described press tool 50 to stamp a surface-plated metal sheet to produce a metallic member. The manufacturing method includes the step of placing a metal sheet 10 on the counter-pad 22 and die 24, the step of pushing the projecting portion 511 of the punch 51 into the metal sheet 10, and the step of moving the counter-pad 22 and sheet holder 53 closer to each other to stamp the metal sheet

10. The various steps will be described below with reference to FIGS. 24 to 26.

[0100] A metal sheet 10 is placed on the counter-pad 22 and die 24 (see FIG. 24). In the present embodiment, too, in some implementations the top and bottom of the press tool 50 (i.e., the arrangement in the z-direction) may be reversed, where the metal sheet 10 is placed on the punch 51 and sheet holder 53 before being worked.

[0101] The projecting portion 511 of the punch 51 is pushed into the metal sheet 10 (see FIG. 25). For example, the sheet holder 53 and die 24 are caused to sandwich the metal sheet 10 to hold the metal sheet 10. With the sheet kept in this state, the punch 51 is moved closer to the counter-pad 22 to push the projecting portion 511 of the punch 51 into the metal sheet 10.

[0102] The counter-pad 22 and sheet holder 53 are moved closer to each other to stamp the metal sheet 10 (see FIG. 26). Thus, the metal sheet 10 is separated into a metallic member 14 and remainder 149. In the present embodiment, the portion of the sheet sandwiched between the sheet holder 53 and die 24 provides the metallic member 14.

[Metallic Member]

[0103] The metallic member 14 has the same construction as the metallic member 11 (FIG. 9) of the first embodiment except that it has a different planar shape (shape in an xy-plane). More specifically, the metallic member 14 is formed by stamping a surface-plated metal sheet, and includes a cut edge surface formed through the stamping. This cut edge surface includes a sheared surface and a recessed surface, where at least a portion of the recessed surface is covered with the plating layer 10a.

[Effects of Present Embodiment]

[0104] The press tool 50, the method of manufacturing a metallic member, and the metallic member 14 according to the fourth embodiment of the present invention have been described. The press tool 50 according to the present embodiment and the method of manufacturing a metallic member according to the present embodiment also provide go-around sections of the plating layer 10a from both sides of the cut edge surface arranged in the thickness direction. This provides a metallic member 14 having a cut edge surface with improved corrosion resistance.

[Fifth Embodiment]

[Press tool]

[0105] FIG. 27 is a cross-sectional view of a press tool 60 according to a fifth embodiment of the present invention, schematically illustrating its construction. The press tool 60 includes a counter-pad 62, which replaces the counter-pad 22 (FIG. 22) of the press tool 50 of the fourth embodiment.

[0106] The counter-pad 62 includes a projecting portion 621 at a circumferential edge of the face 62a that faces the metal sheet 10.

[0107] FIG. 28 is a cross-sectional view of a portion of the counter-pad 62. The projecting portion 621 includes a corner 621a at its outer circumference, the corner having a radius of curvature *R4*. As used herein, the outer circumference of the projecting portion 621 means the side of the projecting portion 621 adjacent to the die 24.

[0108] The radius of curvature *R4* of the corner 621a has the same preferable ranges as the radius of curvature *R1* (FIG. 2) of the corner 231a of the projecting portion 231 of the sheet holder 23. The radius of curvature *R3* (FIG. 23) and the radius of curvature *R4* may be equal, or may be different.

[0109] The height *h4* of the projecting portion 621 has the same preferable ranges as the height *h1* (FIG. 2) of the projecting portion 231 of the sheet holder 23. The height *h3* (FIG. 23) and the height *h4* may be equal, or may be different.

[Method of Manufacturing Metallic Member]

[0110] A method of manufacturing a metallic member according to the present embodiment uses using the above-described press tool 60 to stamp a surface-plated metal sheet to produce a metallic member. The manufacturing method includes the step of placing a metal sheet 10 on the counter-pad 62 and die 24, the step of pushing the projecting portion 511 of the punch 51 and the projecting portion 621 of the counter-pad 62 into the metal sheet 10, and the step of moving the counter-pad 62 and sheet holder 53 closer to each other to stamp the metal sheet 10. The various steps will be described below with reference to FIGS. 29 to 31.

[0111] A metal sheet 10 is placed on the counter-pad 62 and die 24 (see FIG. 29). In the present embodiment, too, in some implementations the top and bottom of the press tool 60 (i.e., the arrangement in the z-direction) may be reversed, where the metal sheet 10 is placed on the punch 51 and sheet holder 53 before being worked.

[0112] The projecting portion 511 of the punch 51 and the projecting portion 621 of the counter-pad 62 are pushed into the metal sheet 10 (see FIG. 30). For example, the sheet holder 53 and die 24 are caused to sandwich the metal sheet 10 to hold the metal sheet 10. With the sheet kept in this state, the punch 51 and counter-pad 62 are moved closer to each other to push the projecting portion 511 of the punch 51 and the projecting portion 621 of the counter-pad 62 into the metal sheet 10.

[0113] The counter-pad 62 and sheet holder 53 are moved closer to each other to stamp the metal sheet 10 (see FIG. 31). Thus, the metal sheet 10 is separated into a metallic member 15 and remainder 159. In the present embodiment, the portion of the sheet sandwiched be-

tween the sheet holder 53 and die 24 provides the metallic member 15.

[Metallic Member]

[0114] The metallic member 15 has the same construction as the metallic member 12 (FIG. 15) of the second embodiment except that it has a different planar shape (shape in an xy-plane). Specifically, the metallic member 15 is formed by stamping a surface-plated metal sheet, and includes a cut edge surface formed through the stamping. This cut edge surface includes a sheared surface and recessed surfaces, where at least portions of the recessed surfaces are covered with the plating layer 10a.

[Effects of Present Embodiment]

[0115] The press tool 60, the method of manufacturing a metallic member, and the metallic member 15 according to the fifth embodiment of the present invention have been described. According to the present embodiment, the projecting portions 511 and 621 are pushed into the metal sheet 10 to supply the plating layer 10a from both sides of the metal sheet 10 arranged in the thickness direction. Further, when the remaining middle portion is stamped through, the predetermined radius of curvature *R4* of the corner 621a of the projecting portion 621 allows a larger amount of the plating layer 10a to provide a go-around section on the cut edge surface. This provides a metallic member 15 having a cut edge surface with improved corrosion resistance.

[Sixth Embodiment]

[Press tool]

[0116] FIG. 32 is a cross-sectional view of a press tool 70 according to a sixth embodiment of the present invention, schematically illustrating its construction. The press tool 70 includes a counter-pad 72, which replaces the counter-pad 22 (FIG. 22) of the press tool 50 of the fourth embodiment.

[0117] FIG. 33 is a cross-sectional view of a portion of the counter-pad 72. The face 72a of the counter-pad 72 that faces the metal sheet 10 is a flat surface parallel to the metal sheet 10. The counter-pad 72 includes a double corner at its outer circumference. As used herein, the outer circumference of the counter-pad 72 means its side adjacent to the die 24. The double corner includes a first sub-corner 721 and a second sub-corner 722. The second sub-corner 722 is located farther from the metal sheet 10 than the first sub-corner 721 is as measured in the thickness direction of the metal sheet 10 (i.e., z-direction), and located closer to the die 24 than the first sub-corner 721 is as measured in in-plane directions of the metal sheet 10 (i.e., xy-in-plane directions).

[0118] The step height *sh2* of the double corner has the same preferable ranges as the step height *sh1* (FIG. 17) of the double corner of the die 44. The width *w2* of the double corner has the same preferable ranges as the width *w1* (FIG. 17) of the double corner of the die 44.

[0119] The radius of curvature *Rp4* of the second sub-corner 722 has the same preferable ranges as the radius of curvature *Rp2* (FIG. 17) of the second sub-corner 442 of the die 44. The radius of curvature *Rp3* of the first sub-corner 721 is not limited to any particular value. For example, the radius of curvature *Rp3* may be 0 to 0.5 times the radius of curvature *Rp4.* The radius of curvature *Rp3* may be zero.

[Method of Manufacturing Metallic Member]

[0120] A method of manufacturing a metallic member according to the present embodiment uses the above-described press tool 70 to stamp a surface-plated metal sheet to produce a metallic member. The manufacturing method includes the step of placing a metal sheet 10 on the counter-pad 72 and die 24, the step of pushing the projecting portion 511 of the punch 51 into the metal sheet 10, and the step of moving the counter-pad 72 and sheet holder 53 closer to each other to stamp the metal sheet 10. The various steps will be described below with reference to FIGS. 34 to 36.

[0121] A metal sheet 10 is placed on the counter-pad 72 and die 24 (see FIG. 34). In the present embodiment, too, in some implementations the top and bottom of the press tool 70 (i.e., the arrangement in the z-direction) may be reversed, where the metal sheet 10 is placed on the punch 51 and sheet holder 53 before being worked.

[0122] The projecting portion 511 of the punch 51 is pushed into the metal sheet 10 (see FIG. 35). For example, the sheet holder 53 and die 24 are caused to sandwich the metal sheet 10 to hold the metal sheet 10. With the sheet kept in this state, the punch 51 is moved closer to the counter-pad 72 to push the projecting portion 511 of the punch 51 into the metal sheet 10.

[0123] The counter-pad 72 and sheet holder 53 are moved closer to each other to stamp the metal sheet 10 (see FIG. 36). Thus, the metal sheet 10 is separated into a metallic member 16 and remainder 169. In the present embodiment, the portion of the sheet sandwiched between the sheet holder 53 and die 24 provides the metallic member 16.

[Metallic Member]

[0124] The metallic member 16 has the same construction as the metallic member 13 (FIG. 21) of the third embodiment except that it has a different planar shape (shape in an xy-plane). Specifically, the metallic member 16 is formed by stamping a surface-plated metal sheet, and includes a cut edge surface formed through the stamping. This cut edge surface includes a sheared surface and a recessed surface, where at least a portion of the recessed surface is covered with the plating layer

10a.

[Effects of Present Embodiment]

[0125] According to the present embodiment, during the step of stamping the metal sheet 10, the width *w2* (FIG. 33) of the double corner increases the clearance between the counter-pad 72 and sheet holder 53, thus increasing the size of a roll-over adjacent to the undercuts on the cut edge surface. As a result, the portion of the sheet that is in contact with the second sub-corner 722 is inclined appropriately and, during formation using the second sub-corner 722, the plating layer 10a can be moved more easily onto the cut edge surface. This provides a metallic member 16 having a cut edge surface with improved corrosion resistance.

EXAMPLES

[0126] Now, the present invention will be described more specifically with reference to examples. The present invention is not limited to these examples.

[0127] For a surface-plated metal sheet, the behavior of the plating layer during the working thereof by the press tool 20 (FIG. 1) was analyzed by CAE. The used software was LS-DYNA (registered trademark). FIG. 37 schematically illustrates the distribution of the plating layer found when the projecting portion 231 of the sheet holder 23 had been pushed into the surface-plated metal sheet, calculated by CAE. The sheet thickness of the surface-plated metal sheet being analyzed was 3.2 mm; the plating thickness was not considered; and the push-in depth *S* was 1.6 mm. The analysis was conducted while the radius of curvature *R1* (FIG. 2) of the corner 231a of the projecting portion 231 of the sheet holder 23 was varied, and the relationship between the radius of curvature *R1* and the distance of coating with plating (i.e., dimension of the area covered with the plating layer as measured in the thickness direction of the surface-plated metal sheet), *d*, was determined.

[0128] The results are shown in FIG. 38. FIG. 38 shows that the larger the radius of curvature *R1,* the larger the area covered with the plating layer.

[0129] Next, the press tool 20 (FIG. 1), press tool 30 (FIG. 10), and press tool 40 (FIG. 16) were used to determine, through analysis by CAE, the proportion of the cut edge surface coated with plating found when the surface-plated metal sheet had been stamped. The sheet thickness of the surface-plated metal sheet being analyzed was 3.2 mm, and the plating thickness was not considered. The clearance *CL* (FIG. 1 etc.) was 0.1 mm.

[0130] The height *h1* (FIG. 2) of the projecting portion 231 of the sheet holder 23 was 1.6 mm, and the radius of curvature *R1* of the corner 231a was 0.9 mm. Further, for analysis of a simulation of the press tool 30 (FIG. 10), the height *h2* (FIG. 11) of the projecting portion 341 of the die 34 was 1.6 mm, and the radius of curvature R2of the corner 341a was 0.9 mm. For analysis of a simulation of the press tool 40 (FIG. 16), the radius of curvature *Rp1* (FIG. 17) of the first sub-corner 441 of the die 44 was 0.05 mm, the radius of curvature *Rp2* of the second sub-corner 442 was 0.5 mm, the step height *sh1* was 0.5 mm, and the width *w1* was 0.5 mm. For a comparative example, a press tool 20 (FIG. 1) was analyzed where the radius of curvature *R1* (FIG. 2) of the corner 231a of the projecting portion 231 of the sheet holder 23 was 0 mm and otherwise the same conditions as stated above applied.

[0131] Similarly to the analysis in FIG. 37, dots simulating the plating layer were set on the sheet surface and their movements were tracked to estimate the distance of coating with plating. As shown in FIG. 39, in the cut edge surface, the dimensions of the areas covered with the plating layer as measured in the thickness direction of the surface-plated metal sheet were denoted by *d1* and *d2,* respectively, and their sum *d1+d2* was divided by the sheet thickness *T,* ((*d1+d2*)/*T*), which was treated as the proportion of coating with plating.

[0132] The results are shown in FIG. 40. FIG. 40 demonstrates that the use of the press tool 20, press tool 30, or press tool 40 improved the proportion of coating with plating over the use of the press tool of the comparative example.

[0133] Although embodiments of the present invention have been described, the above-described embodiments are merely illustrative examples useful for carrying out the present invention. Thus, the present invention is not limited to the above-described embodiments, and the above-described embodiments, when carried out, may be modified as appropriate within the scope of the invention.

REFERENCE SIGNS LIST

[0134]

10: metal sheet (surface-coated metal sheet)
10a: plating layer (coating layer)
11, 12, 13, 14, 15, 16: metallic member
111, 121, 131: cut edge surface
111a, 121a, 131a: sheared surface
111b, 121b, 131b: recessed surface
111c, 121c, 131c: fracture surface
111d, 131d: undercut
121d: second recessed surface
111e, 121e, 131e: undercut
121f: undercut
119, 129, 139, 149, 159, 169: remainder
20, 30, 40, 50, 60: press tool
21, 51: punch
22, 62, 72: counter-pad
23, 53: sheet holder
231: projecting portion
231a: corner
24, 34, 44: die

Claims

1. A method of manufacturing a metallic member by using a press tool to stamp a metal sheet having front and back faces covered with a coating layer,
the press tool including:

a punch;
a counter-pad located opposite to the punch, the metal sheet being positioned between the punch and the counter-pad;
a sheet holder located adjacent to the same side of the metal sheet as the punch as determined along a thickness direction of the sheet and positioned to surround the punch along in-plane directions of the metal sheet; and
a die located adjacent to the same side of the metal sheet as the counter-pad as determined along the thickness direction of the sheet and positioned to surround the counter-pad along in-plane directions of the metal sheet,
the sheet holder including a projecting portion at an inner circumferential edge of a face facing the metal sheet,
the projecting portion of the sheet holder including a corner at an inner circumference, the corner having a radius of curvature *R1,*
the radius of curvature *R1* being not smaller than 0.10 times a thickness of the metal sheet,
the manufacturing method comprising:

pushing the projecting portion of the sheet holder into the metal sheet; and
moving the punch and the die closer to each other to stamp the metal sheet.

2. The method of manufacturing a metallic member according to claim 1, wherein:

the die includes a projecting portion at an inner circumferential edge of a face facing the metal sheet;
the projecting portion of the die includes a corner at an inner circumference, the corner having a radius of curvature *R2*; and
the radius of curvature R2is not smaller than 0.10 times the thickness of the metal sheet,
the manufacturing method further comprising:
during the pushing of the projecting portion of the sheet holder into the metal sheet, pushing the projecting portion of the die into the metal sheet.

3. The method of manufacturing a metallic member according to claim 1, wherein:

the die includes a double corner at an inner circumference;
the double corner includes:

a first sub-corner; and
a second sub-corner located farther from the metal sheet than the first sub-corner is as measured in the thickness direction of the metal sheet, and located closer to the counter-pad than the first sub-corner is as measured in in-plane directions of the metal sheet; and
the second sub-corner has a radius of curvature *Rp2* not smaller than 0.10 times the thickness of the metal sheet.

4. A method of manufacturing a metallic member by using a press tool to stamp a metal sheet having front and back faces covered with a coating layer,
the press tool including:

a punch;
a counter-pad located opposite to the punch, the metal sheet being positioned between the punch and the counter-pad;
a sheet holder located adjacent to the same side of the metal sheet as the punch as determined along a thickness direction of the sheet and positioned to surround the punch along in-plane directions of the metal sheet; and
a die located adjacent to the same side of the metal sheet as the counter-pad as determined along the thickness direction of the sheet and positioned to surround the counter-pad along in-plane directions of the metal sheet,
the punch including a projecting portion at a circumferential edge of a face facing the metal sheet,
the projecting portion of the punch including a corner at an outer circumference, the corner having a radius of curvature *R3,*
the radius of curvature *R3* being not smaller than 0.10 times a thickness of the metal sheet,
the manufacturing method comprising:

pushing the projecting portion of the punch into the metal sheet; and
moving the counter-pad and the sheet holder closer to each other to stamp the metal sheet.

5. The method of manufacturing a metallic member according to claim 4, wherein:

the counter-pad includes a projecting portion at a circumferential edge of a face facing the metal sheet;
the projecting portion of the counter-pad includes a corner at an outer circumference, the corner having a radius of curvature *R4*;

the radius of curvature *R4* is not smaller than 0.10 times the thickness of the metal sheet,
the manufacturing method further comprising:
during the pushing of the projecting portion of the punch into the metal sheet, pushing the projecting portion of the counter-pad into the metal sheet.

6. The method of manufacturing a metallic member according to claim 4, wherein:

the counter-pad includes a double corner at a circumferential edge of a face facing the metal sheet;
the double corner includes:

a first sub-corner;
a second sub-corner located farther from the metal sheet than the first sub-corner is as measured in the thickness direction of the metal sheet, and located closer to die than the first sub-corner is as measured in in-plane directions of the metal sheet; and
the second sub-corner has a the radius of curvature *Rp4* not smaller than 0.10 times the thickness of the metal sheet.

7. A press tool comprising:

a punch;
a counter-pad located opposite to the punch, a metal sheet representing a workpiece being positioned between the punch and the counter-pad;
a sheet holder located adjacent to the same side of the metal sheet as the punch as determined along a thickness direction of the sheet and positioned to surround the punch along in-plane directions of the metal sheet; and
a die located adjacent to the same side of the metal sheet as the counter-pad as determined along the thickness direction of the sheet and positioned to surround the counter-pad along in-plane directions of the metal sheet,
the sheet holder including a projecting portion at an inner circumferential edge of a face facing the metal sheet,
the projecting portion of the sheet holder including a corner at an inner circumference, the corner having a radius of curvature *R1,*
the radius of curvature *R1* being not smaller than 0.2 mm.

8. The press tool according to claim 7, wherein:

the die includes a projecting portion at an inner circumferential edge of a face facing the metal sheet;
the projecting portion of the die includes a corner at an inner circumference, the corner having a radius of curvature *R2*; and
the radius of curvature *R2* is not smaller than 0.2 mm.

9. The press tool according to claim 7, wherein:

the die includes a double corner at an inner circumference;
the double corner includes:

a first sub-corner;
a second sub-corner located farther from the metal sheet than the first sub-corner is as measured in the thickness direction of the metal sheet, and located closer to the counter-pad than the first sub-corner is as measured in in-plane directions of the metal sheet; and
the second sub-corner has a radius of curvature *Rp2* not smaller than 0.1 mm.

10. A press tool comprising:

a punch;
a counter-pad located opposite to the punch, a metal sheet representing a workpiece being positioned between the punch and the counter-pad;
a sheet holder located adjacent to the same side of the metal sheet as the punch as determined along a thickness direction of the sheet and positioned to surround the punch along in-plane directions of the metal sheet; and
a die located adjacent to the same side of the metal sheet as the counter-pad as determined along the thickness direction of the sheet and positioned to surround the counter-pad along in-plane directions of the metal sheet,
the punch including a projecting portion at a circumferential edge of a face facing the metal sheet,
the projecting portion of the punch including a corner at an outer circumference, the corner having a radius of curvature *R3,*
the radius of curvature *R3* being not smaller than 0.2 mm.

11. The press tool according to claim 10, wherein:

the counter-pad includes a projecting portion at a circumferential edge of a face facing the metal sheet;
the projecting portion of the counter-pad includes a corner at an outer circumference, the corner having a radius of curvature *R4*; and
the radius of curvature *R4* is not smaller than 0.2

mm.

12. The press tool according to claim 10, wherein:

the counter-pad includes a double corner at a circumferential edge of a face facing the metal sheet;
the double corner includes:

a first sub-corner;
a second sub-corner located farther from the metal sheet than the first sub-corner is as measured in the thickness direction of the metal sheet, and located closer to the die than the first sub-corner is as measured in in-plane directions of the metal sheet; and
the second sub-corner has a radius of curvature *Rp4* not smaller than 0.1 mm.

13. A metallic member formed by stamping a metal sheet having front and back faces covered with a coating layer, including a cut edge surface formed by the stamping,
the cut edge surface including:

a sheared surface; and
a recessed surface represented by a curved surface having a shape protruding inwardly with respect to the member,
at least a portion of the recessed surface being covered with the coating layer.

14. The metallic member according to claim 13, wherein:

the cut edge surface further includes an undercut contiguous to the recessed surface; and
not less than 50 % of a total area of the recessed surface and the undercut is covered with the coating layer.

15. The metallic member according to claim 13 or 14, wherein:

the cut edge surface further includes a second undercut contiguous to the sheared surface; and
the sheared surface is located between the recessed surface and the second undercut as determined along a thickness direction of the metallic member.

16. The metallic member according to claim 13 or 14, wherein:

the cut edge surface further includes a second recessed surface represented by a curved surface having a shape protruding inwardly with respect to the member, and a second undercut contiguous to the second recessed surface; and
the sheared surface is located between the recessed surface and the second recessed surface as determined along a thickness direction of the metallic member.

17. The metallic member according to claim 13 or 14, wherein an amount of sinking represented by a distance between a tangent to the sheared surface and an inwardmost point on the recessed surface is 0.01 to 0.10 times a thickness of the metallic member.

Fig.1

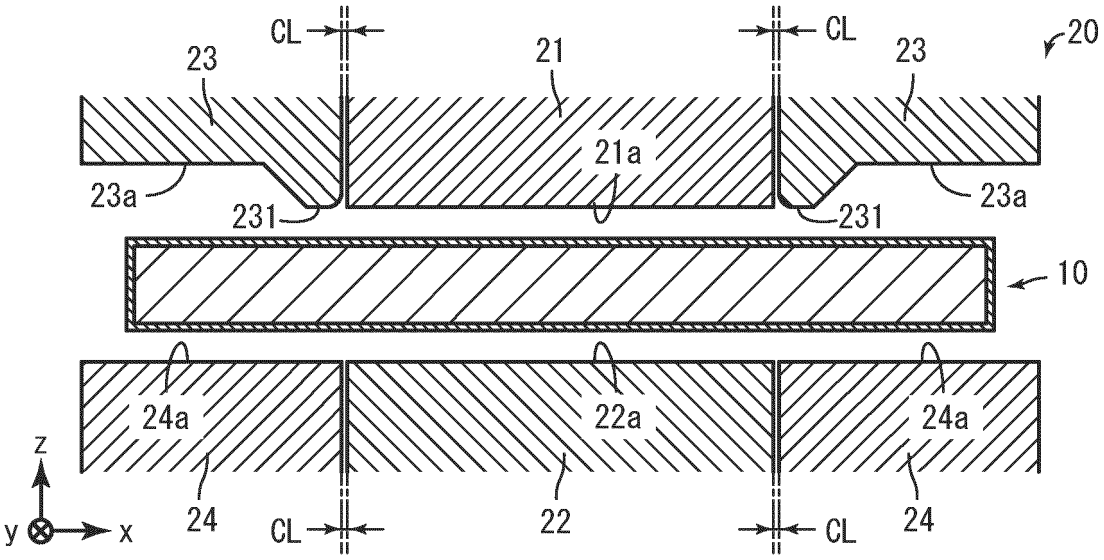


Fig.2

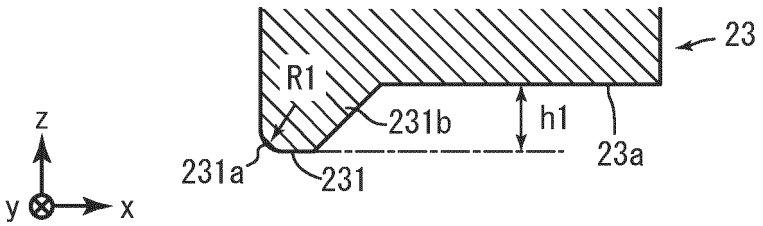


Fig.3

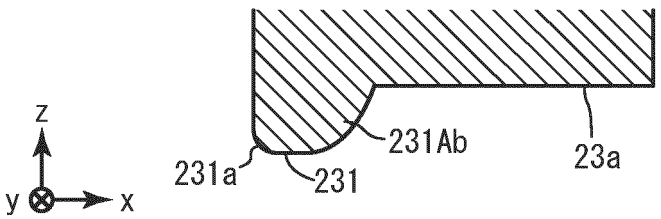


Fig.4

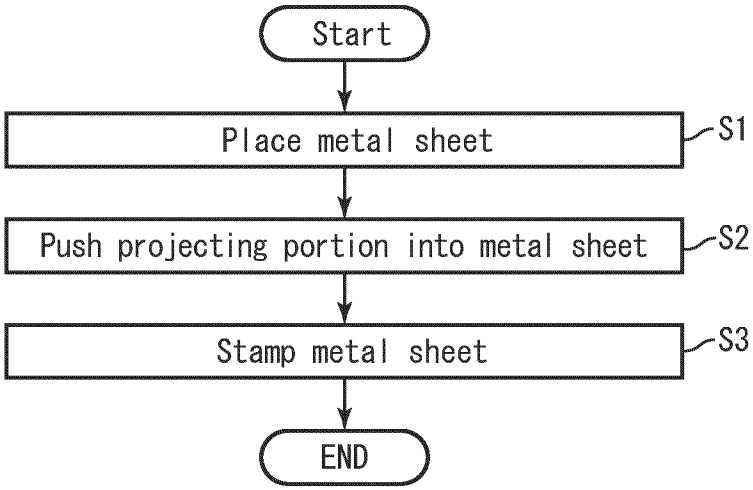


Fig.5

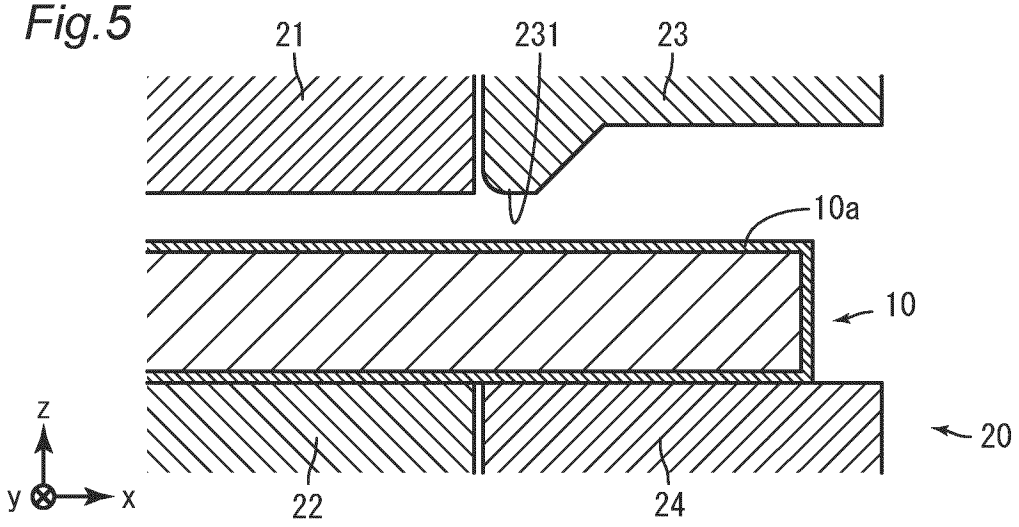


Fig.6

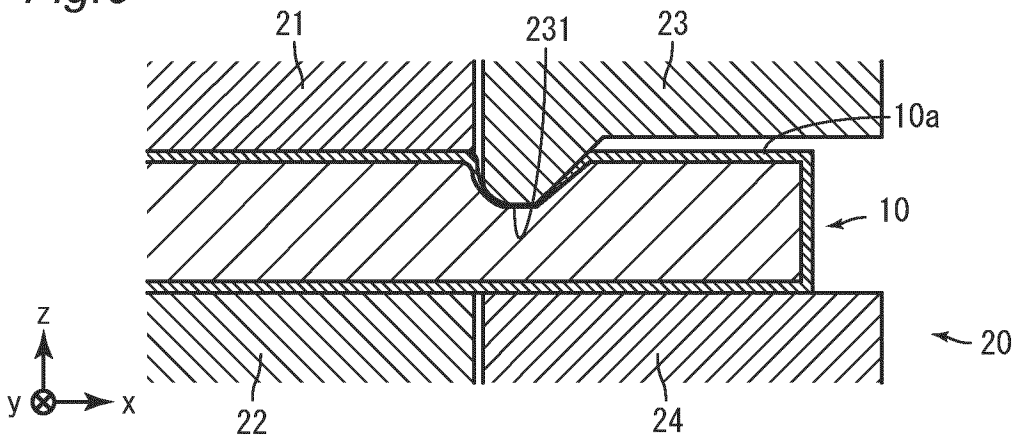


Fig.7

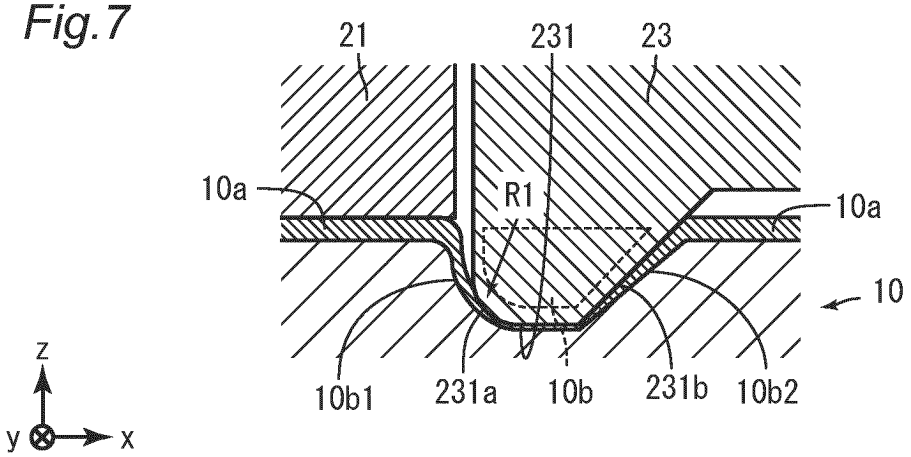


Fig.8

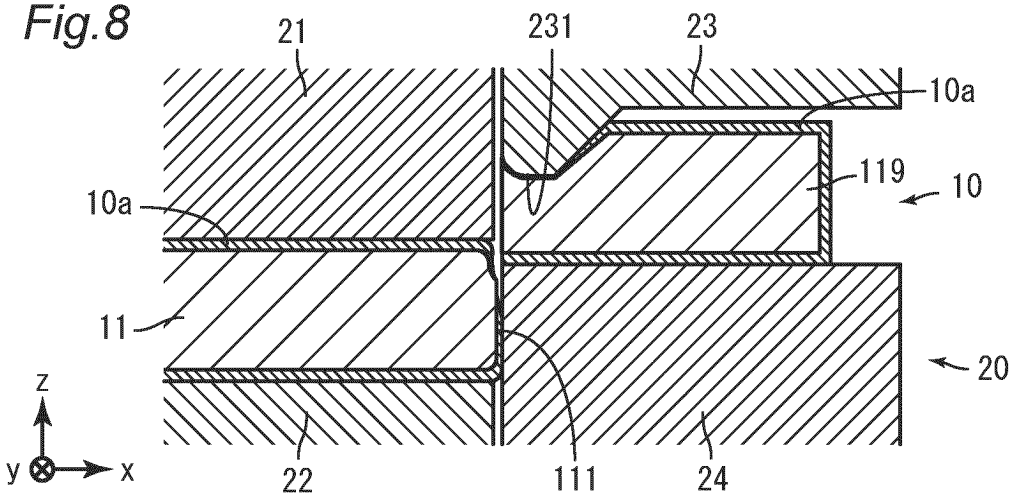


Fig.9

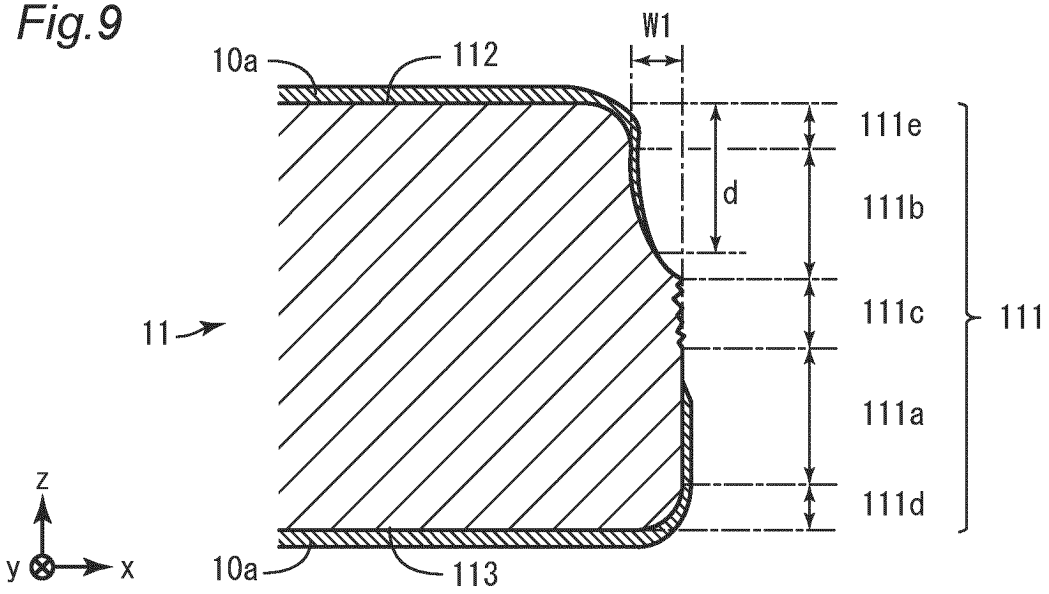


Fig.10

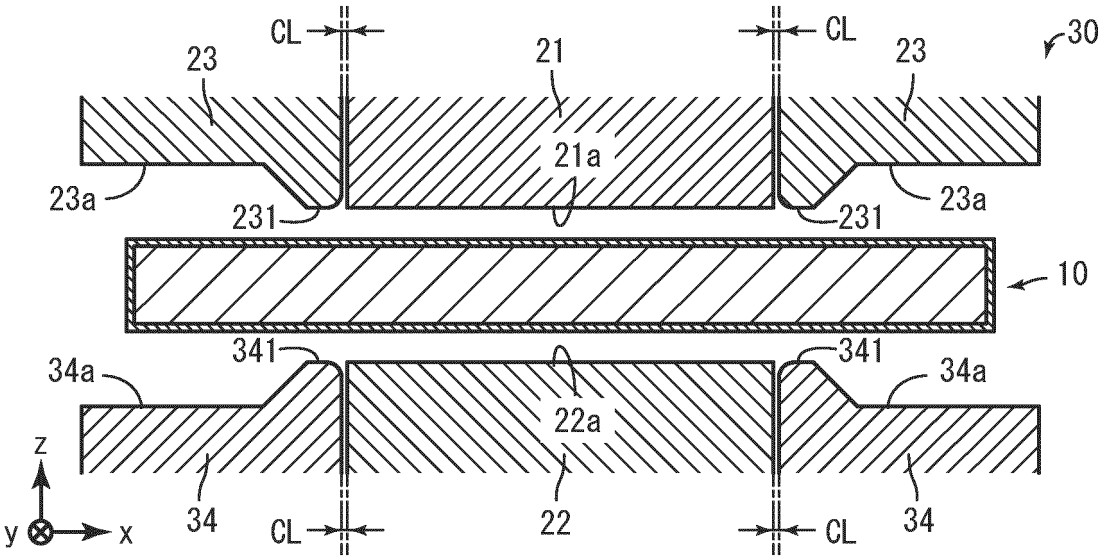


Fig.11

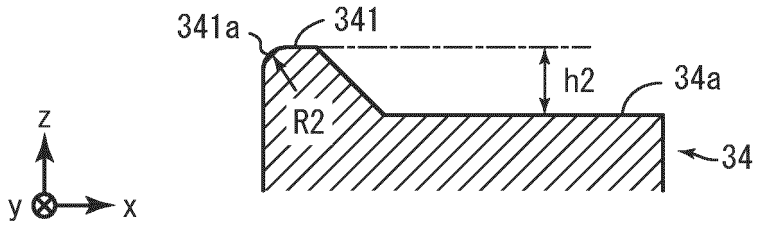


Fig.12

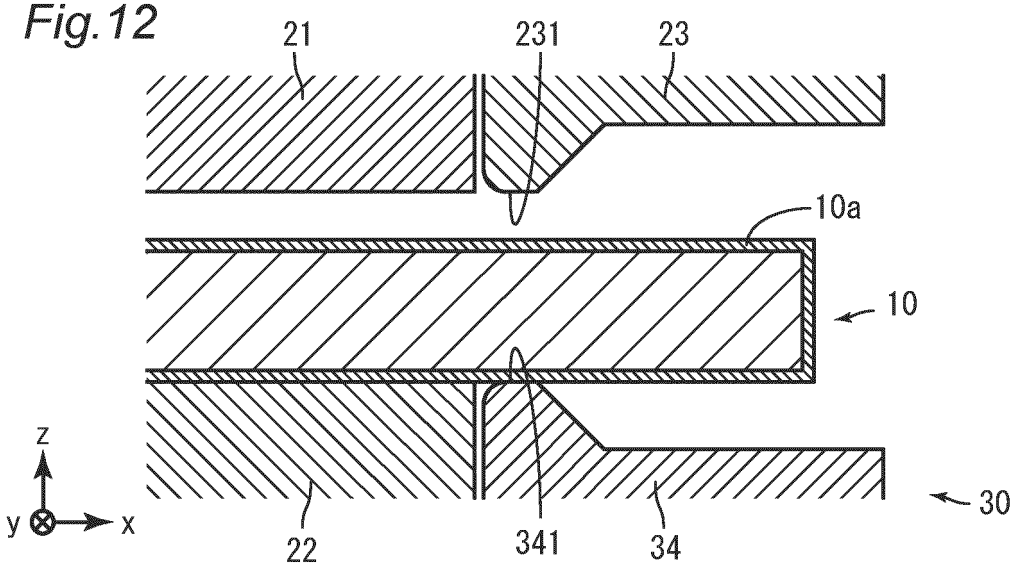


Fig.13

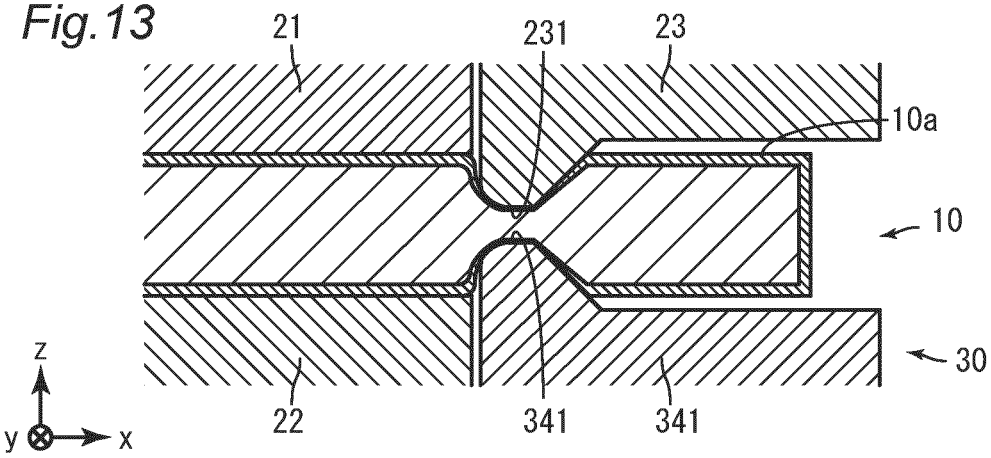


Fig.14

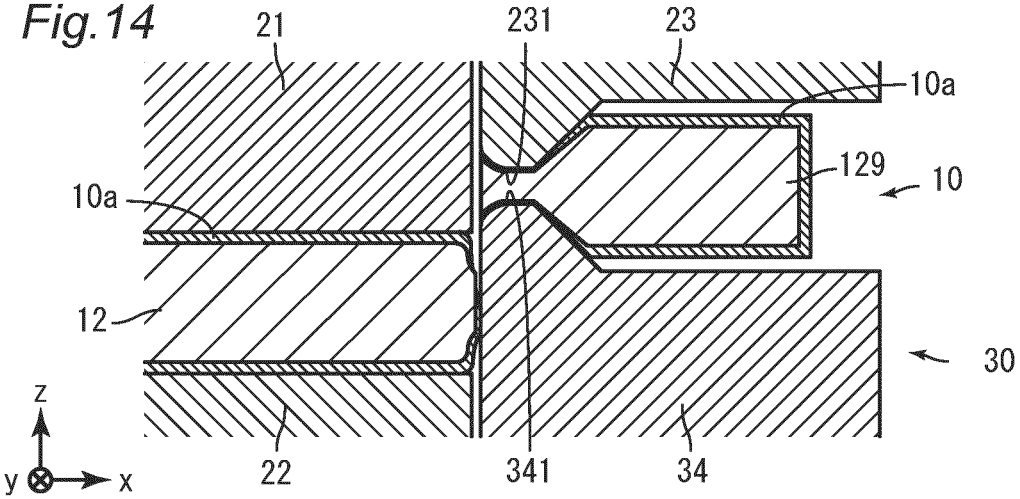


Fig.15

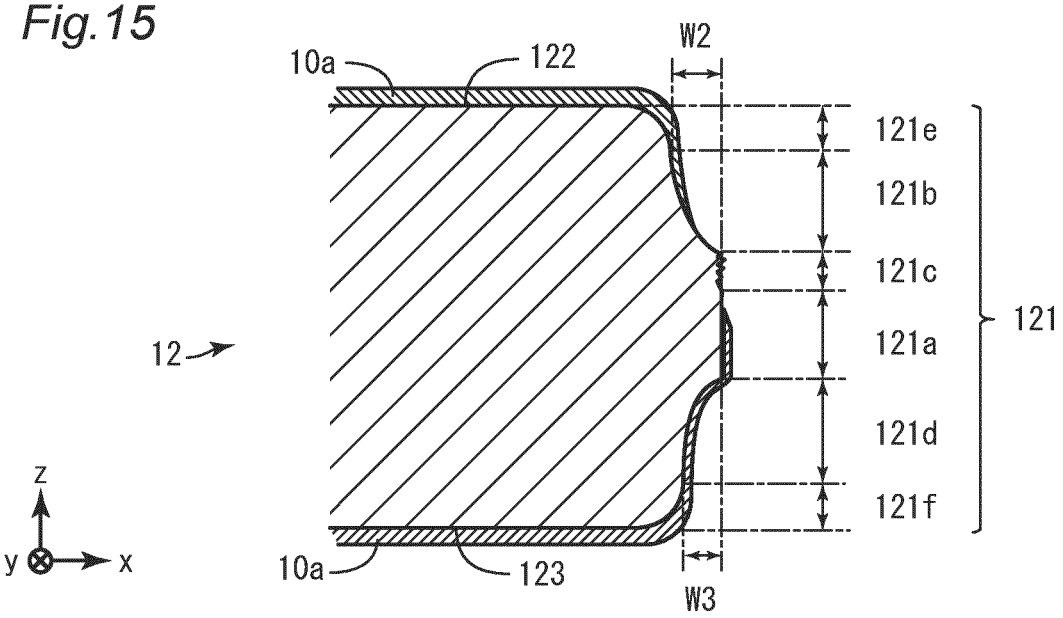


Fig.16

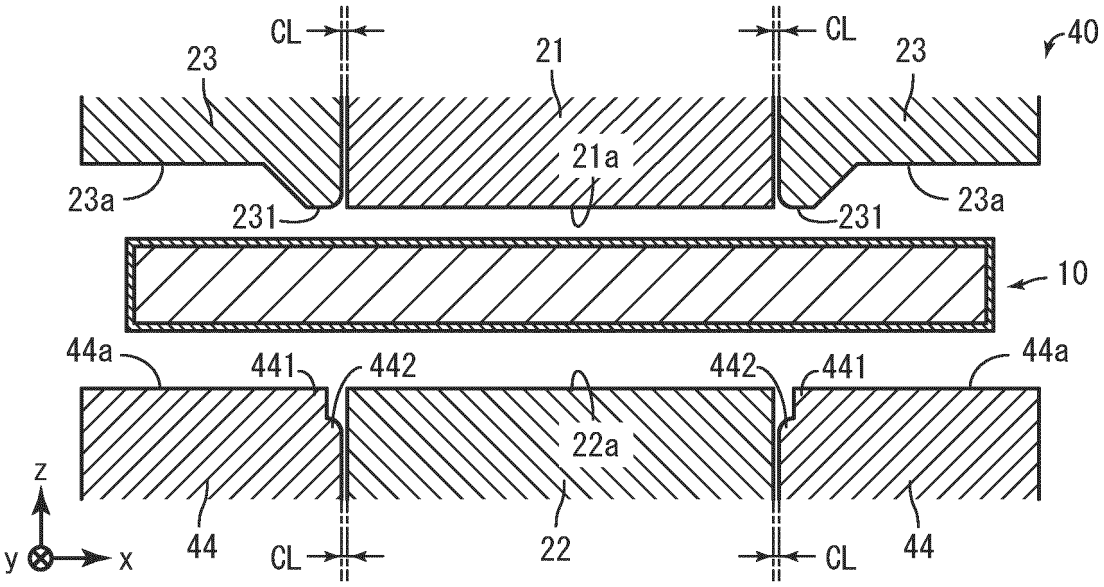


Fig.17

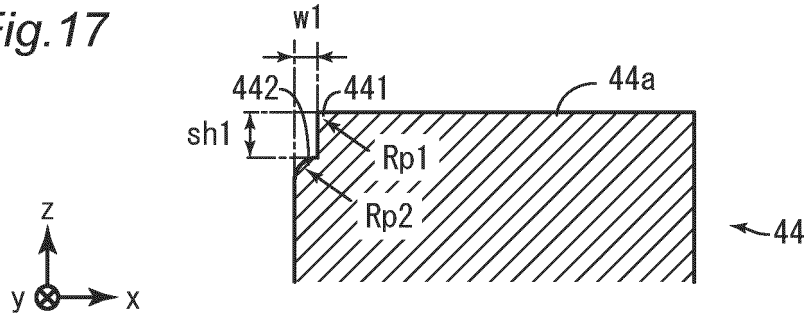


Fig.18

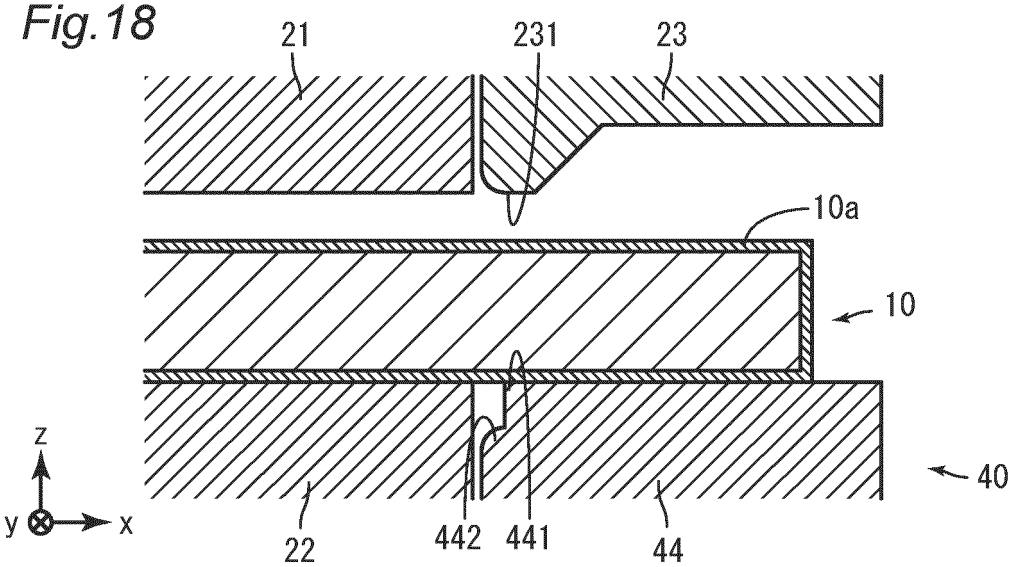


Fig.19

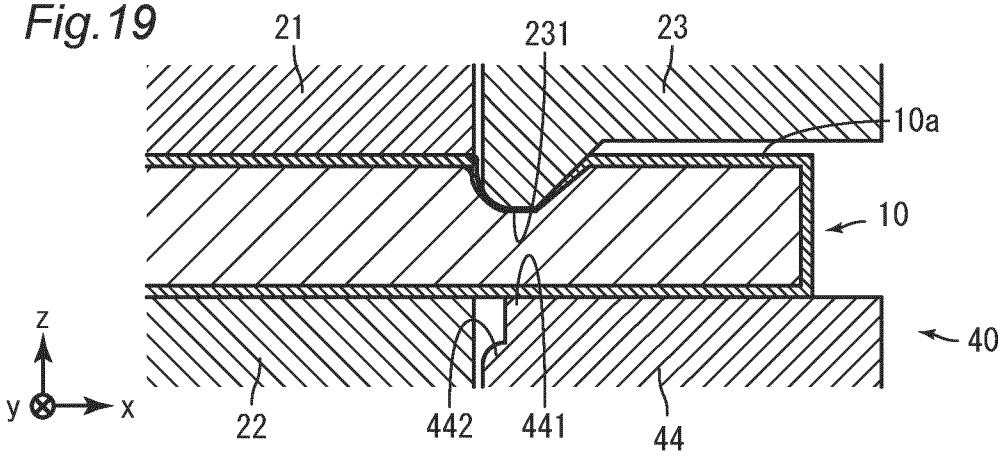


Fig.20

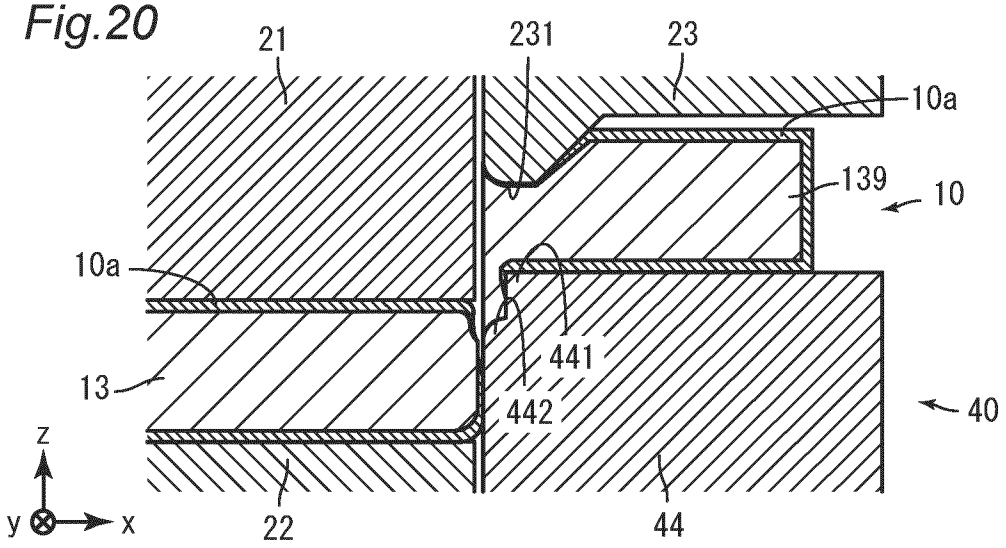


Fig.21

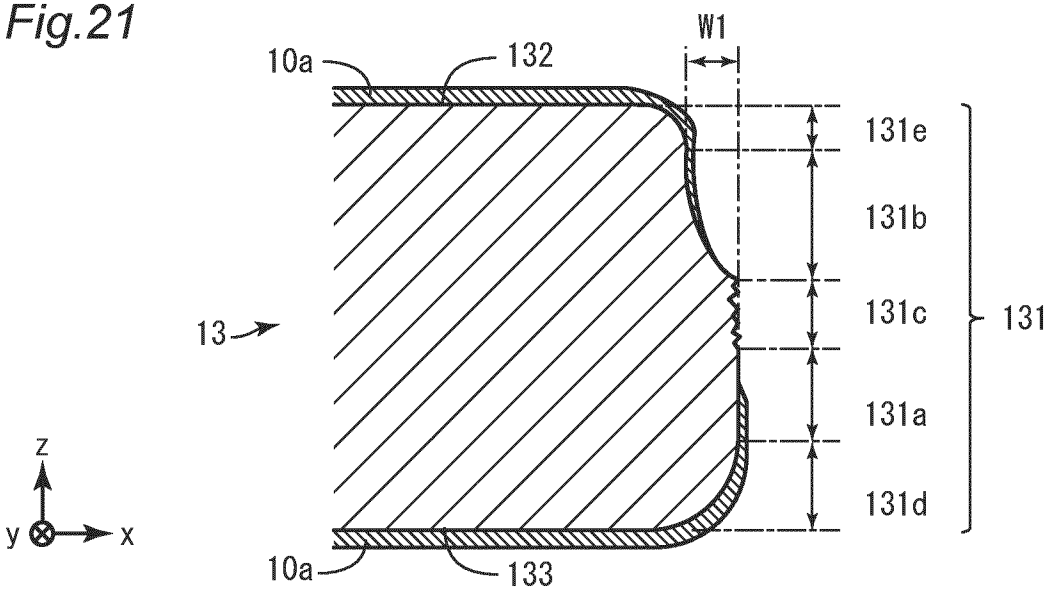


Fig.22

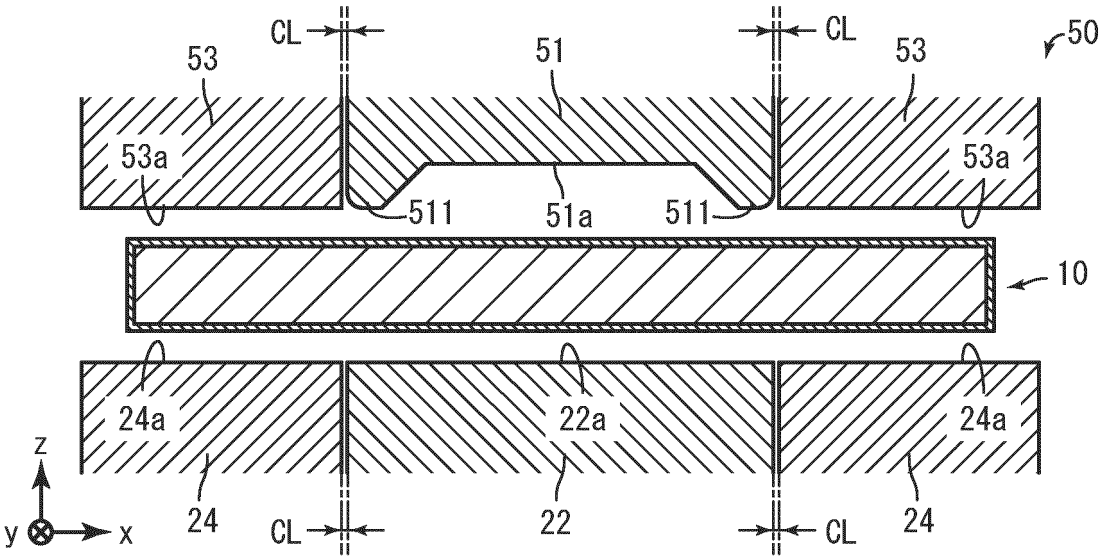


Fig.23

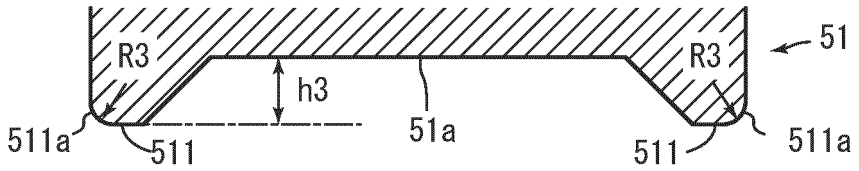


Fig.24

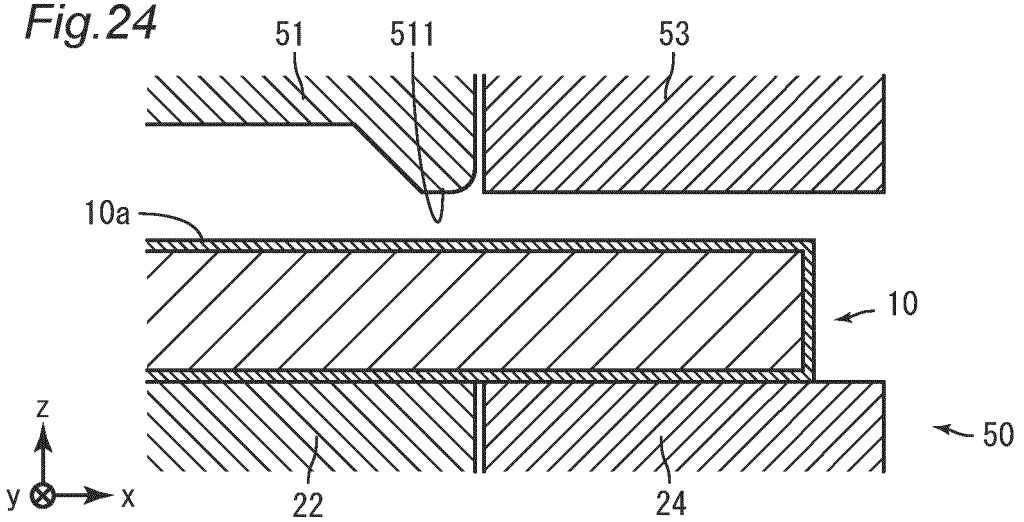


Fig.25

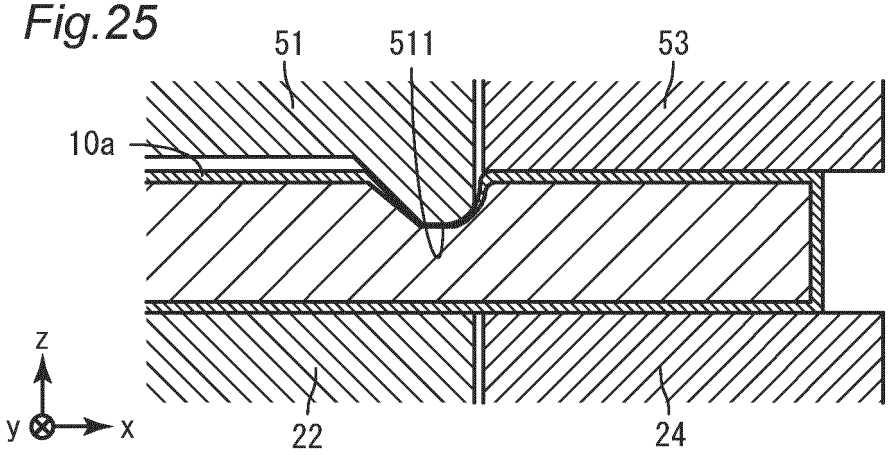


Fig.26

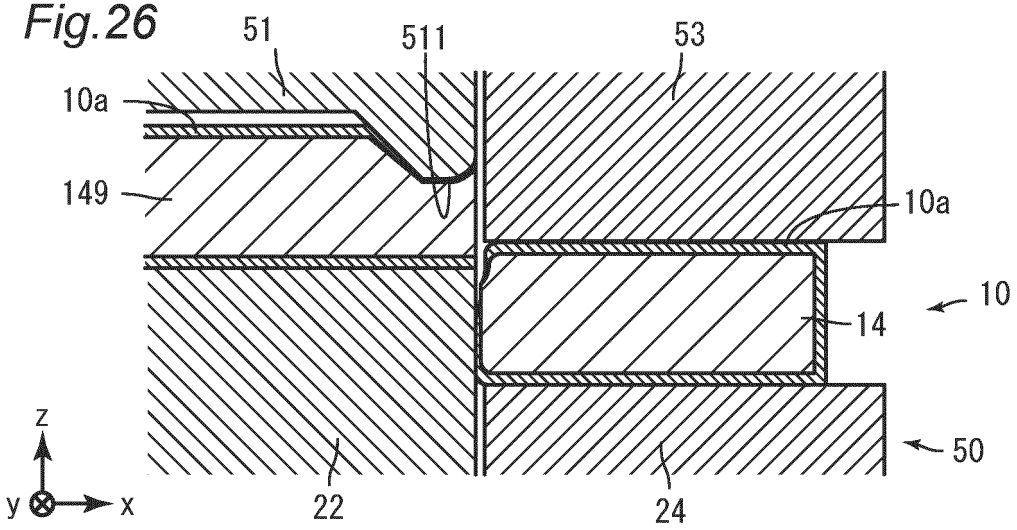


Fig.27

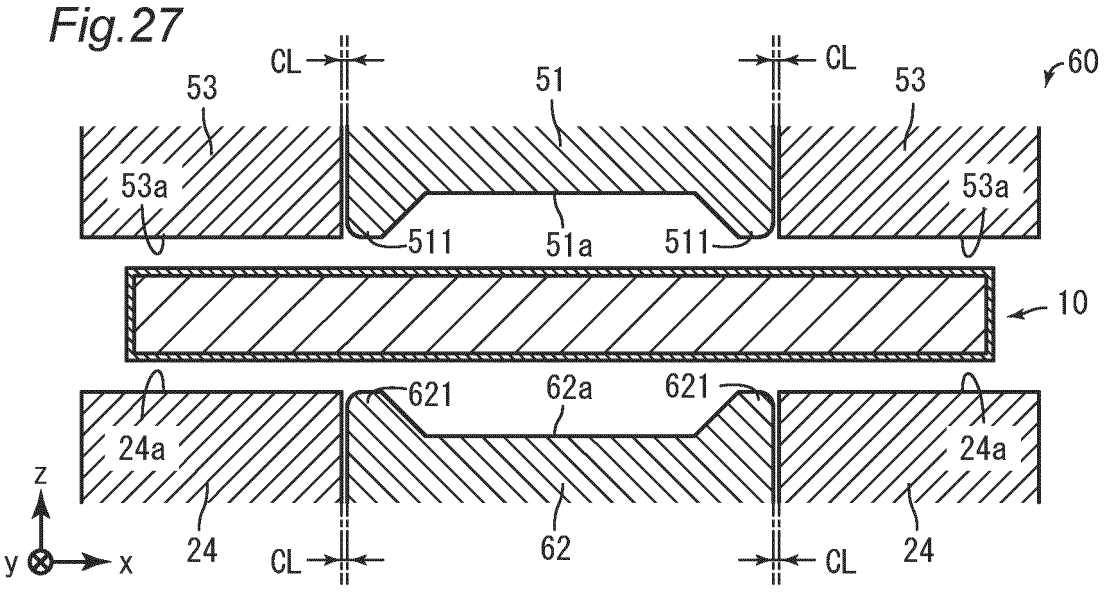


Fig.28

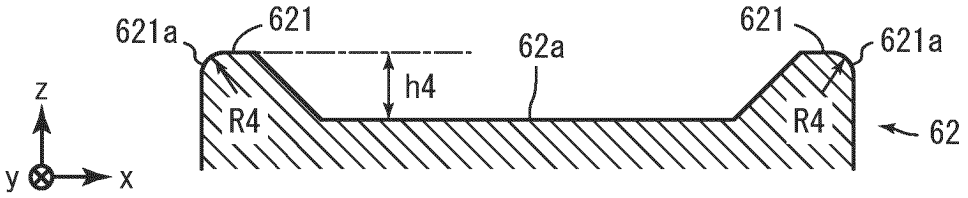


Fig.29

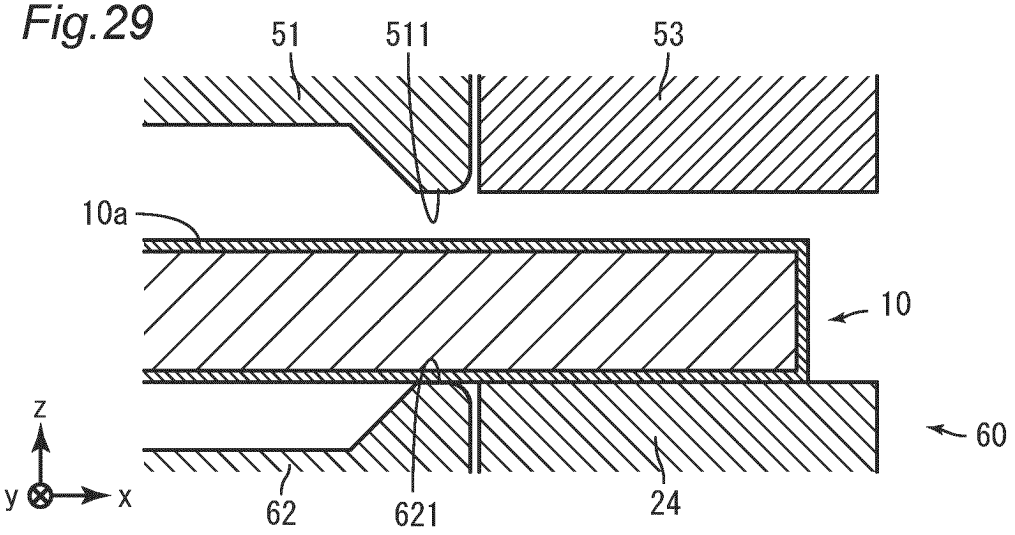


Fig.30

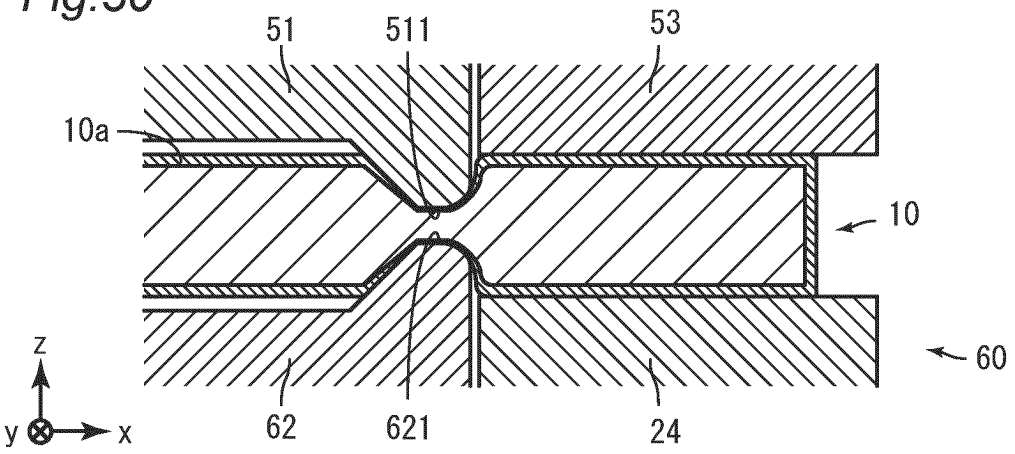


Fig.31

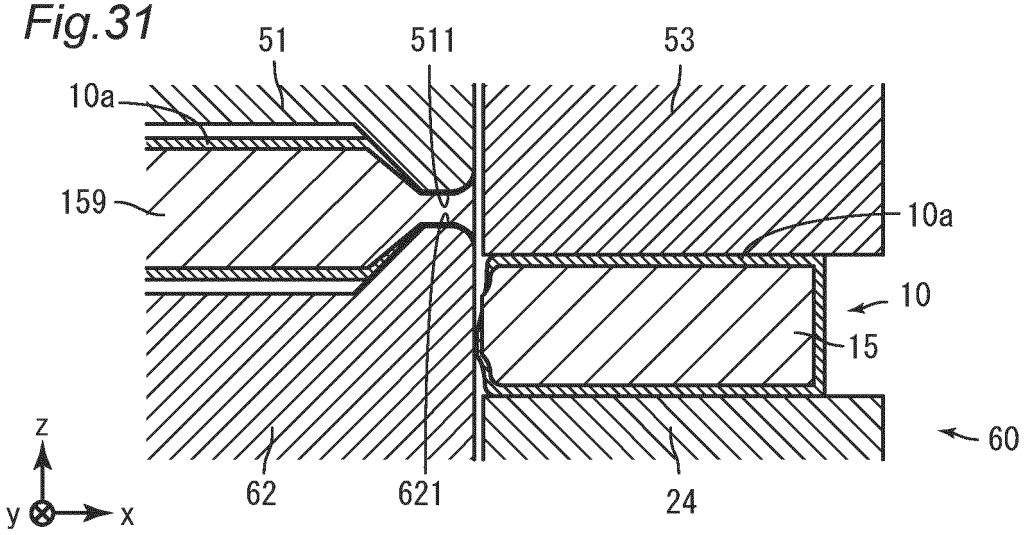


Fig.32

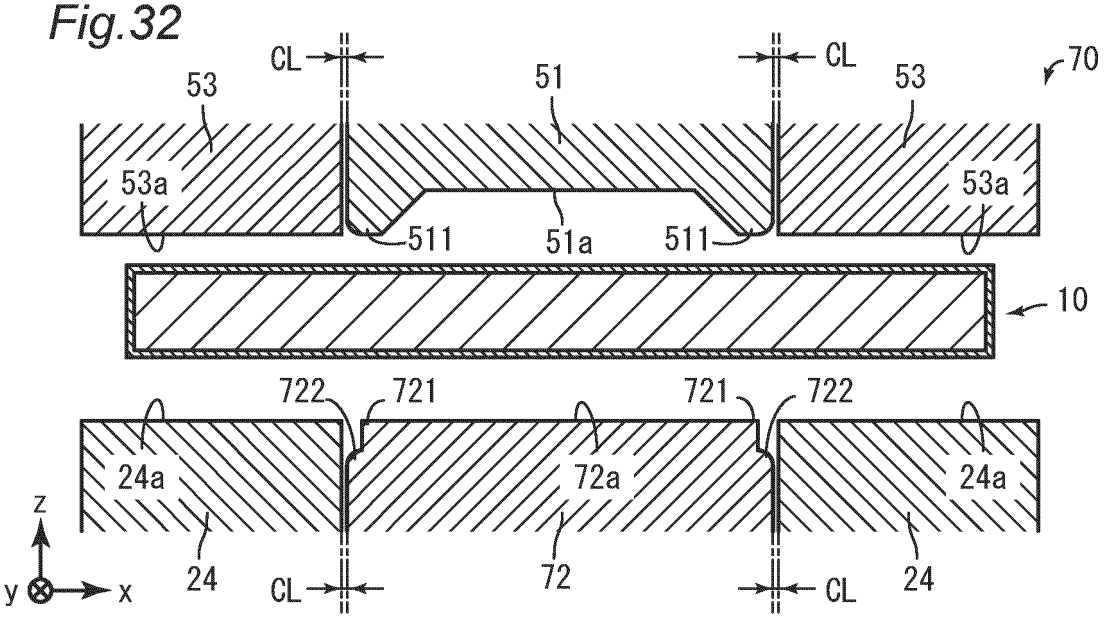


Fig.33

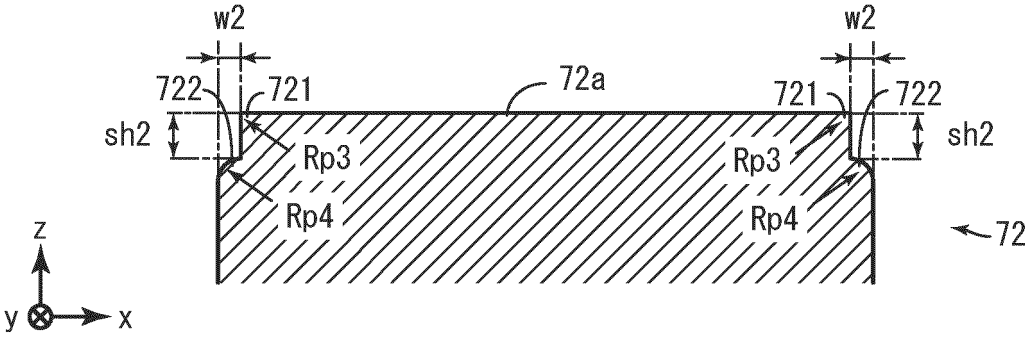


Fig.34

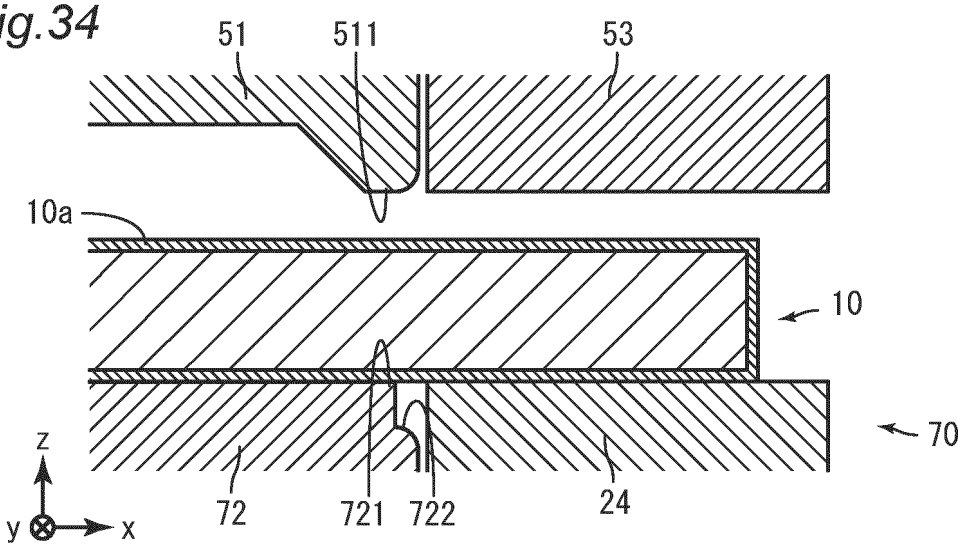


Fig.35

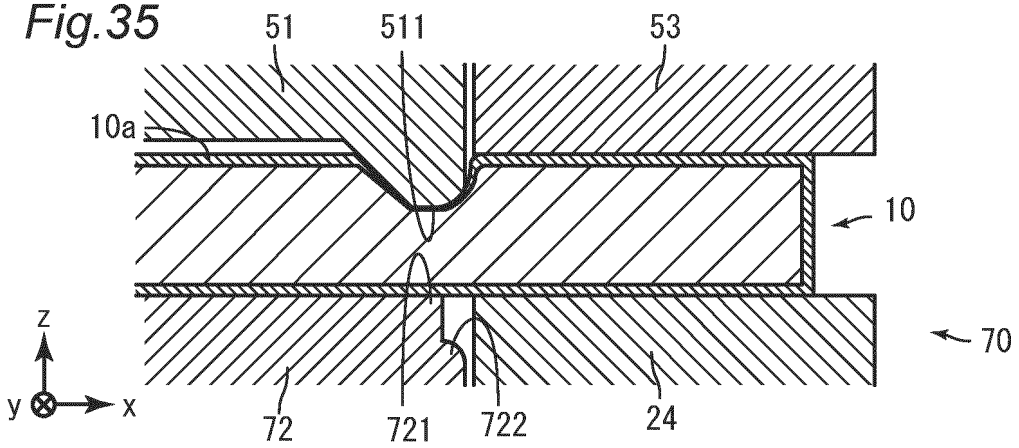


Fig.36

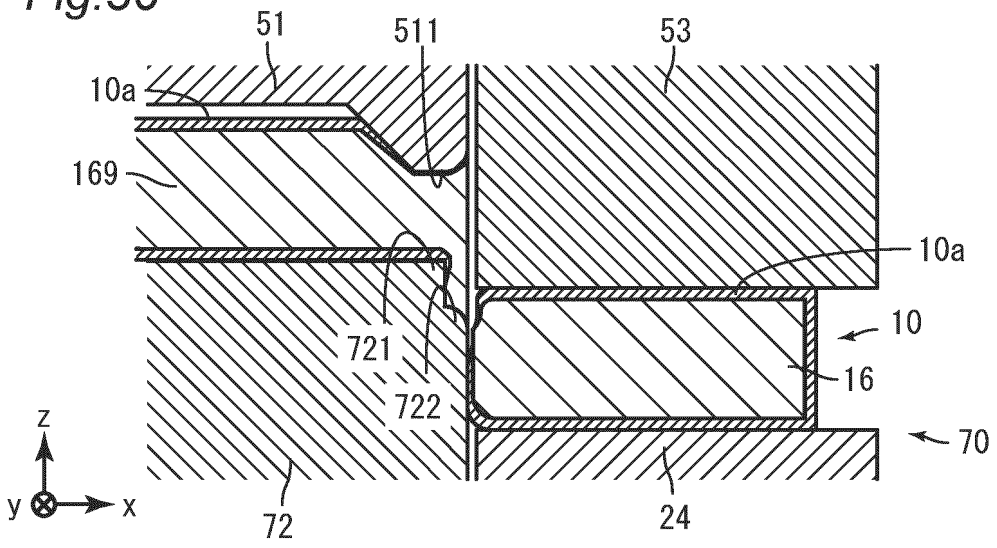


Fig.37

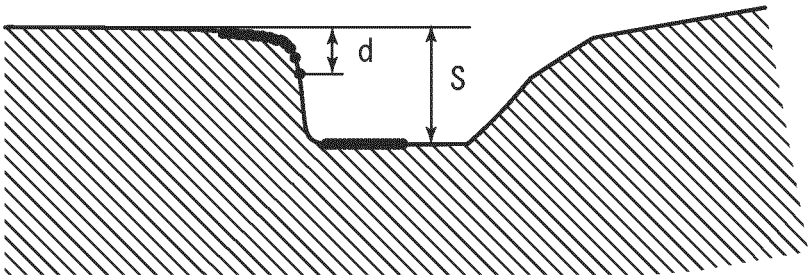


Fig.38

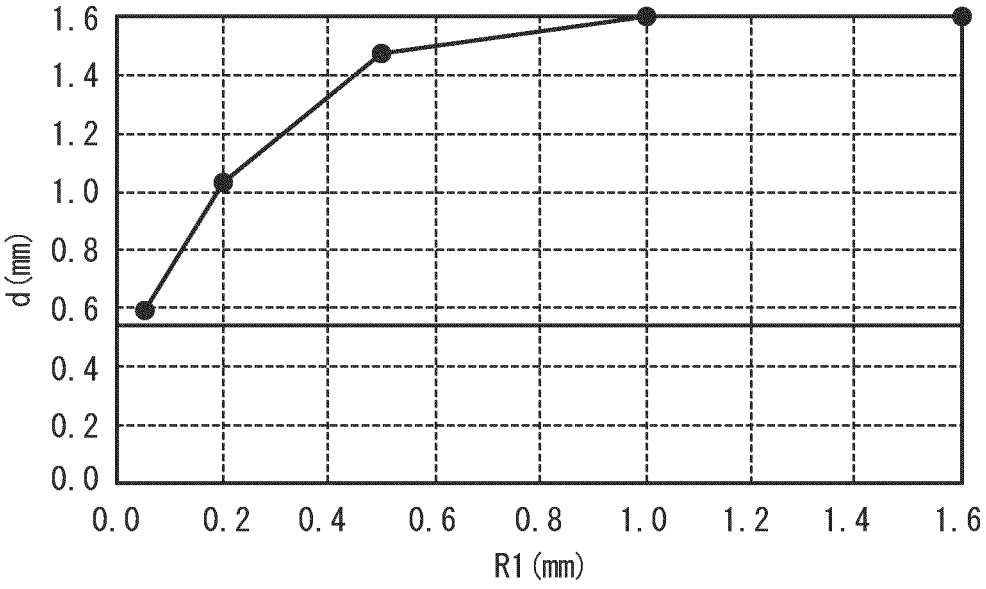


Fig.39

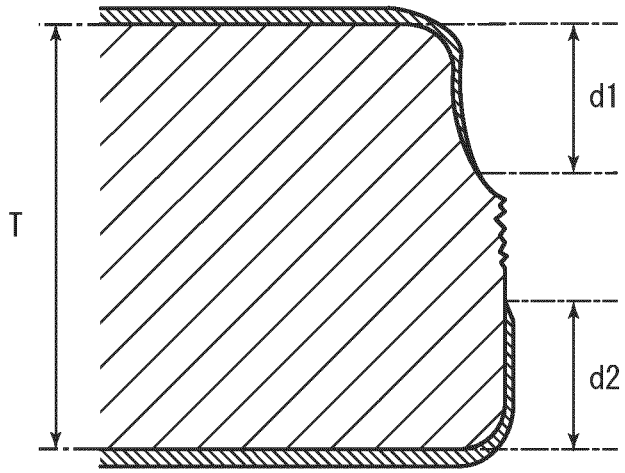
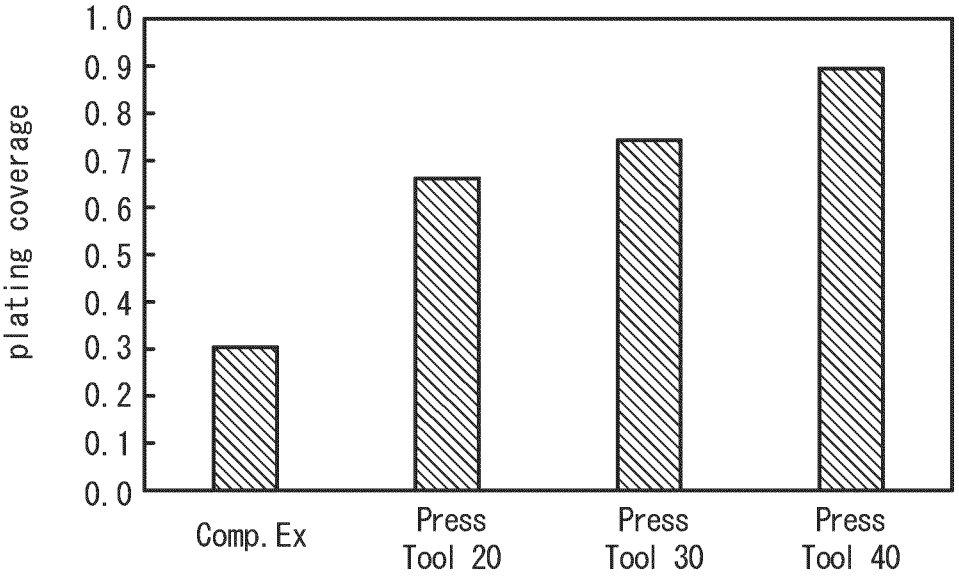

T
d1
d2

Fig.40


plating coverage
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Comp. Ex
Press Tool 20
Press Tool 30
Press Tool 40

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2023/016706

A. CLASSIFICATION OF SUBJECT MATTER

B21D 28/16(2006.01)i; ***B21D 28/14***(2006.01)i
FI: B21D28/16; B21D28/14 B

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)

B21D28/16; B21D28/14; B21D22/02

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

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2023
Registered utility model specifications of Japan 1996-2023
Published registered utility model applications of Japan 1994-2023

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.
Y	JP 08-332529 A (MITSUBISHI MOTORS CORP.) 17 December 1996 (1996-12-17) paragraph [0004], fig. 7	13-17
A		1-12
Y	JP 2002-035861 A (NISHIYAMA TETSUMOU SEISAKUSHO KK) 05 February 2002 (2002-02-05) paragraphs [0013]-[0024], fig. 5-10	13-17
A	WO 2020/183882 A1 (NIPPON STEEL CORP.) 17 September 2020 (2020-09-17) entire text, all drawings	1-17
A	US 3211034 A (KIENZLE APPARATE G.M.B.H.) 12 October 1965 (1965-10-12) entire text, all drawings	1-16
A	JP 2021-133391 A (NIPPON STEEL CORP.) 13 September 2021 (2021-09-13) entire text, all drawings	1-17
A	JP 2017-087294 A (NISSHIN STEEL CO., LTD.) 25 May 2017 (2017-05-25) entire text, all drawings	1-17

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

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

Date of the actual completion of the international search	Date of mailing of the international search report
29 June 2023	**11 July 2023**
Name and mailing address of the ISA/JP **Japan Patent Office (ISA/JP)** **3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915** **Japan**	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2023/016706

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2009-287082 A (JFE STEEL CORP.) 10 December 2009 (2009-12-10) entire text, all drawings	1-17
A	JP 2020-032437 A (NIPPON STEEL CORP.) 05 March 2020 (2020-03-05) entire text, all drawings	1-17
A	JP 06-182461 A (TOYOTA AUTO BODY CO., LTD.) 05 July 1994 (1994-07-05) entire text, all drawings	1-17

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2023/016706

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 08-332529 A	17 December 1996	(Family: none)	
JP 2002-035861 A	05 February 2002	(Family: none)	
WO 2020/183882 A1	17 September 2020	US 2022/0250177 A1 entire text, all drawings EP 3939714 A1 CN 113557096 A KR 10-2021-0135568 A	
US 3211034 A	12 October 1965	GB 914793 A DE 1169404 B CH 383302 A	
JP 2021-133391 A	13 September 2021	(Family: none)	
JP 2017-087294 A	25 May 2017	(Family: none)	
JP 2009-287082 A	10 December 2009	(Family: none)	
JP 2020-032437 A	05 March 2020	(Family: none)	
JP 06-182461 A	05 July 1994	(Family: none)	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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

Patent documents cited in the description

- JP 2021133391 A **[0004] [0009] [0010]**
- JP 2017087294 A **[0005] [0009] [0010]**
- JP 2009287082 A **[0006] [0009] [0010]**
- JP 2020032437 A **[0007] [0009]**
- JP H6182461 A **[0008] [0009]**
- JP 2000210731 A **[0008] [0009]**
- JP 2005014062 A **[0008] [0009]**