



(11)

EP 4 545 198 A1

(12)

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

(43) Date of publication:
30.04.2025 Bulletin 2025/18

(51) International Patent Classification (IPC):
B21D 5/02 (2006.01)

(21) Application number: **23831146.8**

(52) Cooperative Patent Classification (CPC):
B21D 5/02

(22) Date of filing: **16.06.2023**

(86) International application number:
PCT/JP2023/022344

(87) International publication number:
WO 2024/004699 (04.01.2024 Gazette 2024/01)

(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

(72) Inventors:
• **MATSUMOTO, Tetsunori**
Isehara-shi, Kanagawa 259-1196 (JP)
• **YANAGAWA, Atsumu**
Isehara-shi, Kanagawa 259-1196 (JP)

(74) Representative: **Grünecker Patent- und Rechtsanwälte**
PartG mbB
Leopoldstraße 4
80802 München (DE)

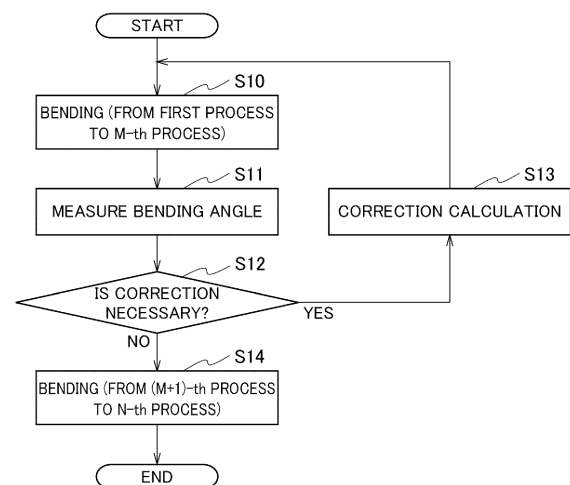
(30) Priority: **27.06.2022 JP 2022102595**

(71) Applicant: **Amada Co., Ltd.**
Isehara-shi, Kanagawa 259-1196 (JP)

(54) **BENDING METHOD**

(57) Provided is a series of processes of repeating bending of a workpiece (W) by applying pressure to the workpiece (W) with an upper tool (8) attached to an upper table (7) and a lower tool (6) attached to a lower table (5) of a press brake (1) from a first process to an N-th process while feeding the workpiece (W) at a predetermined pitch so as to bend the workpiece (W) at N processing positions, thereby bending the workpiece (W) at a desired bending angle. The series of processes includes: a measuring process of measuring a bending angle of the workpiece (W) at completion of an M-th process; and a calculation process of correcting a table output for applying pressure to the workpiece (W) based on a measurement value of the bending angle of the workpiece (W) measured in the measuring process and a target value of the bending angle of the workpiece (W) at completion of the M-th process. In a case where the table output is corrected, the bending is restarted from a previous process which is the M-th process or a process before the M-th process based on the corrected table output.

FIG. 1



Description

[TECHNICAL FIELD]

5 **[0001]** The present disclosure relates to a bending method.

[BACKGROUND ART]

10 **[0002]** A press brake for bending a workpiece by applying pressure to the workpiece using a tool is known. As one bending method using the press brake, "FR bending" is known as a processing method in which a workpiece is bent at a desired bending angle by intermittently repeating minute bending while feeding the workpiece.

15 **[0003]** Patent Literature 1 discloses a method of correcting processing data while bending a workpiece. In the method of Patent Literature 1, correction data is calculated based on an error between an actual bending angle obtained up to a predetermined process and a target bending angle. When the correction data is calculated, bending is started from the next process, and bending after the next process is performed according to the correction data.

20 **[0004]** Patent Literature 2 discloses a press brake having an upper table for holding a punch and a lower table for holding a die, and a workpiece is clamped and bent by the punch and the die. When performing a certain process, the press brake measures a shape of the workpiece based on displacement data received by a two-dimensional laser displacement sensor. A stroke for lowering the punch toward the die is corrected so that the difference between a measured shape of the workpiece and a predetermined target shape of the workpiece becomes small. When the stroke is corrected, bending is started from the next process, and bending after the next process is performed with a corrected stroke.

[Citation List]

25 [Patent Literature]

[0005]

30 [Patent Literature 1] JP H06-39439 A
 [Patent Literature 2] JP 2018-126784 A

[SUMMARY OF INVENTION]

35 **[0006]** However, according to the methods disclosed in Patent Literature 1 and 2, the correction does not have an effect on the processing positions in which the bending is performed before the correction, resulting in a bending state with the error remaining. From the viewpoint of product quality, it is desirable that there are less variations in the bending state at respective processing positions.

40 **[0007]** An aspect of some embodiments includes a series of processes of repeating bending of a workpiece by applying pressure to the workpiece with an upper tool attached to an upper table and a lower tool attached to a lower table of a press brake from a first process to an N-th process (where N is a natural number) while feeding the workpiece at a predetermined pitch so as to bend the workpiece at N processing positions, thereby bending the workpiece at a desired bending angle, the series of processes including: a measuring process of measuring a bending angle of the workpiece at completion of an M-th process (where M is a natural number less than N); and a calculation process of correcting a table output for applying pressure to the workpiece based on a measurement value of the bending angle of the workpiece measured in the measuring process and a target value of the bending angle of the workpiece at completion of the M-th process, wherein, in a case where the table output is corrected, the bending is restarted from a previous process which is the M-th process or a process before the M-th process based on the corrected table output.

45 **[0008]** According to the aspect of some embodiments, since bending is restarted from the previous process, pressure is again applied to the workpiece based on the corrected table output even at the processing position in which bending has already been performed. Through again applying pressure to the workpiece, deviation from the target value generated in the bending performed before correction is corrected and a desired bending state can be obtained even at the processing position related to the previous process. Further, pressure is applied to the workpiece based on the corrected table output in the processes subsequent to the M-th process, a desired bending state can be obtained even at processing positions related to the subsequent processes.

50 **[0009]** According to the aspect of some embodiments, variations in the bending state at each processing position can be suppressed. Thus, the product quality can be improved.

[BRIEF DESCRIPTION OF DRAWINGS]

[0010]

[FIG. 1] FIG. 1 is a flowchart illustrating a procedure of a bending method according to an embodiment.

[FIG. 2] FIG. 2 is a perspective view illustrating a press brake which performs bending.

[FIG. 3] FIG. 3 is an explanatory diagram illustrating a bending angle and processing positions of a workpiece.

[FIG. 4] FIG. 4 is an explanatory diagram illustrating a first process of bending.

[FIG. 5] FIG. 5 is a diagram illustrating a bending angle when a third process is completed.

[FIG. 6] FIG. 6 is a diagram illustrating an operation screen displayed on an operation panel in accordance with a correction calculation.

[FIG. 7] FIG. 7 is a view illustrating a screen indicating a correction result.

[DESCRIPTION OF EMBODIMENTS]

[0011] A bending method according to an embodiment will be described below with reference to the drawings.

[0012] FIG. 1 is a flowchart illustrating a procedure of a bending method according to the present embodiment. FIG. 2 is a perspective view illustrating a press brake which performs bending. In the following description, a left-right direction X, a front-rear direction Y, and an up-down direction Z are used to define the press brake 1. The left-right direction X and the front-rear direction Y correspond to two directions orthogonal to each other in a horizontal direction, and the up-down direction Z corresponds to a vertical direction. However, these directions are only used for convenience in explaining the press brake 1 in the present embodiment.

[0013] A bending method according to the present embodiment includes a series of processes of repeating bending of a workpiece W by applying pressure to the workpiece W with an upper tool 8 attached to an upper table 7 and a lower tool 6 attached to a lower table 5 of the press brake 1 from a first process to an N-th process (where N is a natural number) while feeding the workpiece W at a predetermined pitch, so as to bend the workpiece W at N processing positions, thereby bending the workpiece W at a desired bending angle. The series of processes includes: a measuring process of measuring a bending angle of the workpiece W at completion of an M-th (where M is a natural number less than N) process; and a calculation process of correcting a table output for applying pressure to the workpiece W based on a measurement value of the bending angle of the workpiece W measured in the measuring process and a target value of the bending angle of the workpiece W at completion of the M-th process. In a case where the table output is corrected, the bending is restarted from a previous process which is the M-th process or a process before the M-th process based on the corrected table output.

[0014] Hereinafter, configuration of the press brake 1 will be described. The press brake 1 is a processing machine which bends the workpiece W by applying pressure to the workpiece W using the upper tool 8 which is a tool such as a punch and the lower tool 6 which is a tool such as a die.

[0015] The press brake 1 includes the lower table 5, the upper table 7, left and right lifting mechanisms 9L, 9R, left and right crowning mechanisms 19L, 19R, a control device 30, and an operation panel 35.

[0016] The press brake 1 includes left and right side frames 3L, 3R arranged at a distance in the left-right direction X. The upper table 7 extends in the left-right direction X and is supported by front upper portions of the side frames 3L, 3R. The upper table 7 is configured to be movable in the up-down direction Z. The lower table 5 extends in the left-right direction X and is supported by front lower portions of the side frames 3L and 3R.

[0017] An upper tool holder for detachably holding the upper tool 8 is provided on a lower side of the upper table 7. A holder groove for inserting a base of the upper tool 8 is formed in the upper tool holder in the left-right direction X. The upper tool holder has a clamp mechanism for fixing the upper tool 8 to the upper table 7.

[0018] A lower tool holder for detachably holding the lower tool 6 is provided on an upper side of the lower table 5. A holder groove for inserting a base of the lower tool 6 is formed in the lower tool holder in the left-right direction X. The lower tool holder has a clamp mechanism for fixing the lower tool 6 to the lower table 5.

[0019] The left and right lifting mechanisms 9L and 9R are provided on left and right upper portions of the side frames 3L, 3R, respectively. The left and right lifting mechanisms 9L, 9R are mechanisms for moving the upper table 7 in the up-down direction Z, and are, for example, hydraulic cylinders. However, a combination of an electric motor and a reduction gear may be used for the left and right lifting mechanisms 9L, 9R. The left and right lifting mechanisms 9L, 9R can be independently controlled. The left and right stroke positions of the upper table 7 can be independently controlled by the left and right lifting mechanisms 9L, 9R. The stroke position is a relative position (a depth value, D value) from an upper end of the lower table 5 to a lower end of the upper table 7, and is one of parameters corresponding to the table output for applying pressure to the workpiece W.

[0020] A front plate 11 and a rear plate 13 are provided on a front side and a rear side of the lower table 5, respectively. The front plate 11 and the rear plate 13 are integrally attached to the lower table 5 through left and right pivot shafts 15L, 15R penetrating in the front-rear direction Y.

[0021] The left and right crowning mechanisms 19L, 19R are provided at left and right positions of the lower table 5 with respect to a center position in the left-right direction X.

[0022] The respective left and right crowning mechanisms 19L, 19R are fixed to the front plate 11 and the rear plate 13. By operating the left and right crowning mechanisms 19L and 19R, a part of the lower table 5 can be bent upward or downward.

[0023] The left and right crowning mechanisms 19L, 19R can be independently controlled. The left and right crowning mechanisms 19L, 19R can adjust crowning output. The crowning output indicates how much the lower table 5 is to be curved and which position of the lower table 5 is to be curved, and is one of the parameters corresponding to the table output for applying pressure to the workpiece W.

[0024] The control device 30 includes, for example, a computer such as a numerical control (NC) device. The computer mainly includes a hardware processor such as a central processing unit (CPU), a memory, and various interfaces. The memory and various interfaces are connected to the hardware processor via a bus. A predetermined computer program is installed in the computer. When the hardware processor executes the computer program, the computer executes the functions provided in the control device 30.

[0025] The control device 30 controls the operation of the press brake 1. Specifically, the control device 30 controls the left and right lifting mechanisms 9L and 9R, and the left and right crowning mechanisms 19L and 19R. The control device 30 controls the left and right lifting mechanisms 9L and 9R based on left and right D values to lower the upper table 7 and apply pressure to the workpiece W. The control device 30 controls the left and right crowning mechanisms 19L and 19R based on the crowning output, so that pressure can be applied to the workpiece W with the lower table 5 partially curved.

[0026] The operation panel 35 has, for example, a display unit such as a liquid crystal display and an input unit such as a touch panel. The operation panel 35, controlled by the control device 30, displays various setting screens and operation screens, and outputs information input from an operator to the control device 30.

[0027] In bending using the press brake 1 configured in such a manner, the operator places the workpiece W in a shape of a plate on the lower tool 6 attached to the lower table 5. At this point, the operator positions the workpiece W by abutting the workpiece W against a back gauge (not illustrated) positioned at a predetermined position behind the lower table 5. Then, the control device 30 lowers the upper table 7 toward the lower table 5 in response to an instruction from the operator. As a result, pressure is applied to the workpiece W between the upper tool 8 and the lower tool 6, and the workpiece W is bent in a desired bending state.

[0028] Hereinafter, a bending method which is one of features of the present embodiment will be described. The bending method in the present embodiment is suitable for FR bending using the press brake 1. FR bending is a bending method in which the workpiece W is bent at a desired bending angle by repeating bending from a first process to an N-th process while feeding the workpiece W at a predetermined pitch so as to bend the workpiece W at N processing positions.

[0029] FIG. 3 is an explanatory diagram illustrating a bending angle and processing positions of the workpiece W. A bending angle αt of the workpiece W is an internal angle of the workpiece W curved due to a bending effect at each processing position. FIG. 3 illustrates an example in which the bending angle αt of the workpiece W is 90 degrees. For example, when "N" is 20, the bending is repeated from the first process to the twentieth process, and the workpiece W is bent at 20 processing positions from P1 to P20. When the bending angle αt of the workpiece W is 90 degrees, the bending state of the workpiece W obtained in each process (each processing position) is ideally 4.5 degrees.

[0030] Referring to FIG. 1, in step S10, the bending is performed from the first process to the M-th process. FIG. 4 is an explanatory diagram illustrating the first process of the bending. In the drawing, a left side corresponds to a rear side in the front-rear direction Y of the press brake 1, and a right side corresponds to a front side in the front-rear direction Y of the press brake 1. Directions of the workpiece W placed on the lower tool 6 can be defined with reference to the press brake 1. A back gauge side of the press brake 1 is a rear side of the workpiece W, and an operator side is a front side of the workpiece W. In the first process, pressure is applied at a first processing position P1 by the upper tool 8 and the lower tool 6, and bending is performed to the first processing position P1.

[0031] FIG. 5 is a diagram illustrating a bending angle when a third process is completed. When the first process is completed, the operator feeds the workpiece W at a predetermined pitch and positions the workpiece W so that a second processing position P2 is positioned between the upper tool 8 and the lower tool 6. Then, in a second process, bending is performed at the second processing position P2. Such processes are performed up to the M-th process. "M" is a natural number less than N, and the M-th process is the third process in the present embodiment.

[0032] When the third process is completed, the operator temporarily stops operation of the press brake 1. Then, in step S11, a bending angle $\alpha 3$ of the workpiece W is measured when the third process is completed (a measuring process). The bending angle $\alpha 3$ can be measured manually by the operator using an angle sensor. Alternatively, the control device 30 may operate the angle sensor mounted on the press brake 1 to automatically measure the bending angle $\alpha 3$ in response to a predetermined operation on the operation panel 35 performed by the operator. When the operator manually measures a bending angle, the operator inputs a measurement value of the bending angle $\alpha 3$ to the operation panel 35, and the control device 30 can acquire information of the value. When the control device 30 automatically measures the bending angle $\alpha 3$, the control device 30 can directly acquire a measurement value of the bending angle $\alpha 3$ from the angle sensor.

[0033] However, the bending angle of the workpiece W is not only measured when the third process is completed, but may be measured when the second process is completed, or when a fourth process or a process after the fourth process is completed. Note that the bending angle of the workpiece W is preferably measured in a range of 165 degrees or more and 175 degrees or less. For this reason, among the first to twentieth processes, a process in which the bending angle at completion of the process is 165 degrees or more and 175 degrees or less is set as the M-th process.

[0034] The bending angle may be measured intentionally by the operator when the M-th process is completed, but is not limited thereto. For example, the operator operates the operation panel 35 and sets, in the control device 30, the M-th process for which a bending angle is measured. The control device 30 may use the completion of the M-th process as a trigger to urge the operator to measure a bending angle or to automatically measure a bending angle. Alternatively, the control device 30 stores a target value of a bending angle of the workpiece W at completion of each process, whereby the control device 30 determines whether or not the target value of the bending angle falls within a range of 165 degrees or more and 175 degrees or less when each process is completed. Then, the control device 30 may urge the operator to measure the bending angle or automatically measure the bending angle, using, as a trigger, completion of a process in which the target value of the bending angle is 165 degrees or more and 175 degrees or less.

[0035] In step S12, the operator determines whether correction is necessary. When bending of 90 degrees is performed through all 20 processes, the target value of the bending angle α_3 of the workpiece W at completion of the third process is 166.5 degrees. If the difference between the measurement value of the bending angle α_3 and the target value (166.5 degrees) of the bending angle α_3 of the workpiece W at completion of the third process is equal to or greater than a predetermined threshold value, the operator determines that correction is necessary. On the other hand, if the difference between the measurement value of the bending angle α_3 and the target value (166.5 degrees) of the bending angle α_3 of the workpiece W at completion of the third process is smaller than a predetermined threshold value, the operator determines that correction is unnecessary. Whether or not correction is necessary may be determined by the operator or the control device 30.

[0036] If correction is necessary, proceed to a step S13. On the other hand, if correction is not necessary, bending is performed from the fourth process to the twentieth process in step S14.

[0037] In step S13, the control device 30 performs a correction calculation based on the bending angle α_3 (calculation process). FIG. 6 is a diagram illustrating an operation screen displayed on an operation panel in accordance with the correction calculation. The operation panel 35 displays items of a first display item 350, second and third display items 351 and 352, fourth to seventh display items 353, 354, 355, 356, and first to third operation items 357, 358, 359.

[0038] The first display item 350 indicates a target value of the bending angle α_3 of the workpiece W at completion of the third process. The second display item 351 indicates the current number of processes, that is, the number of times of bending up to the current process (for example, "3 times"), and the third display item 352 indicates the total number of processes, that is, the total number of times of bending (for example, "20 times").

[0039] The fourth to seventh display items 353, 354, 355 and 356 indicate measurement values of the bending angle α_3 . When the bending angle α_3 is measured at one representative point such as a center of the workpiece W in the left-right direction, and a measurement value of this representative point is treated as the bending angle α_3 of the workpiece W as a whole, the measurement value of the bending angle α_3 is indicated as the fourth display item 353. On the other hand, when the bending angle α_3 is measured at a plurality of positions, for example, at three positions of a left side, a center, and a right side of the workpiece W, measurement values of the bending angle α_3 at the left side, the center, and the right side are indicated as the fifth to seventh display items 354, 355, and 356, respectively.

[0040] The first and second operation items 357, 358 are operation items for selecting a correction mode of the table output between overall correction and longitudinal correction. The overall correction is a method of uniformly correcting the table output between the left and right ends of the workpiece W based on the measurement value of the bending angle α_3 measured at the representative point. The longitudinal correction is a method of correcting the table output based on the measurement values of the bending angle α_3 at the left side, the center, and the right side of the workpiece W so that the bending angle between the left and right ends of the workpiece W becomes uniform. The overall correction can be selected by operating the first operation item 357 and the longitudinal correction can be selected by operating the second operation item 358. The third operation item 359 is an operation item for executing the correction calculation.

[0041] After confirming the display items 350 to 356, the operator selects the overall correction or the longitudinal correction through the first and second operation items 357 and 358, and then operates the third operation item 359. Thus, the control device 30 executes correction calculation corresponding to the selected correction mode.

[0042] First, a description will be given of a case where the first operation item 357 corresponding to the overall correction is selected. The control device 30 calculates an accumulated error in a case where the bending is continued from a first process to a twentieth process, based on an error between the measurement value of the bending angle α_3 of the workpiece W at completion of the third process and the target value of the bending angle α_3 of the workpiece W at completion of the third process. The control device 30 then calculates a bending correction amount β that cancels out the accumulated error. The bending correction amount β is calculated by, for example, Formula 1.

[Formula 1]

$$\text{Bending correction amount } \beta = (\alpha_{3t} - \alpha_{3m}) \times (\text{RNW}/\text{RNM})$$

[0043] In Formula 1, " α_{3t} " is the target value of the bending angle α_3 of the workpiece W at completion of the third process and " α_{3m} " is the measurement value of the bending angle α_3 of the workpiece W at completion of the third process. "RNW" is the total number of processes and "RNM" is the current number of processes.

[0044] For example, when the measurement value of the bending angle α_3 of the workpiece W is 170 degrees and the target value of the bending angle α_3 of the workpiece W is 166.5 degrees, the bending correction amount β is -23.33 degrees $((166.5 \text{ degrees} - 170 \text{ degrees}) \times (20/3))$.

[0045] When the bending correction amount β is specified, the control device 30 calculates a corrected table output based on the bending correction amount β . When the overall correction is selected, the control device 30 corrects the D value as the table output. However, the control device 30 may correct the crowning output or may correct the D value and the crowning output.

[0046] Assuming that the bending angle α_3 is uniform between the left and right ends of the workpiece W, the control device 30 calculates corrected left and right D values based on the bending correction amount β . As illustrated in FIG. 7, the control device 30 indicates the left and right D values as the eighth and ninth display items 360 and 361. According to this calculation method, the corrected left and right D values can be automatically calculated from the measurement value of the bending angle α_3 without the operator calculating left and right bending correction amounts β and β' and then inputting the left and right bending correction amounts β and β' to the 10 and 11 display items 362 and 363, respectively.

[0047] However, the operator may calculate the left and right bending correction amounts β and β' and input the left and right bending correction amounts β and β' as the tenth and eleventh display items 362 and 363, respectively, using the operation panel 35. In this case, the control device 30 calculates the corrected left and right D values based on the input left and right bending correction amounts β and β' .

[0048] On the other hand, when the longitudinal correction is selected, the control device 30 calculates the bending correction amount β for each of left end, center, and right end measurement points. Then, the control device 30 calculates a corrected table output based on the bending correction amount β at each of the measurement points so that the bending angle between the left and right ends of the workpiece W becomes uniform.

[0049] When the longitudinal correction is selected, the control device 30 corrects both D value and the crowning output as the table output. However, the control device 30 may correct only one of the D values or the crowning output.

[0050] As illustrated in FIG. 1, when the correction calculation is completed, the operator restarts operation of the press brake 1 by operating the operation panel 35 to restart the bending from the first process (step 10). However, using completion of the correction calculation as a trigger, the control device 30 may restart the operation of the press brake 1 and control the press brake 1 so that the bending is automatically restarted from the first process.

[0051] In the first process after restarting bending, pressure is applied at the first processing position P1 by the upper tool 8 and the lower tool 6, and bending is performed at the processing position P1. This bending is performed with a corrected table output under control of the control device 30. Similarly, in the second and third processes, bending is performed with a corrected table output for the processing positions P2 and P3.

[0052] Then, in step S11, the bending angle α_3 is measured and it is determined whether correction is necessary. If correction is necessary, correction calculation is performed again in step S13. On the other hand, if correction is not necessary, bending is performed from the fourth process to the twentieth process in step S14.

[0053] Through the series of processes described above, the workpiece W is bent at an obtuse angle at 20 processing positions P1 to P20, whereby the workpiece W is bent at a desired bending angle.

[0054] According to the bending method in the present embodiment, since the bending is restarted from the previous process, pressure is again applied to the workpiece W based on the corrected table output even at the processing positions in which the bending has already been performed. By applying pressure again to the workpiece W, deviation from the target value that is generated in the bending performed before correction is corrected, and a desired bending state can be obtained even at the processing positions related to the previous processes. Further, pressure is applied to the workpiece W based on the corrected table output in the processes subsequent to the M-th process, so that a desired bending state can be obtained even at the processing positions related to the subsequent processes. Therefore, variations in the bending state at each processing position can be suppressed. Thus, the product quality can be improved.

[0055] In the present embodiment, the table output preferably includes a D value (depth value) which is a relative stroke position from an upper end of the lower table 5 to a lower end of the upper table 7.

[0056] According to this bending method, the depth value can be corrected in a calculation process. Thus, an amount of pressure applied to the workpiece W by the upper tool 8 and the lower tool 6 can be adjusted, so that a desired bending state can be obtained at each processing position.

[0057] In the present embodiment, the table output preferably further includes a crowning output for bending one of the upper table 7 and the lower table 5 relative to the other table.

[0058] According to this bending method, the crowning output can be corrected in the calculation process. Thus, an amount of pressure applied to the workpiece W by the upper tool 8 and the lower tool 6 can be adjusted, so that a desired bending state can be obtained at each processing position.

[0059] In the present embodiment, the M-th process is a process among the first to N-th processes, in which the target value of the bending angle of the workpiece W is within the predetermined angle range.

[0060] According to this bending method, the bending angle while performing the measuring process can be limited. Thus, it is possible to consider measurement accuracy of the bending angle of the workpiece W and processing accuracy in case of restarting the bending from a previous process.

[0061] In the present embodiment, the angle range is 165 degrees or more and 175 degrees or less.

[0062] When the bending angle of the workpiece W is larger than 175 degrees, the workpiece W is in a state close to planar. In consideration of measurement accuracy by an angle sensor, it is preferable to perform the measurement process in a range in which the bending angle of the workpiece W is 175 degrees or less. On the other hand, when the bending angle of the workpiece W becomes less than 165 degrees, the bending processes have moved ahead and a rear end side of the workpiece W is separated from the back gauge. Therefore, the workpiece W cannot abut against the back gauge. Further, the curved workpiece W rises to protrude toward the operator side, so that it becomes difficult for the operator to hold the workpiece W. In addition, when the bending angle of the workpiece W is less than 165 degrees, a large curvature of the workpiece W makes it difficult to bend the workpiece W at the same processing positions when the bending is restarted from a previous process. Therefore, the angle range is preferably 165 degrees or more and 175 degrees or less.

[0063] In the present embodiment, the calculation process includes: calculating the accumulated error in a case where the bending is continued up to the N-th process, based on the error between the measurement value of the bending angle of the workpiece W and the target value of the bending angle of the workpiece W at completion of the M-th process; and correcting the table output so as to cancel out the accumulated error.

[0064] According to this bending method, when the bending angle of the workpiece W is measured, the corrected table output can be automatically calculated. Thus, the table output can be corrected more easily.

[0065] In the present embodiment, in a case where the bending angle of the workpiece W is measured at one point between the left and right ends of the workpiece W in the measurement process, the calculation process includes regarding the measurement value of the bending angle at the one point as the bending state of the workpiece W as a whole, and uniformly correcting the table output between the left and right ends of the workpiece W based on the measurement value of the bending angle of the workpiece W. On the other hand, in a case where the bending angle of the workpiece W is measured at a plurality of points between left and right ends of the workpiece W in the measurement process, the calculation process includes correcting the table output based on the measurement value of the bending angle of the workpiece W at the plurality of points so that the bending angle between the left and right ends of the workpiece W becomes uniform.

[0066] According to this bending method, in a case where the bending angle of the workpiece W is measured at one point, the table output can be uniformly corrected by assuming that the workpiece W as a whole has the bending angle. Further, in a case where the bending angle of the workpiece W is measured at a plurality of points, the correction can be performed according to each bending angle and bending accuracy is thereby improved. Thus, the correction method can be switched according to the number of points at which the bending angle is measured, so that a correction method can be selected according to the needs of the operator.

[0067] In the embodiment described above, the bending angle is measured and the correction value is calculated at a completion of the third process. However, after the processing is restarted and the fourth to sixth processes are completed, the bending angle may be measured and the correction value may be calculated. The processing may be restarted from the fourth process based on the result of the calculation of the correction value.

[0068] Although the processing is restarted from the first process in the embodiment described above, the first process may be intentionally omitted, and the processing may be restarted from the second process. However, when the processing is restarted from the first process, the bending state becomes uniform at all processing positions and the variations in the bending state are most suppressed.

[0069] Although embodiments of the present invention have been described above, the description and drawings forming part of this disclosure should not be understood as limiting the invention. Various alternative embodiments, examples and operating techniques will become apparent to those skilled in the art from this disclosure.

[0070] The present disclosure of the present application is related to the subject matter of Japanese Patent Application No. 2022-102595 filed with the Japanese Patent Office on June 27, 2022, the entire disclosure of which is incorporated herein by reference.

Claims

1. A bending method comprising a series of processes of repeating bending of a workpiece by applying pressure to the workpiece with an upper tool attached to an upper table and a lower tool attached to a lower table of a press brake from a first process to an N-th process (where N is a natural number) while feeding the workpiece at a predetermined pitch so as to bend the workpiece at N processing positions, thereby bending the workpiece at a desired bending angle, the series of processes comprising:

a measuring process of measuring a bending angle of the workpiece at completion of an M-th process (where M is a natural number less than N); and

a calculation process of correcting a table output for applying pressure to the workpiece based on a measurement value of the bending angle of the workpiece measured in the measuring process and a target value of the bending angle of the workpiece at completion of the M-th process,

wherein, in a case where the table output is corrected, the bending is restarted from a previous process which is the M-th process or a process before the M-th process based on the corrected table output.

2. The bending method according to claim 1, wherein the M-th process is a process among the first to the N-th processes in which the bending angle of the workpiece is within a predetermined angle range at completion of the process.

3. The bending method according to claim 2, wherein the angle range is 165 degrees or more and 175 degrees or less.

4. The bending method according to any one of claims 1 to 3, wherein the calculation process comprises:

calculating an accumulated error for the bending continued up to the N-th process based on an error between the measurement value of the bending angle of the workpiece and the target value of the bending angle of the workpiece at completion of the M-th process; and

correcting the table output so as to cancel out the accumulated error.

5. The bending method according to any one of claims 1 to 3, wherein,

in a case where the bending angle of the workpiece is measured at one point between left and right ends of the workpiece in the measuring process, the calculating process comprises regarding the measurement value of the bending angle of the workpiece at the one point as the bending angle of the workpiece as a whole and uniformly correcting the table output between the left and right ends of the workpiece; and

in a case where the bending angle of the workpiece is measured at a plurality of points between the left and right ends of the workpiece in the measuring process, the calculation process comprises correcting the table output based on the measurement value of the bending angle of the workpiece at the plurality of points so that the bending angle between the left and right ends of the workpiece becomes uniform.

FIG. 1

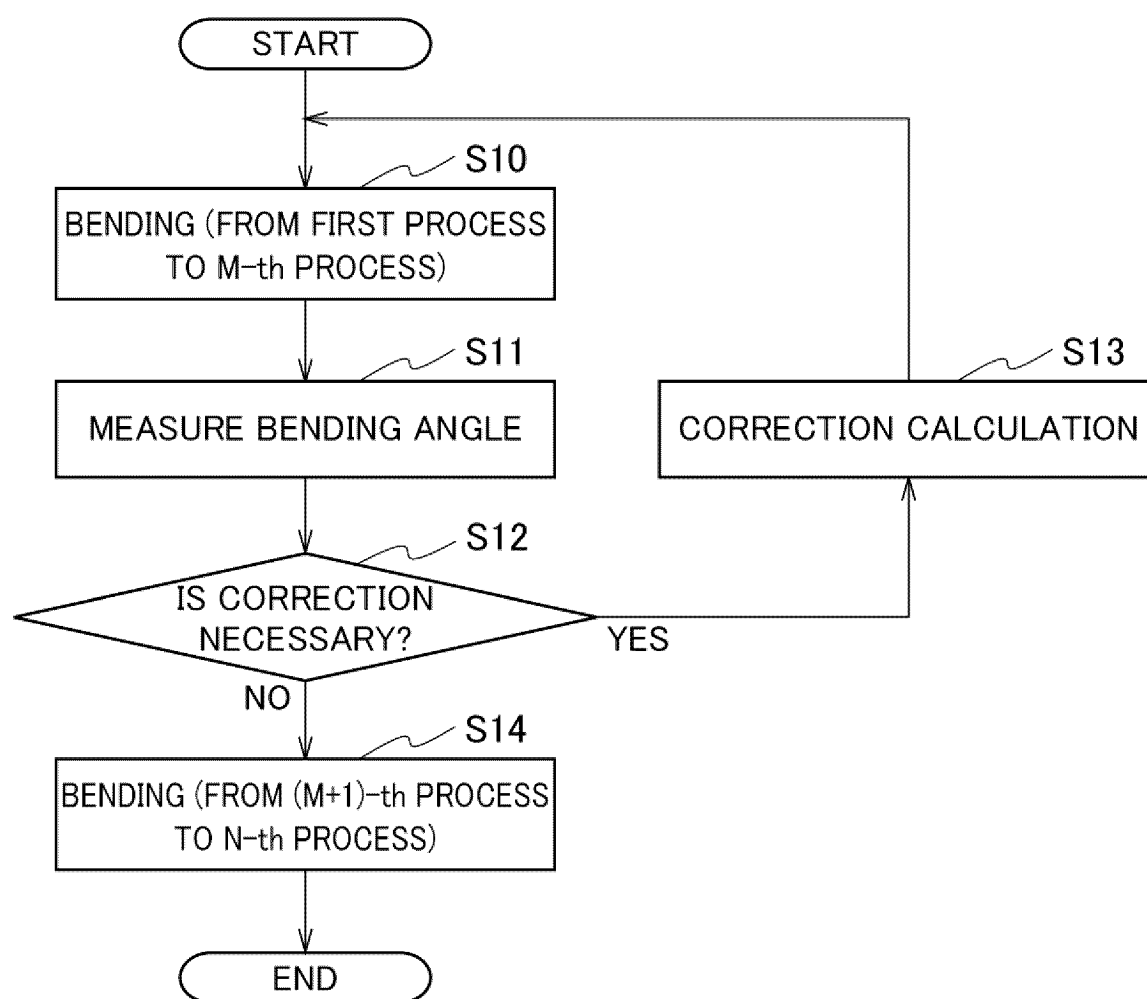


FIG. 2

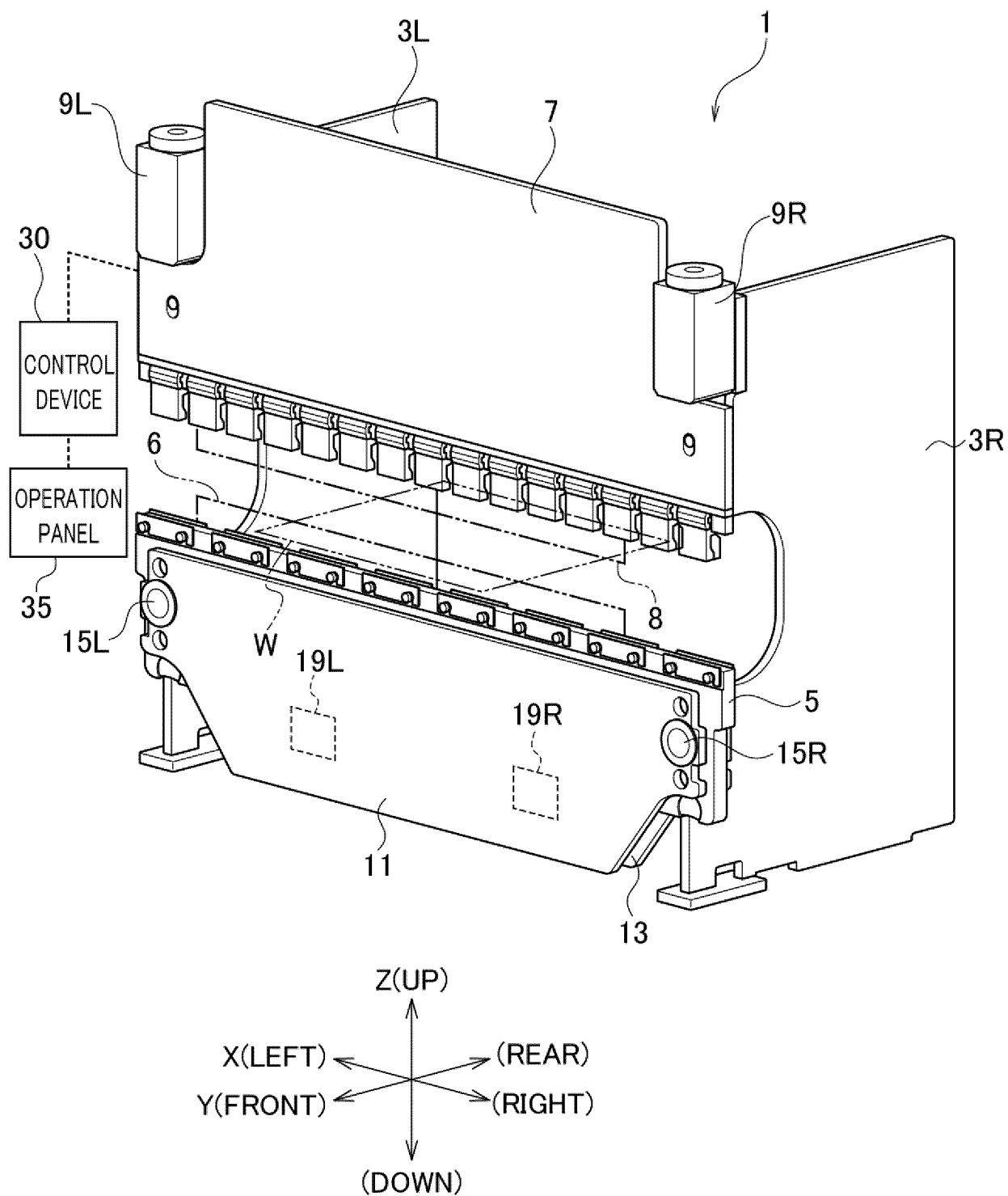


FIG. 3

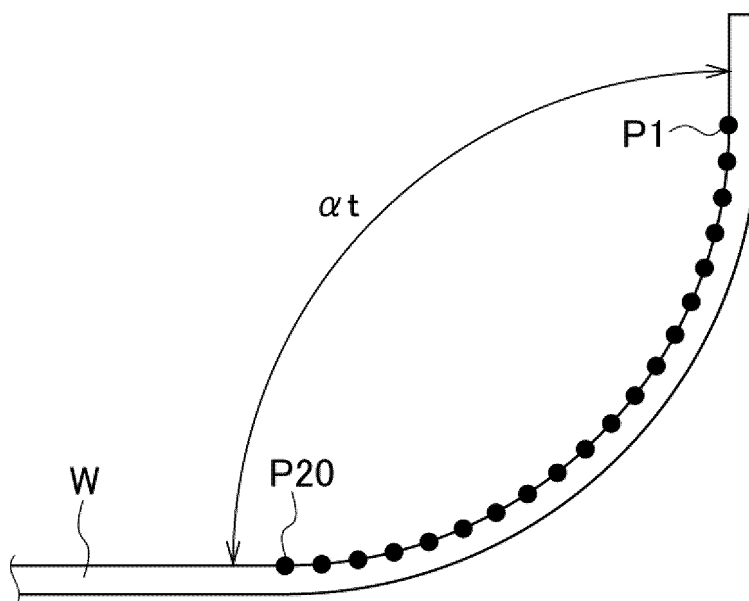


FIG. 4

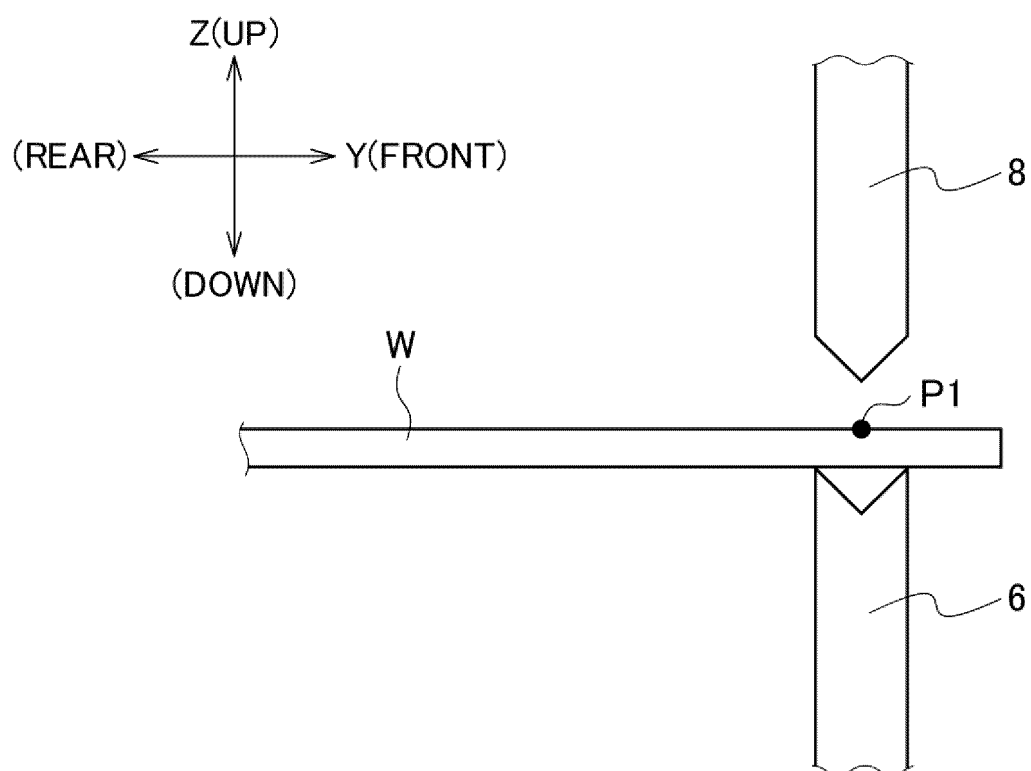


FIG. 5

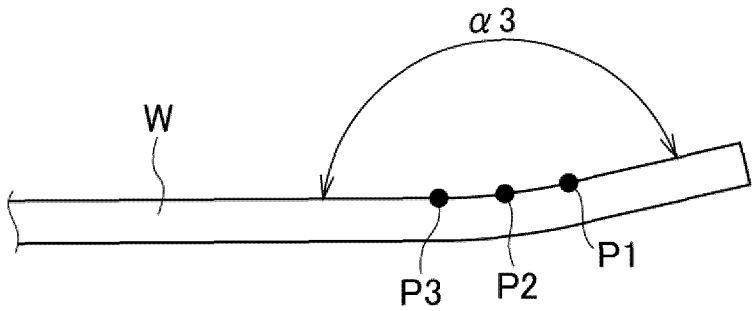
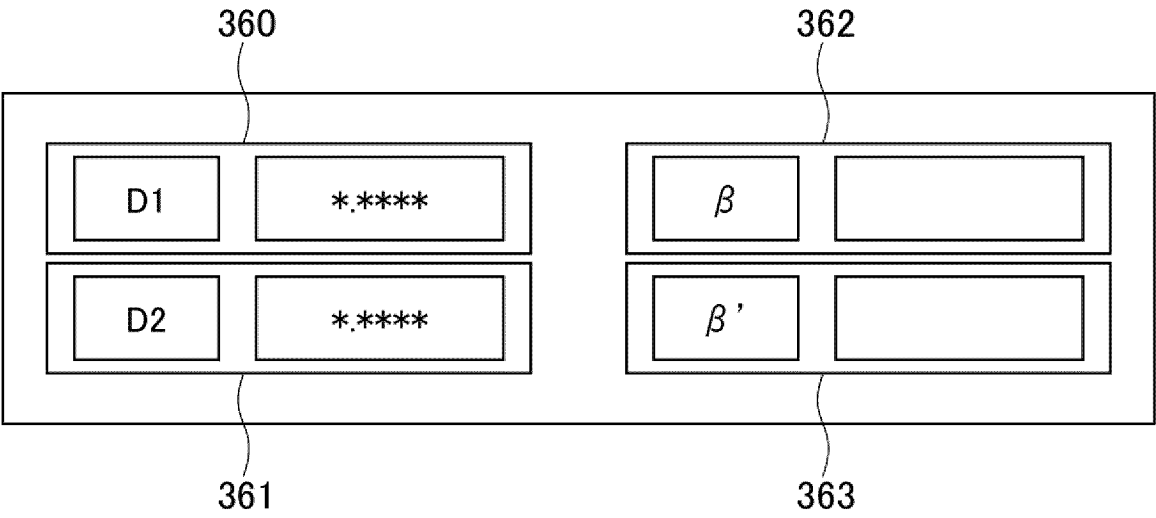


FIG. 6

TARGET VALUE 350		NUMBER OF TIMES OF BENDING	
***.**DEGREES		*	/**
MEASUREMENT VALUE 353		351	352
AS A WHOLE			
***.**DEGREES			
LEFT SIDE 354		CENTER 355	RIGHT SIDE 356
***.**DEGREES	***.**DEGREES	***.**DEGREES	
OVERALL CORRECTION		359	
LONGITUDINAL CORRECTION		SET	

FIG. 7



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2023/022344

A. CLASSIFICATION OF SUBJECT MATTER**B21D 5/02**(2006.01)i

FI: B21D5/02 Y; B21D5/02 V

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)

B21D5/02

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.
A	JP 7-314043 A (KOMATSU LTD.) 05 December 1995 (1995-12-05) entire text, all drawings	1-5
A	JP 2008-23600 A (AMADA DENSHI KK) 07 February 2008 (2008-02-07) entire text, all drawings	1-5
A	JP 2004-202545 A (AMADA CO., LTD.) 22 July 2004 (2004-07-22) entire text, all drawings	1-5
A	JP 2000-51953 A (AMADA DENSHI KK) 22 February 2000 (2000-02-22) entire text, all drawings	1-5

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

* Special categories of cited documents:	"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
"A" document defining the general state of the art which is not considered to be of particular relevance	"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
"E" earlier application or patent but published on or after the international filing date	"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
"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)	"&" document member of the same patent family
"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	

Date of the actual completion of the international search

24 August 2023

Date of mailing of the international search report

05 September 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.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2023/022344

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP	7-314043	A	05 December 1995	US 5704238 A entire text, all drawings WO 1995/026240 A1 EP 752290 A1	
JP	2008-23600	A	07 February 2008	(Family: none)	
JP	2004-202545	A	22 July 2004	(Family: none)	
JP	2000-51953	A	22 February 2000	(Family: none)	

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 H0639439 A [0005]
- JP 2018126784 A [0005]
- JP 2022102595 A [0070]