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

(11) EP 3 750 650 A1

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

(43) Date of publication:
16.12.2020 Bulletin 2020/51

(21) Application number: **19748250.8**

(22) Date of filing: **01.02.2019**

(51) Int Cl.:
B22D 17/00 *(2006.01)* ***B22C 9/06*** *(2006.01)*
B22D 17/22 *(2006.01)*

(86) International application number:
PCT/JP2019/003557

(87) International publication number:
WO 2019/151466 (08.08.2019 Gazette 2019/32)

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

(30) Priority: **05.02.2018 JP 2018017798**

(71) Applicant: **Kawasaki Jukogyo Kabushiki Kaisha**
Hyogo 650-8670 (JP)

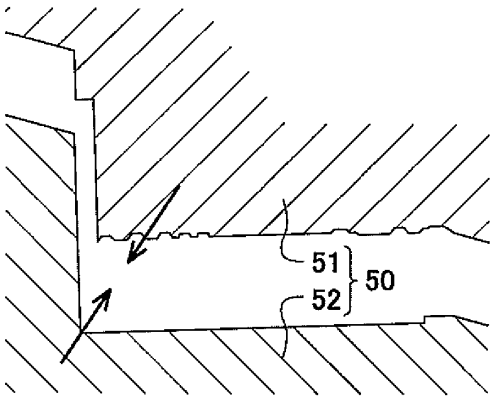
(72) Inventors:
- **TAN, Haruhiko**
  Hyogo 650-8670 (JP)
- **TOMINAGA, Shota**
  Hyogo 650-8670 (JP)

(74) Representative: **Witte, Weller & Partner**
Patentanwälte mbB
Postfach 10 54 62
70047 Stuttgart (DE)

(54) **METHOD OF MANUFACTURING HOUSING**

(57) There is provided a method of producing a casing configured such that adjacent surfaces of the casing are maintained to be perpendicular to each other. A method of producing a casing includes: a first part forming step of forming a first part by pouring molten metal into a cavity formed inside a first die including a first die portion and a second die portion, the cavity corresponding to the first part, the first part including two plate portions connected to each other such that an angle between main surfaces of the two plate portions of the first part becomes 90°, the two main surfaces of the two plate portions of the first part being formed by only one of the first die portion and the second die portion; and a second part forming step of forming a second part by pouring the molten metal into a cavity formed inside a second die including a third die portion and a fourth die portion, the cavity corresponding to the second part, the second part including two plate portions connected to each other such that an angle between main surfaces of the two plate portions of the second part becomes 90°, the two main surfaces of the two plate portions of the second part being formed by only one of the third die portion and the fourth die portion.

FIG.6a



EP 3 750 650 A1

(Cont. next page)

FIG.6c

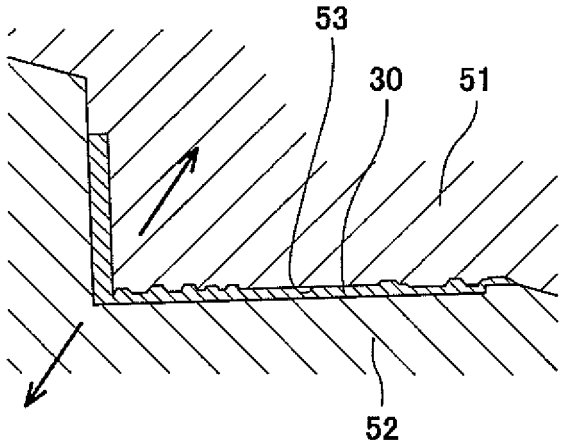


FIG.6b

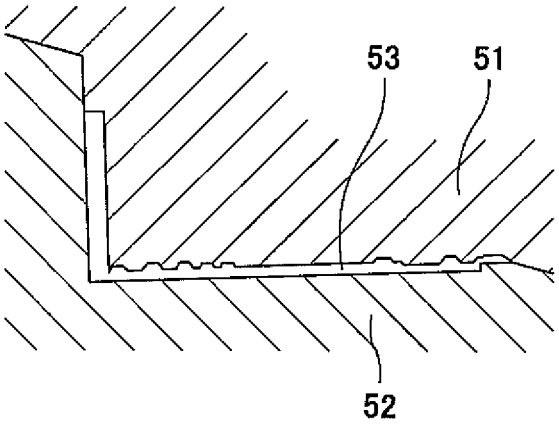
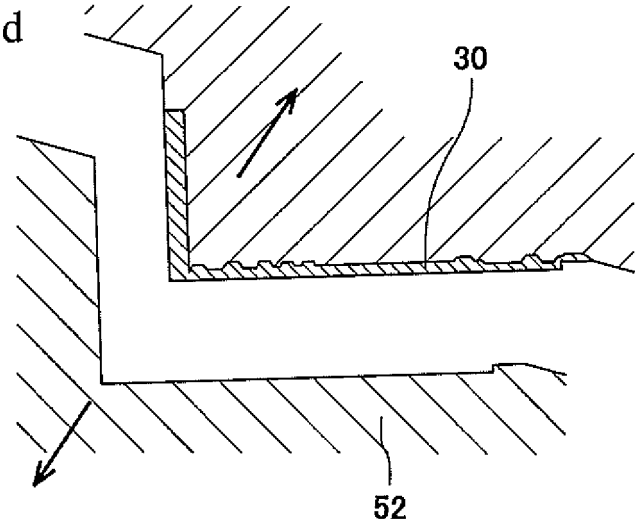


FIG.6d



Description

Technical Field

[0001] The present invention relates to a method of producing a casing by die casting.

Background Art

[0002] In some conventional cases, casings for accommodating control boards are manufactured by die casting. PTL 1 discloses that the casing for accommodating the control board is manufactured by the die casting. In PTL 1, the casing is manufactured by the die casting using aluminum.

Citation List

Patent Literature

[0003] PTL 1: Japanese Laid-Open Patent Application Publication No. 2001-357925

Summary of Invention

Technical Problem

[0004] In PTL 1, a plurality of parts each having a U shape are manufactured by the die casting, and the casing is manufactured by assembling the manufactured U-shaped parts.

[0005] In order to manufacture a part by die casting, a step of removing the manufactured part from a die is required. Typically, when manufacturing a part by die casting, draft needs to be formed at the part such that the part can be removed from the die. Therefore, the part needs to be formed in a tapered shape.

[0006] However, when the part is formed in a tapered shape such that the part can be removed from the die, there is a possibility that adjacent side surfaces of the casing cannot be maintained to be perpendicular to each other. Especially, when a part includes three surfaces, and these three surfaces form a U shape, there is a possibility that adjacent surfaces among the three surfaces of the part cannot be maintained to intersect with each other at a right angle. Therefore, there is a possibility that as a result of the assembling and manufacture of the casing, adjacent surfaces of the casing are not maintained to intersect with each other at a right angle.

[0007] In some cases, the casing that houses the control board is arranged such that a large surface thereof is grounded. Instead, in consideration of an arrangement space, the casing may be arranged by changing the posture thereof such that a small surface thereof is grounded, and the casing stands upright. In such a case, when adjacent surfaces of the casing are not perpendicular to each other, the casing may be arranged in an inclined state. When the casing is arranged in an inclined state, the casing falls down during installation, and the impact by this falling may cause a trouble of the casing.

[0008] The part is formed in a tapered shape so as to be able to be removed from the die. Therefore, when the casing is formed by assembling the parts taken out from the die, opposing inner surfaces of the casing may not be parallel to each other, and an inner space of the casing may be partially narrow. In this case, there is a possibility that since the inner space of the casing is narrow, the capacity inside the casing for accommodation becomes small.

[0009] The present invention was made under these circumstances, and an object of the present invention is to provide a method of producing a casing including adjacent surfaces which are maintained to be perpendicular to each other.

Solution to Problem

[0010] A method of producing a casing according to the present invention includes: a first part forming step of forming a first part by pouring molten metal into a cavity formed inside a first die including a first die portion and a second die portion, the cavity corresponding to the first part, the first part including two plate portions connected to each other such that an angle between main surfaces of the two plate portions of the first part becomes 90°, the two main surfaces of the two plate portions of the first part being formed by only one of the first die portion and the second die portion; a second part forming step of forming a second part by pouring the molten metal into a cavity formed inside a second die including a third die portion and a fourth die portion, the cavity corresponding to the second part, the second part including two plate portions connected to each other such that an angle between main surfaces of the two plate portions of the second part becomes 90°, the two main surfaces of the two plate portions of the second part being formed by only one of the third die portion and the fourth die portion; a casing forming member assembling step of forming a casing forming member including three plate portions by assembling the first part formed in the first part forming step and the second part formed in the second part forming step; and a casing forming step of forming a casing by using the casing forming member formed in the casing forming member assembling step.

[0011] According to the above method of producing the casing, the first part is formed by the first part forming step of forming the first part by pouring the molten metal into the cavity formed inside the first die including the first die portion and the second die portion, the cavity corresponding to the first part, the first part including the two plate portions connected to each other such that the angle between the main surfaces of the two plate portions of the first part becomes 90°, the two main surfaces of the two plate portions of the first part being formed by only one of the first die portion and the second die portion. Moreover, the second part is formed by the second part

forming step of forming the second part by pouring the molten metal into the cavity formed inside the second die including the third die portion and the fourth die portion, the cavity corresponding to the second part, the second part including the two plate portions connected to each other such that the angle between the main surfaces of the two plate portions of the second part becomes 90°, the two main surfaces of the two plate portions of the second part being formed by only one of the third die portion and the fourth die portion. Therefore, the first part and the second part each including the two plate portions connected to each other such that the angle between the main surfaces becomes 90° can be formed. On this account, the casing formed by using these parts is formed such that angle between main surfaces of adjacent surfaces thereof becomes 90°.

[0012] In the first part forming step, the cavity in the first die may be formed such that an intersection line where the main surfaces of the two plate portions of the first part intersect with each other is located at a lowest position inside the first die, and in the second part forming step, the cavity in the second die may be formed such that an intersection line where the main surfaces of the two plate portions of the second part intersect with each other is located at a lowest position inside the second die.

[0013] Since the intersection line where the main surfaces of the two plate portions intersect with each other is located at the lowest position inside each of the first die and the second die, the first part and the second part can be smoothly removed from the first die and the second die.

[0014] In the first part forming step, the cavity in the first die may be provided such that the first part is formed inside the first die in such a posture that a direction in which one of the plate portions of the first part extends from the intersection line is inclined relative to a horizontal plane, and in the second part forming step, the cavity in the second die may be provided such that the second part is formed inside the second die in such a posture that a direction in which one of the plate portions of the second part extends from the intersection line is inclined relative to the horizontal plane.

[0015] Since the first part and the second part are formed inside the first die and the second die in such a posture that the direction in which one of the plate portions extends from the intersection line where the outside surfaces of the two plate portions intersect with each other is inclined relative to the horizontal plane, the first part and the second part can be more smoothly removed from the first die and the second die.

[0016] The molten metal may be prepared by melting aluminum.

[0017] Since the molten metal is prepared by melting aluminum, the casing produced is made of aluminum. Since the casing is made of aluminum, heat generated inside the casing can be efficiently radiated to an outside.

[0018] The casing may be a controller casing accommodating a control board.

[0019] Since the casing is the controller casing accommodating the control board, the controller casing can be formed such that an angle between adjacent outside surfaces thereof becomes a right angle.

[0020] The control board may be a control board configured to control a robot.

[0021] Since the casing is a controller accommodating a control board configured to control a robot, the controller casing accommodating the control board configured to control the robot can be formed such that the angle between adjacent outside surfaces thereof becomes a right angle.

[0022] A method of producing a casing according to the present invention includes: a third part forming step of forming a third part by pouring molten metal into a cavity formed inside a third die including a fifth die portion and a sixth die portion, the cavity corresponding to the third part, the third part including two plate portions connected to each other such that an angle between main surfaces of the two plate portions of the third part becomes 90°, the two main surfaces of the two plate portions of the third part being formed by only one of the fifth die portion and the sixth die portion; a casing forming member assembling step of forming a casing forming member including three plate portions by using and assembling the two third parts formed in the third part forming step; and a casing forming step of forming a casing by using the casing forming member formed in the casing forming member assembling step.

[0023] According to the above method of producing the casing, the third part is formed by the third part forming step of forming the third part by pouring the molten metal into the cavity formed inside the third die including the fifth die portion and the sixth die portion, the cavity corresponding to the third part, the third part including the two plate portions connected to each other such that the angle between the main surfaces of the two plate portions of the third part becomes 90°, the two main surfaces of the two plate portions of the third part being formed by only one of the fifth die portion and the sixth die portion. Moreover, the casing forming member including the three plate portions is formed by using and assembling the two third parts. Therefore, the two third parts each including the two plate portions connected to each other such that the angle between the main surfaces becomes 90° can be formed. On this account, the casing formed by using the two third parts is formed such that the angle between the main surfaces of the adjacent surfaces thereof becomes 90°.

Advantageous Effects of Invention

[0024] According to the present invention, the casing formed such that the angle between the main surfaces of the adjacent surfaces thereof becomes 90° is produced. Therefore, the casing which can be stably arranged even when the grounded surface is changed can be provided.

Brief Description of Drawings

[0025]

FIG. 1 is a perspective view of a casing produced by a casing producing method according to an embodiment of the present invention.

FIG. 2 is a configuration diagram showing a robot and the casing of FIG. 1 used as a casing for a robot controller.

FIG. 3 is a perspective view of a casing forming member located at a lower portion of the casing of FIG. 1.

FIG. 4 is a perspective view showing the casing forming member of FIG. 3, the casing forming member being divided into two parts.

FIG. 5 is a sectional view showing a die and a part which constitutes the casing forming member of FIG. 3 and is formed by die casting.

FIGS. 6A to 6D are configuration diagrams showing steps performed when the part constituting the casing forming member of FIG. 3 is formed by the die casting.

FIG. 7 is a flow chart showing a procedure performed when producing the casing of FIG. 1.

FIGS. 8A to 8C are side views showing the part, constituting the casing forming member of FIG. 3, in steps performed when attaching accessories to an inside of the part.

Description of Embodiments

[0026] Hereinafter, a casing producing method according to an embodiment of the present invention will be described with reference to the attached drawings.

[0027] FIG. 1 is a perspective view showing a casing 100 produced by the casing producing method according to the embodiment of the present invention.

[0028] In the present embodiment, the casing 100 has a rectangular solid shape. Therefore, the casing 100 is formed such that adjacent surfaces thereof intersect with each other at a right angle. The casing 100 accommodates therein a control board of a robot and is configured as a casing for a robot controller that controls the robot.

[0029] FIG. 2 is a configuration diagram showing that the casing 100 of the present embodiment is used as a casing for a robot controller that controls a robot 60.

[0030] As shown in FIG. 2, the casing 100 of the present embodiment accommodates therein a control board 80 configured to control the operation of the robot 60. Therefore, the casing 100 serves as a controller casing that accommodates the control board 80. In the present embodiment, the robot 60 is used as a multiaxial industrial robot.

[0031] The present embodiment describes that the robot controlled by the control board accommodated in the casing is an industrial robot. However, the present invention is not limited to the embodiment. The robot controlled by the control board accommodated in the casing may be a different type of robot. The robot may be of any type as long as the robot is controlled by the control board in the casing. Moreover, the control board accommodated in the casing does not have to be a control board configured to control a robot. A control board configured to control a thing other than a robot may be accommodated in the casing. Furthermore, a thing accommodated in the casing does not have to be a control board. The present invention may be applied to a casing that accommodates a thing other than a control board.

[0032] In the present embodiment, the casing 100 is made of aluminum. When the casing 100 is used as a robot controller, a large amount of heat is generated from the control board 80 while the robot 60 is operating. Therefore, the casing 100 is made of aluminum having high heat radiation performance.

[0033] In the present embodiment, the casing 100 having a rectangular solid shape is formed by using a casing forming member 10 having a U-shaped section.

[0034] FIG. 3 is a perspective view showing two parts of the casing forming member 10 constituting the casing 100. The casing forming member 10 includes a surface which is located at a lower portion of the casing 100 and is grounded.

[0035] The casing forming member 10 is formed to have a U-shaped section by perpendicularly connecting three plate-shaped portions to each other. The casing forming member 10 formed to have a U-shaped section is formed by assembling two L-shaped parts to each other.

[0036] FIG. 4 is a perspective view showing the casing forming member 10 which is divided into two parts (first and second parts) 11 and 12.

[0037] Each of the parts 11 and 12 is formed to have an L-shaped section by connecting two plate-shaped portions (plate portions) such that an angle between main surfaces of the plate portions becomes 90°. In the present embodiment, the part 11 is formed to have an L-shaped section by connecting two plate portions 11a and 11b such that an angle between main surfaces of the plate portions 11a and 11b becomes 90°. To be specific, the two plate portions 11a and 11b are connected to each other such that the angle between the main surfaces thereof becomes 90°. In the present embodiment, the main surfaces of the two plate portions 11a and 11b are outside surfaces of the plate portions 11a and 11b. Similarly, the part 12 is formed to have an L-shaped section by connecting two plate portions 12a and 12b such that an angle between main surfaces of the plate portions 12a and 12b becomes 90°. To be specific, the two plate portions 12a and 12b are connected to each other such that the angle between the main surfaces thereof becomes 90°. In the present embodiment, the main surfaces of the two plate portions 12a and 12b are outside surfaces of the plate portions 12a and 12b.

[0038] Next, a method of producing the casing 100 will be described.

[0039] In the present embodiment, a part 30 constitut-

ing a portion of the casing forming member 10 and having an L-shaped section is formed by die casting. The part 30 is configured to have the L-shaped section by two plate portions 30a and 30b perpendicular to each other.

[0040] FIG. 5 is a sectional view showing a die 50 and the part 30 which is formed by the die casting.

[0041] The die (first die) 50 includes an upper die portion (first die portion) 51 and a lower die portion (second die portion) 52. The upper die portion 51 and the lower die portion 52 are configured to be able to approach each other and separate from each other.

[0042] A cavity 53 corresponding to the shape of the part 30 is formed between the upper die portion 51 and the lower die portion 52. The cavity 53 is used to form the part 30 by the die casting, the part 30 being formed by the two plate portions 30a and 30b perpendicular to each other. When producing the part 30, molten metal prepared by melting aluminum is poured under pressure into an inside of the cavity 53. After that, the molten metal is cooled and solidified inside the cavity 53. With this, the part 30 is formed. As a result, the part 30 having a shape corresponding to the shape of the cavity 53 and made of aluminum is formed.

[0043] The cavity 53 is formed at the die 50 so as to correspond to the part 30. The cavity 53 includes plate-portion cavities 53a and 53b corresponding to the two plate portions 30a and 30b perpendicular to each other. The cavity 53 is formed such that an intersection line 1 where main surfaces of the two plate portions 30a and 30b intersect with each other is located at a lowest position in the die 50. To be specific, the cavity 53 is formed such that a position corresponding to the intersection line 1 where the two plate portions intersect with each other is located at the lowest position in the die 50. Moreover, the cavity 53 is formed such that the part 30 is formed to take such a posture that a direction in which the plate portion 30b extends from the intersection line 1 is inclined relative to a horizontal plane. Therefore, in the cavity 53, the position corresponding to the intersection line 1 where the two plate portions 30a and 30b intersect with each other is located at the lowest position. Furthermore, the cavity 53 is formed such that a direction in which a portion thereof forming the plate portion 30b extends from the intersection line 1 is inclined relative to the horizontal plane.

[0044] Therefore, in the present embodiment, the part 30 is formed to take such a posture that the direction in which the plate portion 30b located at a lower side in the die 50 out of the two plate portions 30a and 30b formed at the part 30 extends is inclined relative to the horizontal plane. In the present embodiment, the part 30 is formed to take such a posture that the direction in which the plate portion 30b extends is inclined relative to the horizontal plane at an angle α that is 1° or more and 2° or less.

[0045] Since the two plate portions 30a and 30b formed at the part 30 are perpendicular to each other, the part 30 is formed to take such a posture that a direction in which the plate portion 30a located at an upper side in the die 50 out of the two plate portions 30a and 30b formed at the part 30 extends is inclined relative to a vertical direction. In the present embodiment, the part 30 is formed to take such a posture that the direction in which the plate portion 30a extends is inclined relative to the vertical direction at the angle α that is 1° or more and 2° or less. Especially, it is desirable that each of the angle at which the plate portion 30b is inclined relative to the horizontal plane and the angle α at which the direction in which the plate portion 30a extends is inclined relative to the vertical direction be 1.5° or more. It should be noted that there is a possibility that if such inclination is large, it is difficult to remove the part from the die due to, for example, the shape of a screw hole formed on the plate portion. Therefore, in the present embodiment, it is preferable that each of the angle at which the plate portion 30b is inclined relative to the horizontal plane and the angle α at which the direction in which the plate portion 30a extends is inclined relative to the vertical direction be 1° or more and 2° or less.

[0046] Steps performed when the part 30 is formed by the die casting will be described with reference to FIGS. 6A to 6D. FIG. 7 is a flow chart showing a procedure performed when producing the casing 100 by the method of producing the casing 100 according to the present embodiment.

[0047] First, as shown in FIG. 6A, the upper die portion 51 and the lower die portion 52 in the die 50 are made to approach each other. Then, as shown in FIG. 6B, the upper die portion 51 and the lower die portion 52 are brought into contact with each other. When the upper die portion 51 and the lower die portion 52 contact each other, and therefore, the die 50 is closed, the cavity 53 is formed between the upper die portion 51 and the lower die portion 52.

[0048] As shown in FIG. 6C, after the cavity 53 is formed, molten metal prepared by heating and melting aluminum is poured into an inside of the cavity 53 formed in an inclined state in the die 50. In order that the molten metal reaches every corner of the cavity 53, the molten metal is poured into the inside of the cavity 53 while being applied with pressure. Thus, the molten metal is poured under pressure to the inside of the cavity 53 (S1).

[0049] When the molten metal is poured under pressure into the inside of the cavity 53, and then, the die 50 is cooled, the molten metal is solidified in the die 50. With this, the part 30 is formed to have a shape corresponding to the cavity 53. Thus, the part 30 having a desired shape is formed in the cavity 53.

[0050] After the part 30 is formed in the cavity 53, the upper die portion 51 and the lower die portion 52 in the die 50 are separated from each other (S2). After the upper die portion 51 and the lower die portion 52 are separated from each other, as shown in FIG. 6D, the part 30 formed between the upper die portion 51 and the lower die portion 52 is taken out from the cavity 53. In the present embodiment, when the upper die portion 51 and the lower die portion 52 are separated from each other, the part 30

is taken out from the cavity 53 while being attached to the upper die portion 51. After the part 30 is taken out from the cavity 53, the part 30 is detached from the upper die portion 51, and thus, the part 30 is taken out from the die 50 (S3).

[0051] At this time, the die 50 is divided into two portions that are the upper die portion 51 and the lower die portion 52, and the part 30 is formed such that two outside surfaces (main surfaces) of the two plate portions 30a and 30b are formed by only one of the upper die portion 51 and the lower die portion 52. In the present embodiment, the two outside surfaces (main surfaces) of the two plate portions 30a and 30b are formed by the lower die portion 52.

[0052] As above, in the present embodiment, the part 30 is produced by the die casting. In the present embodiment, a plurality of parts 30 of different types are formed by the die casting, and the part 11 that is one of the parts 30 serves as the part (first part) 11 out of the parts 11 and 12 constituting the casing forming member 10. Moreover, the die that forms the part 11 serves as the die (first die) 50. As above, the part 11 that is one of the parts 11 and 12 constituting the casing forming member 10 is formed by the die casting (first part forming step). After the part 11 is formed in the die 50, the part 11 is taken out from the die 50 (S3).

[0053] After the part 11 is formed by the die casting, the part (second part) 12 out of the parts 11 and 12 constituting the casing forming member 10 is formed.

[0054] As shown in FIG. 4, the part 11 and the part 12 are different in shape from each other. Therefore, when producing the part 12, a die (second die) different from the die (first die) used when producing the part 11 is used. However, since the part 11 and the part 12 are substantially the same in configuration as each other, steps of producing the part 12 are similar to the steps of producing the part 11. Therefore, the part 12 is also produced through the steps shown in FIGS. 6A to 6D.

[0055] To be specific, as shown in FIG. 6A, the upper die portion (third die portion) and lower die portion (fourth die portion) of the die (second die) are being separated from each other. Then, as shown in FIG. 6B, the upper die portion and lower die portion of the die (second die) are brought into contact with each other, and with this, the cavity is formed therebetween. After the cavity is formed between the upper die portion and lower die portion of the die (second die), as shown in FIG. 6C, the molten metal is poured under pressure into the cavity formed in an inclined state in the die (second die) (S4). After the molten metal is poured under pressure into the die (second die), the die (second die) is cooled. With this, the molten metal is solidified in the die (second die). Thus, the part (second part) is formed. As above, the part (second part) is formed in the cavity (second part forming step). After the part (second part) is formed in the cavity, the upper die portion and lower die portion of the die (second die) are separated from each other (S5). When the upper die portion and the lower die portion are separated from each other, as shown in FIG. 6D, the part (second part) formed between the upper die portion and the lower die portion is taken out from the cavity while being attached to the upper die portion. After the part (second part) is taken out from the cavity, the part (second part) is detached from the upper die portion, and thus, the part (second part) is taken out from the die (second die) (S6).

[0056] It should be noted that the present embodiment describes that the two parts 11 and 12 are different in shape from each other. Therefore, the present embodiment describes that the shape of the cavity is different between the die (first die) that forms the part 11 and the die (second die) that forms the part 12. However, the present invention is not limited to the above embodiment. The shape of the part 11 (first part) and the shape of the part 12 (second part) may be the same as each other.

[0057] In this case, the die that forms the part 11 and the die that forms the part 12 may be common to each other. Two parts (third parts) which constitute the casing forming member 10 and are the same in shape as each other may be formed by a common die (third die) including an upper die portion (fifth die portion) and a lower die portion (sixth die portion). To be specific, the two common parts (third parts) are formed by performing the step (third part forming step) of forming the part (third part) twice. As above, since the two parts (third parts) are produced by the common die, the number of necessary dies can be reduced, and therefore, manufacturing cost for the casing 100 can be reduced.

[0058] After the two parts 11 and 12 constituting the casing forming member 10 are formed by the die casting, the casing forming member 10 is formed by assembling the parts 11 and 12 (casing forming member assembling step) (S7). In the present embodiment, the casing forming member 10 is assembled by fastening the two parts 11 and 12 to each other by screws.

[0059] When two parts are formed by a common die, the casing forming member 10 may be formed by using and assembling these two parts. In this case, the casing forming member 10 may be assembled by fastening the two common parts to each other by screws.

[0060] The casing forming member 10 is formed by fastening the two parts 11 and 12 to each other. In the present embodiment, the plate portion 11b out of the two plate portions 11a and 11b of the part 11 and the plate portion 12a out of the plate portions 12a and 12b of the part 12 are connected to each other to form a single plate portion 13. As a result, the casing forming member 10 includes the three plate portions 11a, 13, and 12b.

[0061] The plate portions 11a and 11b constituting the part 11 are connected to each other such that the angle between the main surfaces of the plate portions 11a and 11b becomes 90°. Therefore, the plate portions 11a and 13 are connected to each other such that the angle between the outer surfaces of the plate portions 11a and 13 becomes 90°. Moreover, the plate portions 12a and 12b constituting the part 12 are connected to each other

such that the angle between the outside surfaces of the plate portions 12a and 12b becomes 90°. Therefore, the plate portions 11a and 13 are connected to each other such that the angle between the outside surfaces of the plate portions 11a and 13 becomes 90°. On this account, the three plate portions 11a, 13, and 12b constituting the casing forming member 10 are connected to each other to form a U shape such that the angle between the adjacent outside surfaces becomes 90°.

[0062] After the casing forming member 10 is formed, the casing 100 is formed by using the casing forming member 10 (casing forming step) (S8). In the present embodiment, the casing 100 is formed by attaching the other side surfaces to the casing forming member 10 having a U shape and also attaching to the casing forming member 10 a surface located at an upper side of the casing 100.

[0063] As shown in FIG. 1, in the casing 100, a surface F1 as a bottom surface to be grounded, a surface F2 adjacent to the surface F1, and a surface (not shown) opposed to the surface F2 are integrally formed as the casing forming member 10 by the die casting. The casing 100 is formed by attaching surfaces other than the surface F1, the surface F2, and the surface opposed to the surface F2 to the casing forming member 10.

[0064] As above, the casing forming member 10 is formed by assembling the parts 11 and 12 obtained by the die casting, and then, the casing 100 is formed by using the casing forming member 10.

[0065] The above embodiment describes that the casing forming member 10 is formed by assembling the two parts 11 and 12 by a method of fastening the two parts 11 and 12 to each other by screws. However, the present invention is not limited to the above embodiment, and the parts may be assembled by a method other than the method of fastening the parts to each other by screws. For example, the parts may be assembled by the other methods, such as adhesion using an adhesive.

[0066] According to the present embodiment, the parts 11 and 12 are formed by the die casting, and the casing forming member 10 is formed by assembling the parts 11 and 12. The parts 11 and 12 that are divided parts of the casing forming member 10 are formed by the die casting. Therefore, since the parts 11 and 12 each including two plate portions are produced by the die casting, each of the parts 11 and 12 can be formed in an L shape formed by connecting two plate portions. Moreover, since each of the parts 11 and 12 includes the two plate portions and is formed in an L shape, each of the parts 11 and 12 can be formed by connecting the two plate portions to each other such that the angle between the outside surfaces of the two plate portions is maintained to be 90°. With this, the casing 100 is formed by connecting the adjacent outside surfaces such that the angle between the adjacent outside surfaces of the casing forming member 10 becomes 90°. Therefore, in the casing 100, adjacent plate members are connected to each other such that the angle between the outside surfaces becomes 90°. With this, in the casing 100, the angle between the outside surfaces of the adjacent plate members is maintained to be 90°.

[0067] Especially, the three plate portions 11a, 13, and 12b constituting the casing forming member 10 are connected to each other such that each of the angle between the outside surfaces of the plate portions 11a and 13 and the angle between the outside surfaces of the plate portions 13 and 12b becomes 90°. Since the angle between the adjacent surfaces of the casing 100 is maintained to be 90°, the casing 100 can be stably arranged even when a grounded surface of the casing 100 is changed. Even when the posture of the casing 100 is changed in accordance with an installation space of the casing 100, the casing 100 can be stably arranged. Therefore, when there is a small space for placing the casing 100, the casing 100 can be arranged by changing the posture in accordance with the small space. For example, even when there is only a thin, long, and narrow installation space, the casing 100 can be stably arranged by changing the posture in accordance with the installation space. With this, the space for the installation of the casing 100 can be used more efficiently. Moreover, since the casing 100 can be stably arranged, the casing 100 can be prevented from falling down, and therefore, the reliability of the casing 100 can be improved. Thus, when the casing 100 is used as a controller of a robot, the reliability of the controller can be improved.

[0068] Especially, the installation space for the casing 100 serving as the controller accommodating the control board 80 may be limited depending on a place where the robot is arranged. In such a case, the casing 100 is required to be arranged within the limited space by changing the posture in accordance with the limited space. For example, when the installation space has a thin and long shape, the casing 100 may be arranged in the installation space by changing the posture of the casing 100 shown in FIG. 1. In FIG. 1, the casing 100 is arranged such that the surface F1 is grounded. However, the casing 100 may be arranged by changing the posture such that the surface F2 is grounded. As above, the casing 100 can be arranged by changing the posture, and therefore, even when the installation space is thin and long, the casing 100 can be arranged in accordance with the thin and long installation space. Thus, the installation space can be used efficiently.

[0069] Moreover, since the adjacent surfaces of the casing 100 are maintained to be perpendicular to each other, the quality of design surfaces of the casing 100 can be improved.

[0070] In the present embodiment, the die 50 is divided into the upper die portion 51 and the lower die portion 52, and the part 30 is formed such that the two outside surfaces (main surfaces) of the two plate portions 30a and 30b are formed by only one of the upper die portion 51 and the lower die portion 52. Therefore, the outside surfaces as the main surfaces of the plate portions 30a and 30b are shaped and formed by a single die portion

(lower die portion 52). With this, the outside surfaces of the plate portions 30a and 30b can be accurately formed such that the angle between the outside surfaces as the main surfaces of the plate portions 30a and 30b becomes 90°.

[0071] Moreover, the part 30 is formed in an inclined posture inside the die 50. The cavity 53 is formed such that: the intersection line 1 where the outside surfaces of the two plate portions 30a and 30b intersect with each other is located at the lowest position in the die 50; and the part 30 is formed in such a posture that the direction in which the plate portion 30b extends from the intersection line 1 is inclined relative to the horizontal plane. Therefore, the cavity 53 is formed inside the die 50 so as to have a downward convex shape. Each of portions of the cavity 53 which portions correspond to the respective plate portions 30a and 30b is configured to have draft. Therefore, although the part 30 produced by the die 50 is formed such that the two plate portions 30a and 30b are perpendicular to each other, the draft used when removing the part 30 from the die 50 is secured. Since the outside surface of the plate portion 30a is inclined relative to the vertical direction, and the outside surface of the plate portion 30b is inclined relative to the horizontal direction, the draft of the part 30 is secured. Therefore, when producing the part 30 by the die casting and taking out the part 30 from the die 50, the part 30 can be smoothly taken out from the die 50.

[0072] In addition to the outside surfaces, the two plate portions of each of the parts 11 and 12 produced by the die casting are maintained to be perpendicular to each other, and therefore, the adjacent plate members of the casing forming member 10 formed by assembling the parts 11 and 12 are maintained to be perpendicular to each other. On this account, when the casing 100 is assembled, the adjacent plate members of the casing 100 are maintained to be perpendicular to each other. At this time, the plate members constituting the casing forming member 10 of the casing 100 are maintained to be perpendicular to each other.

[0073] In the present embodiment, the draft does not have to be formed at the part, and the side surface of the plate portion constituting the part does not have to be formed in a tapered shape. Therefore, the thickness of each plate portion can be made uniform. On this account, the quality of the design surfaces of the casing 100 can be further improved. Moreover, since the thickness of each plate portion constituting the part can be made uniform, a portion where the plate portions are connected to each other and its vicinity can be prevented from becoming thick. Therefore, a larger space can be secured in the vicinity of the portion where the plate portions are connected to each other. With this, accessories and the like can be accommodated in the space in the vicinity of the portion where the plate portions are connected to each other, and thus, a larger number of accessories and the like can be accommodated in the casing. As above, the space in the casing can be used more efficiently.

[0074] Typically, when the casing is used as a controller of a robot, there is a high possibility that the casing becomes relatively large. According to a small casing, even when the angle between the adjacent surfaces of the casing deviates from 90° due to the formation of the draft used when removing a part from the die, influence caused by this is small, and therefore, is not problematic. However, according to a large casing, even when the angle between the adjacent surfaces slightly deviates from 90°, influence caused by this is large. According to the large casing, even when the angle between the adjacent surfaces slightly deviates from 90°, a gradient generated by this deviation becomes large, and therefore, a difference in height between end portions of opposing surfaces becomes large. On this account, when the posture of the casing is changed by changing the grounded surface, the arrangement of the casing may become unstable since the grounded surface of the casing is inclined. Since the casing is arranged in an unstable state, the casing may fall down when contact or vibration occurs while the casing is being arranged.

[0075] In some conventional cases, when producing a relatively large casing by die casting, a portion projecting due to the deviation of an angle between adjacent surfaces from a right angle by the formation of draft is eliminated by being cut. With this, the casing configured such that the angle between the adjacent surfaces is maintained to be 90° can be produced. However, according to this method of eliminating such projecting portion by cutting, a step of eliminating the projecting portion of the casing is required, and therefore, extra labor is required. Moreover, since the eliminated portion is wastefully discarded, a larger amount of material is required, and this increases manufacturing cost for the larger amount of material.

[0076] Even when the casing 100 of the present embodiment is large, the draft used to remove the part from the die 50 is secured while maintaining a state where the plate portions 30a and 30b are perpendicular to each other. The angle between the plate portions 30a and 30b is maintained to be 90°, and as a result, the angle between the adjacent surfaces of the casing 100 is maintained to be 90°. Therefore, even when the posture of the casing 100 is changed such that the grounded surface of the casing 100 is changed, the casing 100 can be arranged in a stable state.

[0077] Furthermore, the structure of the die may be changed in order that the angle between the adjacent surfaces is maintained to be 90° without forming the draft. Adjacent surfaces of a part may be maintained to be perpendicular to each other by changing conditions and operations of closing and opening of die portions of a die. However, when the conditions and operation of the closing and opening of the die portions of the die are changed so as to correspond to a part, and then, the die casting is performed, the shape and operations of the die become complex. Therefore, the manufacturing cost for the die may increase.

[0078] In the present embodiment, the die 50 is divided into the upper die portion 51 and the lower die portion 52, and the part 30 is formed such that the two outside surfaces (main surfaces) of the two plate portions 30a and 30b are formed by only one of the upper die portion 51 and the lower die portion 52. Since the die 50 is divided into the upper die portion 51 and the lower die portion 52, and the outside surfaces of the plate portions 30a and 30b are accurately formed such that the angle between the outside surfaces as the main surfaces of the plate portions 30a and 30b becomes 90°, the part configured such that the angle between the outside surfaces intersecting with each other becomes 90° can be accurately formed by the die 50 having a simple configuration. Since the configuration of the die 50 can be simplified, the manufacturing cost for the casing 100 can be made low.

[0079] In the present embodiment, the parts 30 forming the casing 100 are made of aluminum, and as a result, the casing 100 is made of aluminum. Therefore, high heat radiation performance of the casing 100 is maintained.

[0080] In the present embodiment, the casing 100 accommodates therein the control board 80 configured to control the operation of the robot 60 and is configured as a robot controller. Therefore, a large amount of heat is generated from the control board 80. In the present embodiment, since the casing 100 is made of aluminum, the heat generated from the control board 80 is efficiently radiated to an outside of the casing 100. Therefore, influence of the heat on the function of the control board 80 can be made small.

[0081] Moreover, since the casing 100 is made of aluminum, the casing 100 can be reduced in weight. Therefore, the casing 100 can be easily carried.

[0082] In the present embodiment, the part 30 made of aluminum is produced by the die casting. Therefore, a large number of parts 30 as aluminum products can be produced by the die casting at low cost.

[0083] The casing forming member 10 having a U shape is formed by assembling the parts 30 each having an L shape, and the casing 100 having a box shape is formed by using the casing forming member 10. Therefore, before the L-shaped parts 30 are assembled, work of attaching substrates and accessories can be performed with respect to the part 30. Since the substrates and accessories are attached to the part 30 before the L-shaped parts 30 are assembled, work of attaching the substrates and accessories to the part 30 can be performed in a space that is open upward. Therefore, work of attaching the substrates and accessories to the casing 100 can be easily performed, and assembling work including such attaching work can be easily performed.

[0084] In the present embodiment, as shown in FIG. 4, inside surfaces of the casing 100 are subjected to various machining. Especially when the casing 100 is used as a controller of a robot, in some cases, a substrate is attached to an inside of the casing 100, and heat generated by the substrate is transmitted to a side surface of the casing 100 to be absorbed by the casing 100, i.e., a portion of the side surface of the casing 100 is used as a heat sink. In such cases, since a portion on which the substrate is mounted and a portion which serves as the heat sink are formed on an inside of the side surface of the casing 100, the shape of the inside of the side surface of the casing 100 may become complex.

[0085] As above, when the inside of the side surface of the casing 100 is formed in a complex shape, a portion of the inside of the side surface of the casing 100 is subjected to machine work in some cases. When subjecting the inside surface of the casing 100 to machine work such that the inside surface has a complex shape, a blade of a cutting machine needs to be inserted into a space surrounded by plate-shaped members and needs to be brought into contact with the inside surface of the plate-shaped member. When the member is formed in a U shape, a space into which the blade is inserted is limited, and therefore, it may be difficult to insert the blade into the space surrounded by the plate-shaped members.

[0086] In the present embodiment, the inside surface of the part 30 can be subjected to machining. In the present embodiment, in the middle of the production of the casing 100, the L-shaped parts 30 constituting the U-shaped casing forming member 10 are not assembled yet. Thus, the inside surface of the L-shaped part 30 can be subjected to machining in a state where an upper side is open, and the space is not limited. On this account, the inside surface of the part 30 can be easily and accurately subjected to machining.

[0087] Substrates and accessories are attached to the L-shaped parts 30 which are not assembled yet. Therefore, even when an accessory is attached to the inner side surface of the casing 100, the accessory can be stably attached with a back surface of the part 30 grounded.

[0088] FIGS. 8A to 8C are side views showing the part 30 in steps performed when attaching accessories to the part 30. An example in which two substrates that are upper and lower substrates are attached as the accessories to the part 30 will be described with reference to FIGS. 8A to 8C.

[0089] First, as shown in FIG. 8A, a substrate 70 arranged at a lower side is attached to the grounded plate portion 30b of the part 30. The substrate 70 is attached along the inside surface of the plate portion 30b. At this time, the substrate 70 can be stably attached to the plate portion 30b with the outside surface of the grounded plate portion 30b grounded.

[0090] After the substrate 70 is attached to the grounded plate portion 30b, as shown in FIG. 8B, the grounded surface is changed by changing the posture of the part 30. With this, the plate portion 30b which was grounded when attaching the substrate 70 stands upright, and the plate portion 30a which stood upright when attaching the substrate 70 is grounded.

[0091] When the plate portion 30a is grounded by

changing the posture of the part 30, a substrate 71 attached at an upper side is attached to the plate portion 30a. The substrate 71 is attached along a direction in which the plate portion 30b extends from the side surface of the plate portion 30a. At this time, the substrate 71 can be stably attached to the plate portion 30a with the outside surface of the grounded plate portion 30a grounded.

[0092] In the present embodiment, the substrate 71 is attached to the plate portion 30a through a supporting portion 72. The substrate 71 is attached to the supporting portion 72, and the supporting portion 72 is attached to the plate portion 30a by screws through holes 73 formed on the supporting portion 72. Therefore, the supporting portion 72 can be attached to the plate portion 30a by the screws with the screws perpendicular to the plate portion 30a. Thus, the supporting portion 72 can be stably attached to the plate portion 30a.

[0093] As above, in the present embodiment, since accessories are attached to the L-shaped part 30, the accessories can be attached to the plate portion 30b with the outside surface of the plate portion 30b grounded. Moreover, accessories can be attached to the inside surface of the plate portion 30a with the outside surface of the plate portion 30a grounded. Therefore, accessories can be stably attached to both plate portions of the L-shaped part 30 with the plate portion grounded. On this account, accessories can be easily attached to the casing 100. Furthermore, accessories can be surely attached to the casing 100, and therefore, the reliability of the casing 100 can be improved.

[0094] The above embodiment has described that the molten metal is prepared by melting aluminum. However, the present invention is not limited to the above embodiment. The molten metal may be prepared by a material other than aluminum. A different type of molten metal may be used as long as a casing made of metal can be formed.

Reference Signs List

[0095]

30	part
30a, 30b	plate portion
50	die
53	cavity
100	casing

Claims

1. A method of producing a casing,
the method comprising:

a first part forming step of forming a first part by pouring molten metal into a cavity formed inside a first die including a first die portion and a second die portion, the cavity corresponding to the first part, the first part including two plate portions connected to each other such that an angle between main surfaces of the two plate portions of the first part becomes 90°, the two main surfaces of the two plate portions of the first part being formed by only one of the first die portion and the second die portion;

a second part forming step of forming a second part by pouring the molten metal into a cavity formed inside a second die including a third die portion and a fourth die portion, the cavity corresponding to the second part, the second part including two plate portions connected to each other such that an angle between main surfaces of the two plate portions of the second part becomes 90°, the two main surfaces of the two plate portions of the second part being formed by only one of the third die portion and the fourth die portion;

a casing forming member assembling step of forming a casing forming member including three plate portions by assembling the first part formed in the first part forming step and the second part formed in the second part forming step; and

a casing forming step of forming a casing by using the casing forming member formed in the casing forming member assembling step.

2. The method according to claim 1, wherein:

in the first part forming step, the cavity in the first die is formed such that an intersection line where the main surfaces of the two plate portions of the first part intersect with each other is located at a lowest position inside the first die; and

in the second part forming step, the cavity in the second die is formed such that an intersection line where the main surfaces of the two plate portions of the second part intersect with each other is located at a lowest position inside the second die.

3. The method according to claim 2, wherein:

in the first part forming step, the cavity in the first die is provided such that the first part is formed inside the first die in such a posture that a direction in which one of the plate portions of the first part extends from the intersection line is inclined relative to a horizontal plane; and

in the second part forming step, the cavity in the second die is provided such that the second part is formed inside the second die in such a posture that a direction in which one of the plate portions of the second part extends from the intersection line is inclined relative to the horizontal plane.

4. The method according to any one of claims 1 to 3, wherein the molten metal is prepared by melting aluminum.

5. The method according to any one of claims 1 to 3, wherein the casing is a controller casing accommodating a control board.

6. The method according to claim 5, wherein the control board is a control board configured to control a robot.

7. A method of producing a casing,
the method comprising:

a third part forming step of forming a third part by pouring molten metal into a cavity formed inside a third die including a fifth die portion and a sixth die portion, the cavity corresponding to the third part, the third part including two plate portions connected to each other such that an angle between main surfaces of the two plate portions of the third part becomes 90°, the two main surfaces of the two plate portions of the third part being formed by only one of the fifth die portion and the sixth die portion;
a casing forming member assembling step of forming a casing forming member including three plate portions by using and assembling the two third parts formed in the third part forming step; and
a casing forming step of forming a casing by using the casing forming member formed in the casing forming member assembling step.

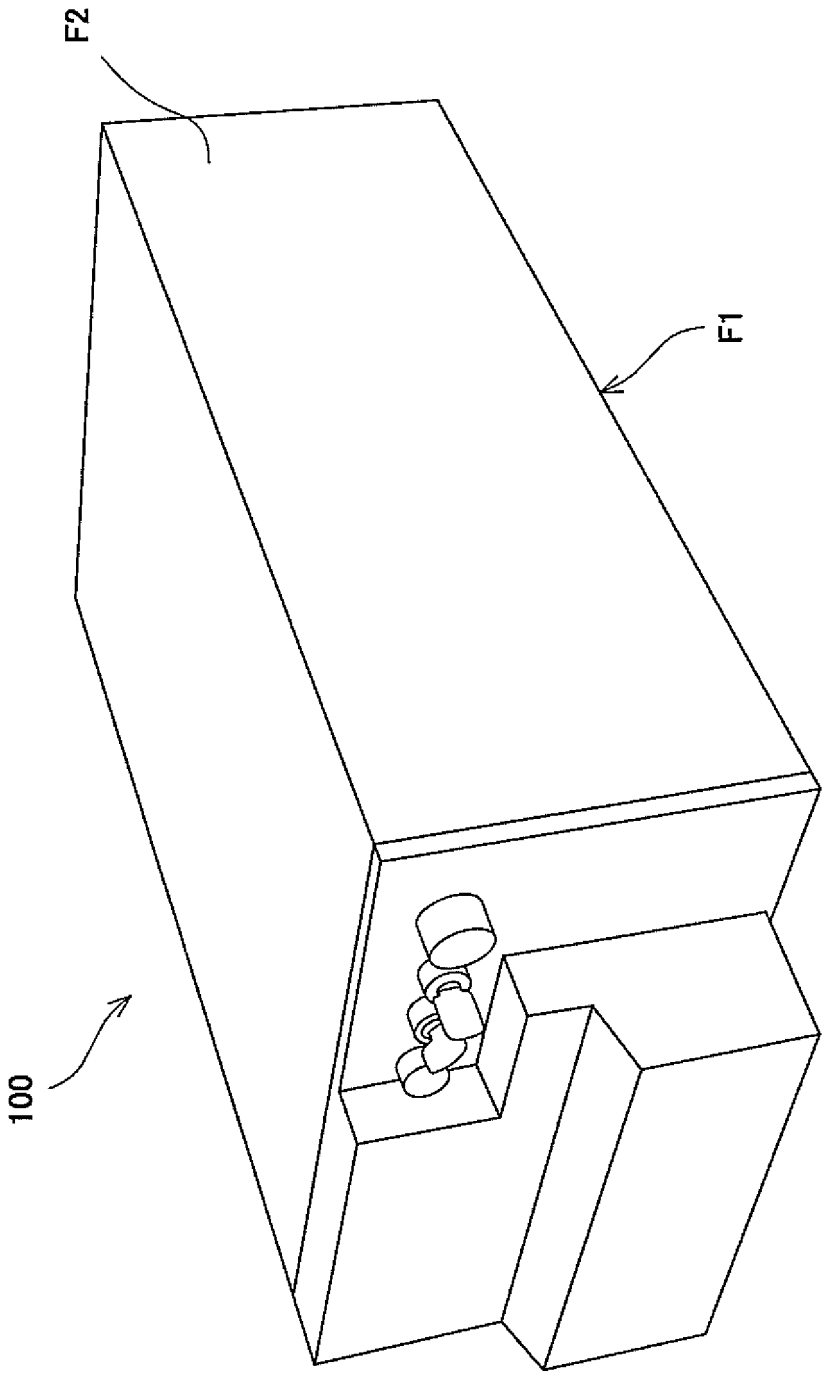


FIG.1

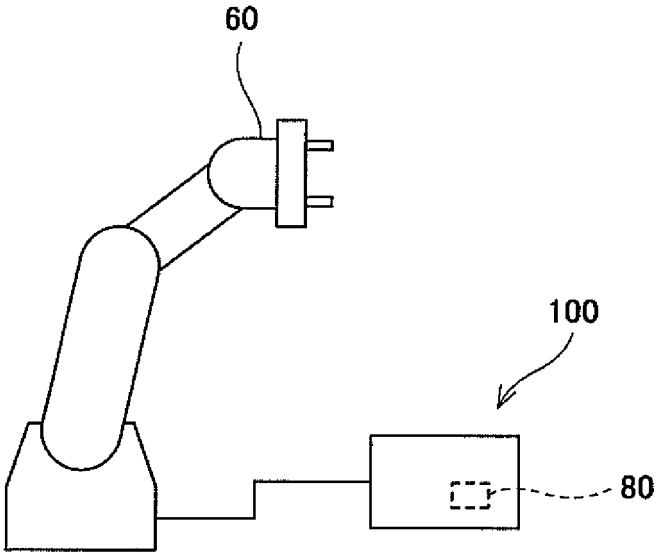


FIG.2

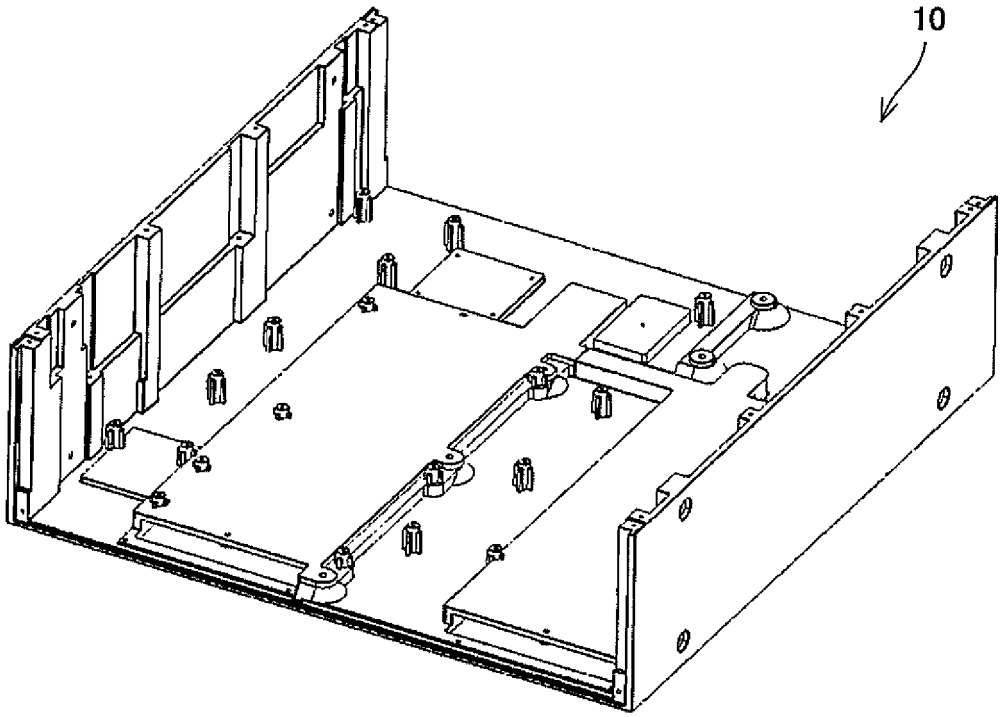


FIG.3

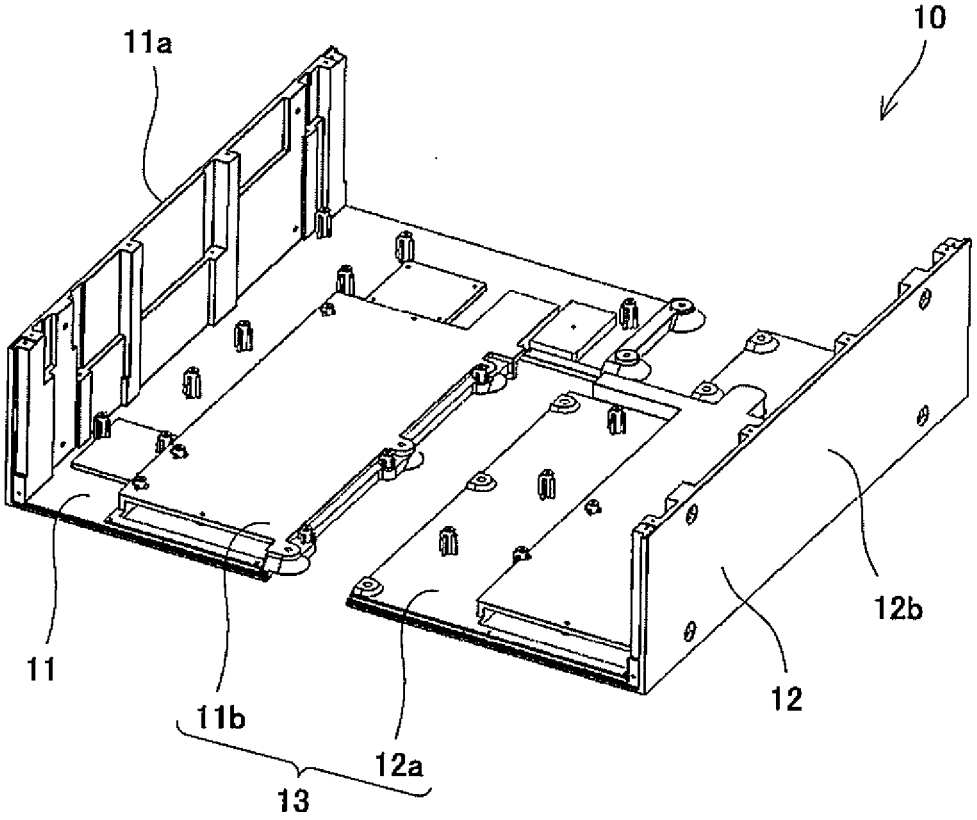


FIG.4

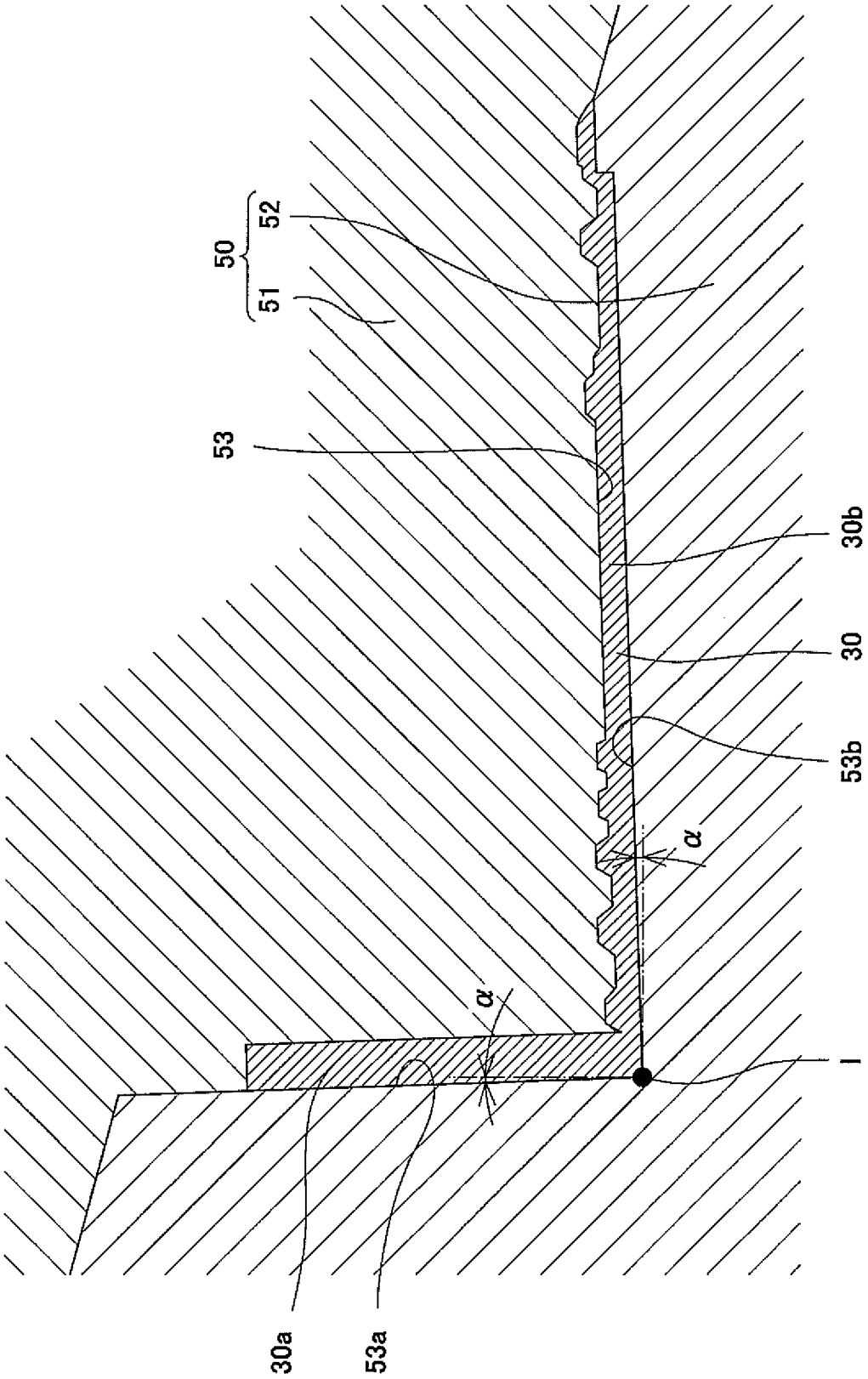


FIG.5

FIG.6b

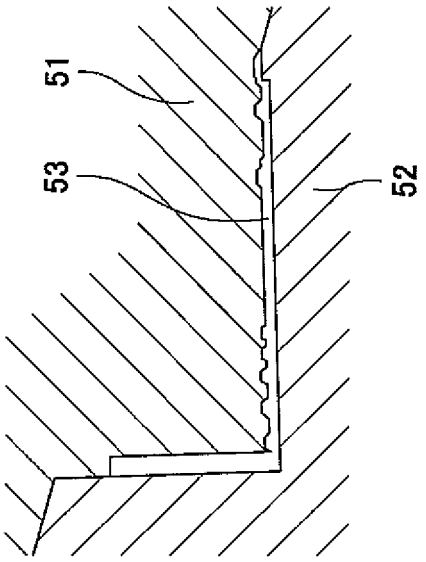


FIG.6d

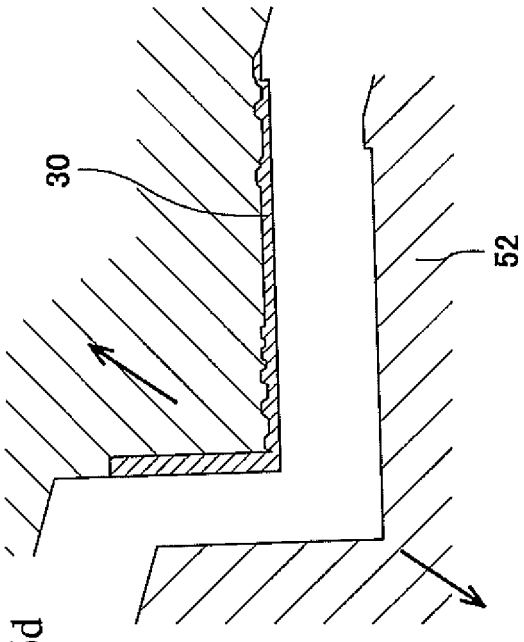


FIG.6a

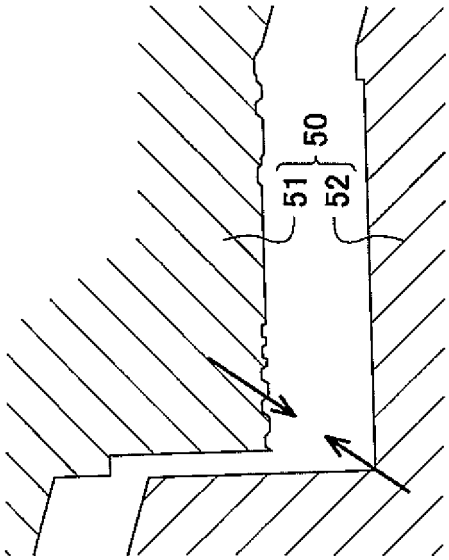
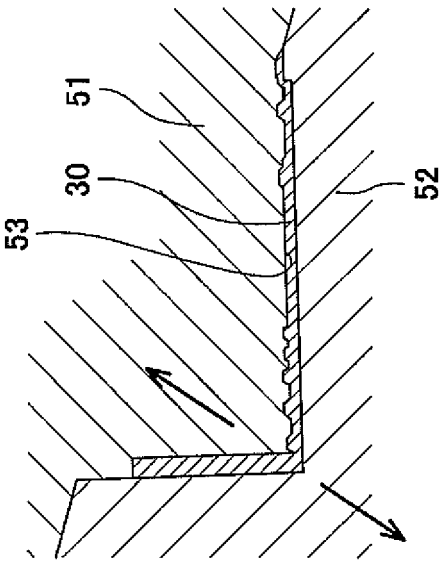


FIG.6c



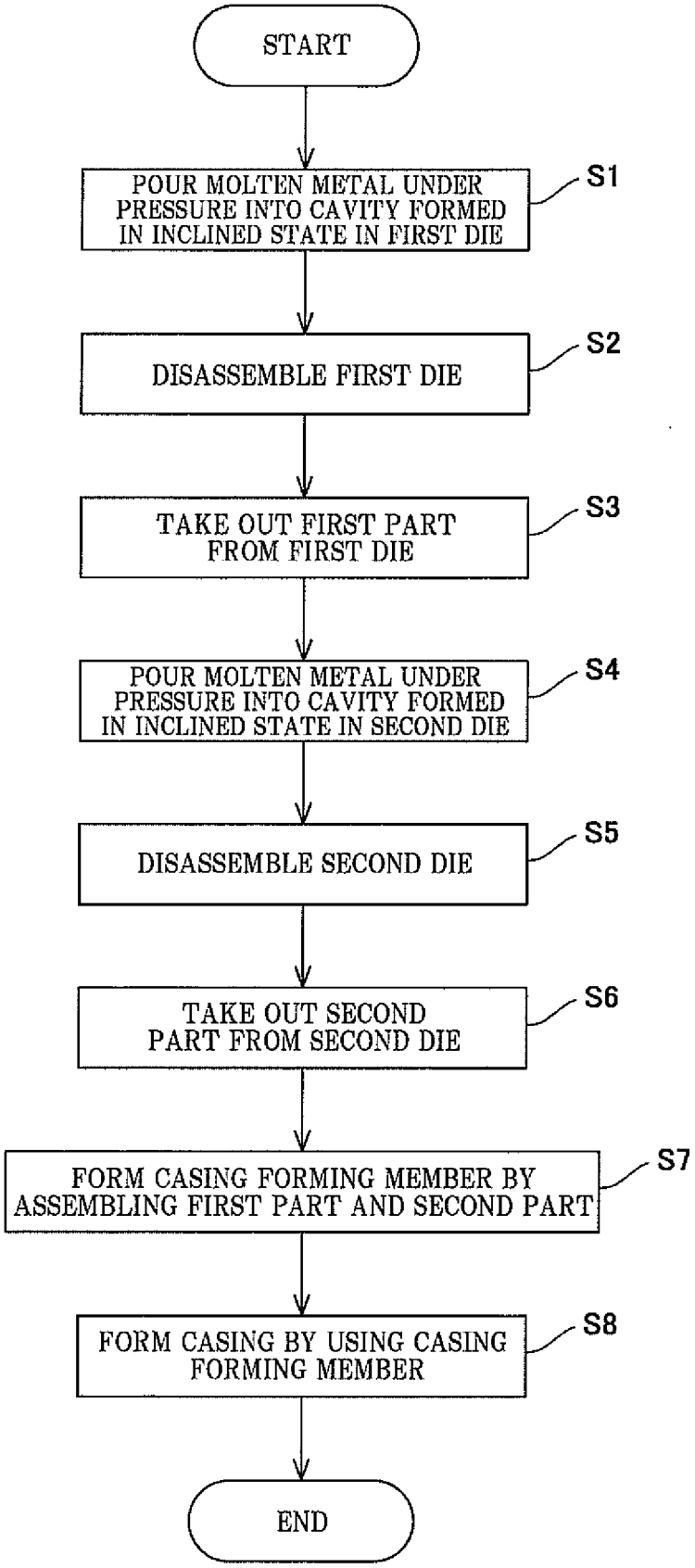

START
POUR MOLTEN METAL UNDER PRESSURE INTO CAVITY FORMED IN INCLINED STATE IN FIRST DIE
S1
DISASSEMBLE FIRST DIE
S2
TAKE OUT FIRST PART FROM FIRST DIE
S3
POUR MOLTEN METAL UNDER PRESSURE INTO CAVITY FORMED IN INCLINED STATE IN SECOND DIE
S4
DISASSEMBLE SECOND DIE
S5
TAKE OUT SECOND PART FROM SECOND DIE
S6
FORM CASING FORMING MEMBER BY ASSEMBLING FIRST PART AND SECOND PART
S7
FORM CASING BY USING CASING FORMING MEMBER
S8
END

FIG.7

FIG.8a

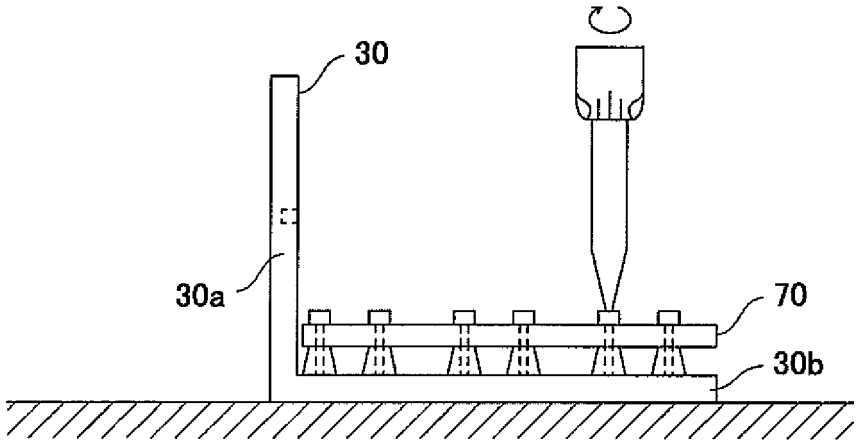


FIG.8b

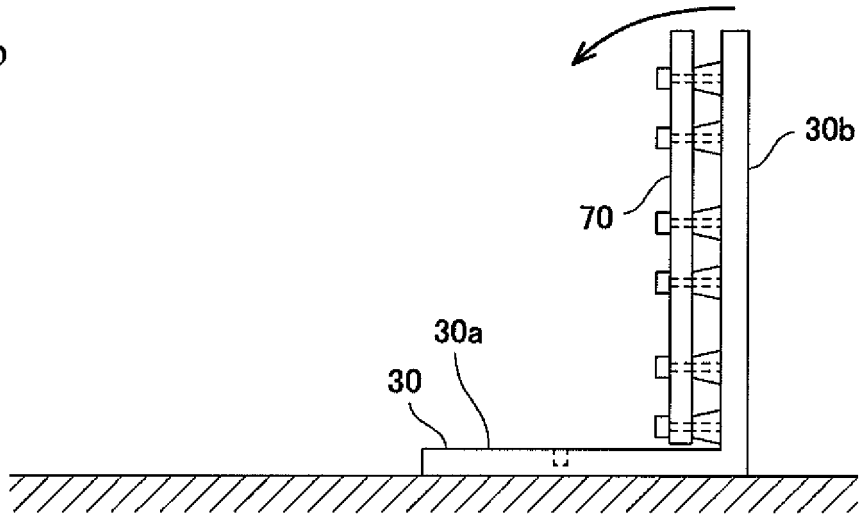
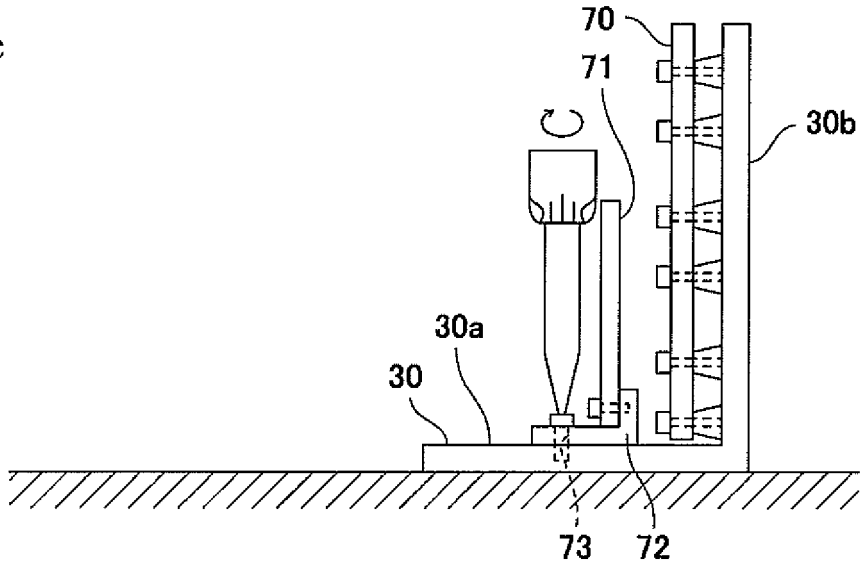


FIG.8c



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2019/003557

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl. B22D17/00(2006.01)i, B22C9/06(2006.01)i, B22D17/22(2006.01)i
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)
Int.Cl. B22D17/00, B22C9/06, B22D17/22

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	1971-2019
Registered utility model specifications of Japan	1996-2019
Published registered utility model applications of Japan	1994-2019

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.
A	JP 8-90211 A (NIPPONDENSO CO., LTD.) 09 April 1996, entire text (Family: none)	1-7
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 86701/1984 (Laid-open No. 4859/1986) (HITACHI, LTD.) 13 January 1986, entire text (Family: none)	1-7
A	JP 3-264320 A (OLYMPUS OPTICAL CO., LTD.) 25 November 1991, entire text (Family: none)	1-7
A	CD-ROM of the specification and drawings annexed to the request of Japanese Utility Model Application No. 13726/1993 (Laid-open No. 71778/1994) (NIKKO COMPANY) 07 October 1994, entire text & KR 20-1994-0022839 U	1-7

☐ 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 15 April 2019 (15.04.2019)	Date of mailing of the international search report 23 April 2019 (23.04.2019)
Name and mailing address of the ISA/ Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (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 2001357925 A **[0003]**