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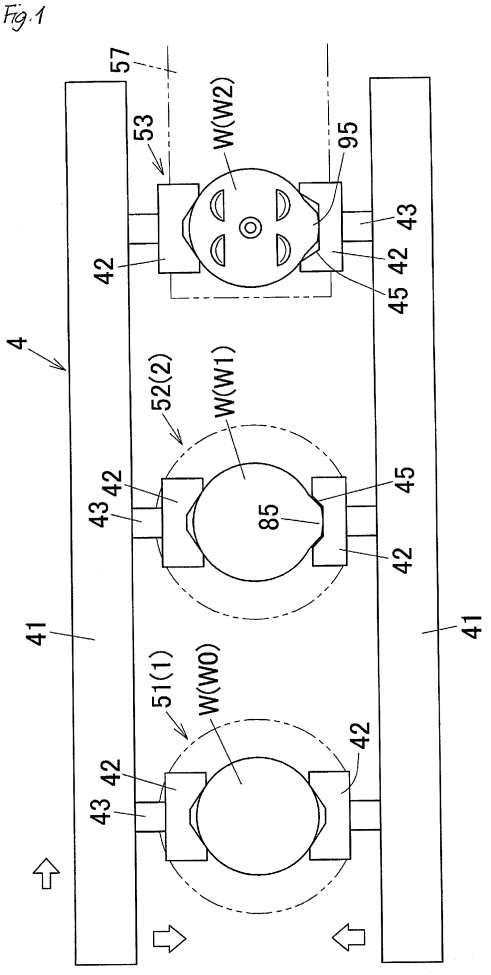
(54) FORGING METHOD

(57) The present invention is to provide a forging method capable of transferring a workpiece with a high degree of positional accuracy. The present invention is directed to a forging method in which a workpiece (W) disposed at a workpiece introducing section (50) is sandwiched and held from both sides of the workpiece with a pair of claws (42) provided to a pair of feed bars (41) arranged on both sides of a transferring line by closing the feed bars (41), and transferred to a workpiece processing section by opening the feed bars (41) after moving the feed bars (41) forward to the workpiece processing section with the workpiece (W) sandwiched and held, and the workpiece (W) transferred to the workpiece processing section is forged. In the method, the workpiece (W) is previously provided with an engaging portion (85) and the claw (42) is previously provided with an engaging portion receiving portion (45) so that the workpiece (W) is positioned by engaging the engaging portion (85) with the engaging portion receiving portion (45) at the time of sandwiching and holding the workpiece (W) with the claws (42).

Fig.1



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Description

TECHNICAL FIELD

[0001] The present invention relates to a forging method for forging a workpiece which is being transferred, and also to its related technologies.

TECHNICAL BACKGROUND

[0002] A multistage forging device configured to perform forming of a workpiece by a number of consecutive forging processing is well known.

[0003] As shown in, for example, Patent Documents 1 and 2 listed below, a conventional multistage forging device is equipped with primary forming dies for performing primary forming of a workpiece, secondary forming dies for performing secondary forming of the workpiece to which the primary forming was performed, and a transfer device for transferring the workpiece form the primary forming dies to the secondary forming dies.

[0004] The transfer device is typically equipped with a pair of feed bars arranged in parallel on both sides of a transferring line, and a pair of claws formed on the inner sides of the pair of feed bars opposed with each other. When the pair of feed bars is closed (approached), a workpiece (primary formed member) formed with, e.g., primary forming dies is sandwiched and held by and between (i.e., chucked with) the pair of claws. While keeping the chucked state, the feed bars are moved toward the downstream side along the transferring line and the workpiece is moved to a position corresponding to the secondary forming dies. Thereafter, the pair of feed bars is opened (i.e., moved away from each other) to release the chucking of the workpiece, whereby the workpiece is set to the secondary forming dies.

PRIOR ART DOCUMENTS

PATENT DOCUMENTS

[0005]

[Patent Document 1] Japanese Examined Laid-open Utility Model Publication No. S63-281737 (JUM-63-281737, B)

[Patent Document 2] Japanese Unexamined Laid-open Patent Publication No. 2007-130680 (JP-2007-130680, A)

SUMMARY OF INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0006] In a multistage forging device for performing a number of forging processing as explained above, although it is possible to obtain a secondary formed product with a complex shape such as an engine piston forming member, since it is processed into a complex shape with the secondary forming, the primary formed member formed by the primary forming has a shape having a volume balance previously and thoroughly calculated to prevent occurrence of defects during the secondary forming. Therefore, when the primary formed member is set to the secondary forming dies, if the primary formed member is displaced from the intended position, there arises a problem that the secondary forming cannot be performed accurately, resulting in occurrence of defects (forming defects) such as lack or engulfment of material in various detail portions.

[0007] Preferred embodiments of the present invention are made in view of the abovementioned and/or other problems in the related arts. The preferred embodiments of the present invention significantly improve the existing methods and/or devices.

[0008] The present invention aims to provide, in view of the problems described above, a forging method and its related technologies capable of preventing occurrence of possible displacement of a workpiece at the time of transferring the workpiece from an upstream side workpiece processing section such as primary forming dies to a downstream side workpiece processing section such as secondary forming dies, and also capable of forging the workpiece with a high degree of accuracy.

[0009] The other purposes and advantages of the present invention will be apparent from the preferred embodiments described below.

MEANS FOR SOLVING THE PROBLEMS

[0010] In order to attain the aforementioned objects, the present invention has the following structure.

[0011] [1] A forging method in which a workpiece disposed at a workpiece introducing section is sandwiched and held from both sides of the workpiece by and between a pair of claws provided to a pair of feed bars arranged on both sides of a transferring line by closing the feed bars, and transferred to a workpiece processing section by moving the feed bars forward with the workpiece held and then opening the feed bars, and the workpiece transferred to the workpiece processing section is subjected to forging,

wherein an engaging portion is formed on the workpiece and an engaging portion receiving portion is formed on one of the claws, and

wherein the workpiece is positioned by engaging the engaging portion with the engaging portion receiving portion at the time of sandwiching and holding the workpiece by and between the claws.

[0012] [2] The forging method as recited in the aforementioned Item 1, wherein one of the engaging portion and the engaging portion receiving portion is constituted by a positioning protrusion and the other thereof is constituted by a positioning dented portion with which the engaging portion is engaged to thereby position the workpiece.

[0013] [3] The forging method as recited in the aforementioned Item 1 or 2, wherein a workpiece discharging section is provided at a downstream side of the workpiece processing section along the transferring line, and plural pairs of claws are provided to the pair of feed bars,
wherein the pair of feed bars is closed to sandwich and hold the workpiece disposed at the workpiece introducing section and the workpiece disposed at the workpiece processing section by and between corresponding pair of claws, and
wherein the feed bars are moved forward with the workpieces sandwiched and held by and between the corresponding pair of claws, and opened to transfer the workpieces sandwiched and held by the corresponding pair of claws on the workpiece processing section and the workpiece discharging section, respectively.

[0014] [4] The forging method as recited in the aforementioned Item 3, wherein the workpiece processing section includes a plurality of workpiece processing sections arranged along the transferring line,
wherein the pair of feed bars is closed to sandwich and hold the workpiece disposed at the workpiece introducing section and the workpiece disposed at the workpiece processing section by and between corresponding pair of claws, moved forward with the workpieces sandwiched and held by and between the corresponding pair of claws, and then opened to transfer the workpieces sandwiched and held by the corresponding pair of claws on the workpiece processing section and the workpiece discharging section respectively.

[0015] [5] The forging method as recited in the aforementioned Item 3 or 4, wherein the workpiece processing section includes a primary workpiece processing section and a secondary workpiece processing section arranged at a downstream side of the primary workpiece processing section,
wherein the primary workpiece processing section is constituted as a primary forming section for obtaining a primary formed member by subjecting the workpiece to die-forging as primary forming, and
wherein the secondary workpiece processing section is constituted as a secondary forming section for obtaining a secondary formed member by subjecting the primary formed member to die-forging as secondary forming.

[0016] [6] The forging method as recited in the aforementioned Item 5, wherein the engaging portion of the workpiece is formed by the primary forming.

[0017] [7] The forging method as recited in the aforementioned Item 5 or 6, wherein the engaging portion to be formed on the primary formed member as the workpiece is constituted by a positioning protrusion,
wherein, after the primary forming, at least a part of the positioning protrusion is pressed to increase a thickness to thereby attain a volume balance of the secondary formed member.

[0018] [8] The forging method as recited in the aforementioned Item 7, wherein the pressing of the at least a part of the positioning protrusion is performed by the secondary forming.

[0019] [9] The forging method as recited in the aforementioned Item 5 or 6,
wherein the engaging portion formed on the primary formed member as the workpiece is constituted by a positional protrusion, and
wherein the positional protrusion is removed after the primary forming to attain a volume balance of the secondary formed member.

[0020] [10] The forging method as recited in any one of the aforementioned Items 5 to 9, wherein a piston member integrally provided with a pair of skirt-portions and a pair of pin-boss portions on one surface side of a land portion is formed as the secondary formed member.

[0021] [11] The forging method as recited in the aforementioned Item 10, wherein the engaging portion is formed on an outer peripheral surface of a skirt scheduled portion corresponding to the skirt portion of the primary formed member.

[0022] [12] The forging method as recited in the aforementioned Item 2, wherein guide portions for guiding the positioning protrusion toward the positioning dented portion are formed on both sides of the positioning protrusion.

[0023] [13] The forging method as recited in any one of the aforementioned Items 1 to 12, wherein the workpiece is made of aluminum or aluminum alloy.

[0024] [14] A forging apparatus in which a workpiece disposed at a workpiece introducing section is sandwiched and held from both sides of the workpiece by and between a pair of claws provided to a pair of feed bars arranged on both sides of a transferring line by closing the feed bars, and transferred to a workpiece processing section by moving the feed bars forward with the workpiece held and then opening the feed bars, and the workpiece transferred to the workpiece processing section is subjected to forging,
wherein the workpiece is provided with an engaging portion and one of the claws is provided with an engaging portion receiving portion, and
wherein the workpiece is positioned by engaging the engaging portion with the engaging portion receiving portion at the time of sandwiching and holding the workpiece with the claws.

[0025] [15] The forging device as recited in the aforementioned Item 14, wherein a workpiece discharging section is provided at a downstream side of the workpiece processing section along the transferring line,
wherein the workpiece processing section includes a primary workpiece processing section and a secondary workpiece processing section arranged at a downstream side of the primary workpiece processing section,
wherein the pair of feed bars are closed to sandwich and hold the workpiece disposed at the workpiece introducing section and the worce disposed at the workpiece processing section by and between corresponding pair of claws, the feed bars are moved forward with the workpieces sandwiched and held by and between the corre-

sponding pair of claws, and opened to transfer the workpieces sandwiched and held by the corresponding pair of claws on the workpiece processing section and the workpiece discharging section respectively,
wherein the primary workpiece processing section includes first forming dies for obtaining a primary formed member by subjecting the workpiece to primary forming, and
wherein the secondary workpiece processing section includes second forming dies for obtaining a secondary formed member by subjecting the primary formed member to secondary forming.

[0026] [16] A workpiece transferring method in which a workpiece disposed at a workpiece introducing section is sandwiched and held from both sides of the workpiece by and between a pair of claws provided to a pair of feed bars arranged on both sides of a transferring line by closing the feed bars, and transferred to a workpiece processing section by moving the feed bars forward with the workpiece held and then opening the feed bars,
wherein an engaging portion is formed on the workpiece and an engaging portion receiving portion is formed on one of the claws, and
wherein the workpiece is positioned by engaging the engaging portion with the engaging portion receiving portion at the time of sandwiching and holding the workpiece by and between the claws.

[0027] [17] A workpiece transferring device in which a workpiece disposed at a workpiece introducing section is sandwiched and held from both sides of the workpiece by and between a pair of claws provided to a pair of feed bars arranged on both sides of a transferring line by closing the feed bars, and transferred to a workpiece processing section by moving the feed bars forward with the workpiece held and then opening the feed bars,
wherein the workpiece is provided with an engaging portion and one of the claws is provided with an engaging portion receiving portion, and
wherein the workpiece is positioned by engaging the engaging portion with the engaging portion receiving portion at the time of sandwiching and holding the workpiece with the claws.

EFFECTS OF THE INVENTION

[0028] According to the forging method of the invention [1], the engaging portion formed on the workpiece is engaged with the engaging portion receiving portion formed on one of claws to position the workpiece at the time of sandwiching and holding (chucking) the workpiece with the pair of claws, preventing possible positional displacements of the workpiecem which in turn enableshigh-precision forging.

[0029] According to the forging method of the invention [2], the workpiece can be positioned assuredly.

[0030] According to the forging method of the invention [3], a plurality of workpieces can be transferred in a simultaneously parallel manner, resulting in enhanced productivity.

[0031] According to the forging method of the invention [4], the workpiece can be processed at a plurality of workpiece processing sections.

[0032] According to the forging method of the invention [5], a forged product having a complex shape can be obtained by two steps of the primary forming and the secondary forming.

[0033] According to the forging method of the invention [6], the engaging portion is formed on the workpiece by the primary forming, which enhances the productivity as compared with a process in which a separate step for forming the engaging portion is performed.

[0034] According to the forging method of the invention [7], adjustments to the volume balance of the forged product can be performed easily.

[0035] According to the forging method of the invention [8], in comparison with a case in which pressing of the engaging protrusion is performed at a separate step, the productivity can be further improved.

[0036] According to the forging method of the invention [9], adjustments to the volume balance of the forged product can be performed easily.

[0037] According to the forging method of the invention [10], a piston member as a forged product can be manufactured.

[0038] According to the forging method of the invention [11], the primary formed member can be transferred in a stable state while positioning the primary formed member assuredly.

[0039] According to the forging method of the invention [12], the workpiece can be positioned more assuredly by engaging the positioning protrusion with the positioning dented portion assuredly.

[0040] According to the forging method of the invention [13], an aluminum forged product can be obtained.

[0041] According to the forging device of the invention [14], in the same manner as mentioned above, the engaging portion provided on the workpiece is engaged with the engaging portion receiving portion provided on one of claws to position the workpiece at the time of sandwiching and holding the workpiece with the pair of claws. Therefore, possible positional displacements of the workpiece can be prevented and the forging can be performed with a high degree of positional accuracy.

[0042] According to the forging device of the invention [15], in the same manner as mentioned above, a forged product having a complex shape can be obtained.

[0043] According to the transferring method of a workpiece of the invention [16], in the same manner as mentioned above, the engaging portion provided on the workpiece is engaged with the engaging portion receiving portion provided on one of claws to position the workpiece at the time of sandwiching and holding the workpiece with a pair of claws, and therefore the possible positional displacements of the workpiece can be prevented and the forging can be performed with a high degree of accuracy.

[0044] According to the transferring device of a workpiece of the invention [17], in the same manner as mentioned above, the engaging portion provided on the workpiece is engaged with the engaging portion receiving portion provided on one of claws to position the workpiece at the time of sandwiching and holding the workpiece with a pair of claws, and therefore possible positional displacements of the workpiece can be prevented and the forging can be performed with a high degree of positional accuracy.

BRIEF DESCRIPTION OF THE DRAWINGS

[0045]

[Fig. 1] Fig. 1 is a top view showing a forging device to which the forging method according to an embodiment of the present invention can be applied.
[Fig. 2] Fig. 2 is a side view showing the forging device of the embodiment.
[Fig. 3] Fig. 3 is an enlarged top view showing the second claw portion of the device shown in Fig. 1.
[Fig. 4] Fig. 4 is a front view showing a piston forming member to be manufactured by the forging device of the embodiment.
[Fig. 5] Fig. 5 is a perspective view showing a primary formed member to be manufactured by the forging device of the embodiment.
[Fig. 6A] Fig. 6A is a top view showing the primary formed member shown in Fig. 5.
[Fig. 6B] Fig. 6B is a front cross-sectional view showing the primary formed member shown in Fig. 5.
[Fig. 6C] Fig. 6C is a side cross-sectional view showing the primary formed member shown in Fig. 5.
[Fig. 7] Fig. 7 is a perspective view showing a forging material to be forged by the forging device of the embodiment.
[Fig. 8] Fig. 8 is a front cross-sectional view showing primary forming dies of the forging device of the embodiment.
[Fig. 9] Fig. 9 is a front cross-sectional view showing secondary forging dies of the forging device of the embodiment.
[Fig. 10A] Fig. 10A is a top view showing a lower die of the secondary forming die shown in Fig. 9.
[Fig. 10B] Fig. 10B is a front cross-sectional view showing the lower die shown in Fig. 10A.
[Fig. 10C] Fig. 10C is a side cross-sectional view showing the lower die shown in Fig. 10A.
[Fig. 11] Fig. 11 is a partially enlarged front cross-sectional view showing the state immediately before placing the primary formed member in the forming cavity of the secondary forming die in the forging device of the embodiment.
[Fig. 12A] Fig. 12A is an enlarged top view showing a periphery of claws of a forging device according to a modified embodiment of the present invention to which the forging method can be applied.
[Fig. 12B] Fig. 12B is an enlarged front view showing the vicinity of the claws shown in Fig. 12A.
[FIG. 13] Fig. 13 is a perspective view showing the primary formed member manufactured by the forging device of the modified embodiment.
[FIG. 14A] Fig. 14A is a top view showing the primary formed product shown in Fig. 13.
[FIG. 14B] Fig. 14B is a side view showing the primary formed member shown in Fig. 13.
[FIG. 14C] Fig. 14C is a front view showing the primary formed member shown in Fig. 13.
[Fig. 15] Fig. 15 is a front cross-sectional view showing primary forming dies of a forging device according to a modified embodiment.
[Fig. 16] Fig. 16 is front cross-sectional view showing secondary forming dies of the forging device according to the modified embodiment.

BEST MODE FOR CARRYING OUT THE INVENTION

[0046] Fig. 1 is a schematic view showing a multistage forging device to which a forging method of an embodiment of the present invention is applied, and Fig. 2 is a side view thereof. As shown in both figures, the forging device is configured to perform two types of die-forging, primary forming and secondary forming, of a workpiece W consecutively transferred by a transfer device 4.

[0047] In this forging device, from the upstream side (left side of the figure) toward the downstream side (right side of the figure) along the transferring line, a workpiece introducing section 50, primary and secondary forming sections 51 and 52, and a workpiece discharging section 53 are arranged in this order.

[0048] In this embodiment, as to the members constituting the forging device and other devices such as the dies 1 and 2 and the workpiece W, their front views are defined as views when seen from the right side (i.e., the workpiece discharging side, or the downstream side) toward the left side (i.e., workpiece introducing side, or the upstream side).

[0049] In this embodiment, the workpiece introducing section 50 is constituted by the downstream side end portion of a workpiece introducing means such as a introducing conveyer 56. The workpiece W is loaded from the outside and then transferred to the conveyer end portion, i.e., the wokpiece introducing section 50, and held there.

[0050] The primary forming section 51 constitutes a primary workpiece processing section and the secondary forming section 52 constitutes a secondary workpiece processing section. The primary forming section 51 and the secondary forming section 52 are provided with primary forming dies 1 and secondary forming dies 2, respectively. At the primary forming section 51, a workpiece W is subjected to primary forming such as rough forming by the primary forming dies 1, and at the secondary forming section 52, the workpiece W is subjected to secondary forming such as main finish forming by the secondary

forming dies 2.

[0051] The workpiece discharging section 53 is constituted by the upstream side end portion of a workpiece discharging means such as a discharging conveyer 57. The workpiece W disposed on the conveyer end portion, or the workpiece discharging section 53, is conveyed to the outside of the device by the discharging conveyer 57.

[0052] The forging device is provided with a transfer device 4 so that the workpiece W can be consecutively transferred from the workpiece introducing section 50 to the primary forming section 51, from the primary forming section 51 to the secondary forming section 52, and from the secondary forming section 52 to the workpiece discharging section 53 with the transfer device 4.

[0053] In this embodiment, the workpiece W before performing the primary forming is denoted as a forging member W0, the workpiece W after performing the primary forming but before performing the secondary forming is denoted as a primary formed member W1, and the workpiece after performing the secondary forming is denoted as a secondary formed member W2, a forged product W2, or a piston member W2. Also, the forging member W0, the primary formed member W1, and the secondary formed member W2 are collectively called "workpiece W."

[0054] As shown in Fig. 4, the piston member W2 as a secondary formed member to be manufactured by the forging device of this embodiment is provided with a circular land portion 91, and a pair of skirt-portions 92 and 92, a pair of pin-boss portions 93 and 93, and side wall portions 94 are integrally formed on one side (lower surface side) of the land portion 91.

[0055] The pair of skirt-portions 92 and 92 is formed on right and left side end portions of the outer circumferential portions on one side surface of the land portion 91 in a downwardly protruded manner.

[0056] The pair of pin-boss portions 93 and 93 is formed on front and rear sides of the middle portion of one side surface of the land portion 91 in a downwardly protruded manner.

[0057] The side wall portions 94 are formed on both the right and left sides of the pair of front and rear pin-boss portions 93 and 93 to connect both the right and left sides of the front side pin-boss portion 93 and corresponding front end portions of the pair of skirt-portions 92 and 92 and connect both the right and left sides of the rear side pin-boss portion 93 and corresponding rear end portions of the pair of skirt-portions 92 and 92 in a downwardly protruded manner.

[0058] As shown in Figs. 5 and Fig. 6A to 6C, the primary formed member W1 of this embodiment has a main body portion 81 having a thick circular plate shape, and a pair of skirt scheduled portions 82 and 82 and a pair of pin-boss scheduled portions 83 and 83 are integrally formed on one surface side (lower surface side) of the main body portion 81.

[0059] A pair of skirt scheduled portions 82 and 82 is formed on the right and left side end portions of the outer circumferential edge portion on one surface side of the main body portion 81 so as to protrude toward the lower surface side, and will be formed into the skirt portions 92 and 92 with secondary forming.

[0060] A pair of pin-boss scheduled portions 83 and 83 is formed on the front and rear sides of the middle portion on one surface side of the land portion 91 so as to protrude toward the lower surface side, and will be formed into a bin-boss portions 93 and 93 with secondary forming.

[0061] Furthermore, a positioning protrusion 85 constituting an engaging portion is integrally formed on one side portion on the outer circumferential surface of the main body portion 81 so as to protrude toward one side direction (in the radially outward direction).

[0062] The upper portion of the positioning protrusion 85 is formed into a trapezoidal shape when seen from its above so as to correspond to the inner circumferential shape of the below-mentioned claw 42 of the feed bar 41, and slant surfaces are formed on both side portions of the trapezoid shaped protrusion 85 so that both the side portions constitute guide portions 86 and 86. Furthermore, the lower portion of the positioning protrusion 85 is formed into a slanted surface which constitutes a lower guide portion 87.

[0063] As shown in Fig. 7, the forging member W0 of this embodiment has a short cylindrical shape (disk shape). As the forging member W0, for example, a member obtained by cutting an aluminum (including aluminum alloy) continuously-casted or extruded bar with a saw to have a volume having a predetermined weight.

[0064] A suitable example of the specific composition of the forging material W0 can be exemplified by an aluminum alloy containing Si: 5 to 18 mass%, Cu: 2 to 5 mass%, Mg: 0.3 to 1.0 mass%, Fe: 0.1 to 0.8 mass%, Ni: 0.2 to 3 mass%, Mn: 0.1 to 0.5 mass%, and Cr: 0.1 to 0.5 mass%.

[0065] As shown in Figs. 1 and 2, the transfer device 4 of this embodiment is equipped with a pair of feed bars 41 and 41 arranged on both sides of the transferring line.

[0066] The pair of feed bars 41 and 41 is extended along the transferring line (in the front and rear direction) and arranged in parallel. It is configured that the pair of feed bars 41 and 41 moves in the approach-separate direction (right and left direction) to open and close by a driving means (not shown) and also moves in the front and rear direction in a synchronized manner. Furthermore, the pair of feed bars 41 and 41 is configured to move in the up-and-down direction in a synchronized manner.

[0067] On the inner sides of the pair of feed bars 41 and 41, a plurality of pairs (three pairs) of claws 42 and 42 opposed to each other are arranged along the front and rear direction at predetermined intervals. Each claw 42 is fixed to the feed bar 41 via a claw holder 43.

[0068] Each pair of claws 42 and 42 is arranged to positions corresponding to the workpiece introducing section 50 and the forming sections 51 and 52 in a state

in which the pair of feed bars 41 and 41 is in a retreated position (in a state in which they are in a leftwardly moved position in Fig. 1), and arranged to positions corresponding to the forming section 51 and 52 and the work discharging section 53 in a state in which the pair of feed bars 41 and 41 is in a forwardly moved position (in a state in which they are in a rightwardly moved position in Fig. 1). When the pair of feed bars 41 and 41 is closed in a state in which they are in a backwardly moved position, each of the workpieces W positioned on the workpiece introducing portion 50 and the forming portions 51 and 52 is sandwiched and held (chucked) by corresponding pair of claws 42 and 42. Furthermore, when the pair of feed bars 41 and 41 is raised and then moved forward (moved to the right side in Fig. 1) while keeping the chucking state, these three pairs of claws 42 and 42 are arranged at positions corresponding to the forming section 51 and 52 and the workpiece discharging section 53, respectively. Furthermore, in this state, when the pair of feed bars 41 and 41 is lowered and then opened, the chucking by the claws 42 is released, and the workpieces W are disposed on the corresponding forming portion 51 and 52 and workpiece discharging section 53. With this, the workpieces W disposed at the workpiece introducing section 50, the primary forming section 51, and the secondary forming section 52 will be transferred to the primary forming section 51, the secondary forming section 52, and the workpiece discharging section 53, respectively. After the transferring operation, the pair of feed bars 41 and 41 retreats and moves backward toward the left side in Fig. 1 and waits for the next operation in an open state (initial state).

[0069] In accordance with the sequence parallel transferring of workpieces W, the workpieces W sequentially supplied to the workpiece introducing section 50 are sequentially transferred to the primary forming section 51, the secondary forming section 52, and the workpiece discharging section 53, and then sequentially discharged.

[0070] In this embodiment, as shown in Figs. 1 and 3, each claw 42 of the transfer device 4 has a positioning dented portion 45 having a V-shaped or a U-shaped groove on the inner side middle portion in a plan view. In the plan view, the inner circumferential shape of the positioning dented portion 45 is formed into a trapezoidal shape corresponding to the outer circumferential shape of the positioning protrusion 85 of the aforementioned primary formed member W1. Both the inner side surfaces of the positioning dented portion 45 having a trapezoid shape are formed to be slanted corresponding to both guide portions 86 and 86 of the positioning protrusion 85, and constitute side guide portions 46 and 46.

[0071] In chucking the primary formed member W1 with the corresponding pair of claws 42 and 42, as will be detailed later, the positioning protrusion 85 of the primary formed member W1 is engaged with the positioning dented portion 45 of one of claws 42 to position the primary formed member W1.

[0072] In this embodiment, the positioning dented portion 45 of the claw 42 constitutes an engaging portion receiving portion.

[0073] Furthermore, in this embodiment, the shape of the positioning protrusion 85 of the primary formed member W1 is formed corresponding to the shape of the positioning dented portion 45 of the claw 42, which utilizes the originally possessed dented portion of the claw 42 as the positioning dented portion 45.

[0074] As shown in Fig. 2, in the forging device of this embodiment, the primary forming dies 1 are arranged at the primary forming section 51, and the secondary forming dies 2 are arranged at the secondary forming section 52.

[0075] As shown in Figs. 2 and 8, the primary forming dies 1 include a lower die 11 and a punch 16 as an upper die.

[0076] The lower die 11 has an upwardly opened forming cavity 12 for forming the primary formed member W1. The inner circumferential surface of the forming cavity 12 is formed corresponding to the outer circumferential surface shape of the primary formed member W1, except for the top end surface of the primary formed member. In other words, on the inner surface of the forming cavity 12, dented portions (forming portions) for forming the main body portion 81, the skirt scheduled portions 82, and the pin-boss scheduled portions 83 of the primary formed member W1 are formed.

[0077] Furthermore, on the inner circumferential side surface of the forming cavity 12, a positioning protrusion forming female die portion 13 having a dented groove shape for forming the positioning protrusion 85 is formed corresponding to the outer surface shape of the positioning protrusion 85.

[0078] The lower die 11 having the aforementioned structure is installed on the lower plate 10 via a lower die holder 14.

[0079] The lower side portion of the punch 16 is formed to have a shape capable of being inserted into the forming cavity 12 of the lower die 11 in a fitted manner. On the outer circumferential side surface of the punch 16, a positioning protrusion forming male die portion 17 having a protruded ledge shape is formed corresponding to the positioning protrusion forming female die portion 13 .

[0080] The punch 16 having the aforementioned structure is installed on the upper plate 20 via a punch holder 18.

[0081] The upper plate 20 is constituted so as to be moved in the up-and-down direction with a lifting and lowering means (not shown). In accordance with the lowering operation of the upper plate 20, the punch 18 is fitted into the forming cavity 12 of the lower die 11. At the time of this punching operation, the positioning protrusion forming male die portion 17 of the punch 18 is fitted into the female die portion 13 of the lower die 11.

[0082] In the bottom portion of the forming cavity of the lower die 11, knockout pins (not shown) are provided such that the pins can be moved upward to protrude upward from the bottom surface of the forming cavity. As

will be explained later, the primary formed member W1 formed in the forming cavity 12 of the lower die 11 is pushed up by the knockout pins and positioned so as to protrude upward from the forming cavity 12 of the lower die 11 by a predetermined amount.

[0083] As shown in Figs. 9 and Figs. 10A to 10C, the secondary forming dies 2 are equipped with a lower die 21 and a punch 26 as an upper die.

[0084] The lower die 21 has an upwardly opened forming cavity 22 for forming the secondary formed member W2. The inner circumferential surface of the forming cavity 22 is formed corresponding to the outer circumferential surface shape of the secondary formed member W2 except for the top end surface of the secondary formed member. In other words, on the inner surface of the forming cavity 22, dented portions (forming portions) for forming the land portion 91, the skirt portions 92, the pin-boss portions 93, and the side wall portions 94 of the secondary formed member W2 are formed.

[0085] Furthermore, on the inner circumferential side surface of the forming cavity 22, a positioning protrusion forming female die portion 23 having a dented groove shape is formed corresponding to the outer surface shape of the positioning protrusion 85.

[0086] The lower die 21 having the aforementioned structure is installed on the lower plate 10 via a lower die holder 24.

[0087] The lower side portion of the punch 26 is formed to have a shape capable of being inserted into the forming cavity 22 of the lower die 21 in a fitted manner. On the outer circumferential side surface of the punch 26, a positioning protrusion forming male die portion 27 having a protruded ledge shape is formed corresponding to the positioning protrusion forming female die portion 23.

[0088] The punch 26 having the aforementioned structure is installed on the upper plate 20 via a punch holder 28.

[0089] When the upper plate 20 is lowered, the secondary forming punch 26 is lowered in synchronization with the primary forming punch 16 to be fitted into the forming cavity 22 of the secondary forming dies 2. At the time of this punching operation, the positioning protrusion forming male die portion 27 of the secondary forming punch 26 is fitted into the female die portion 23 of the lower die 21.

[0090] Also in the secondary forming dies 2, in the same manner as in the primary forming dies, in the bottom portion of the forming cavity 22 of the lower die 21, knockout pins (not shown) are provided such that the pins can be moved upward to protrude upward from the bottom surface of the forming cavity so that the secondary formed member W2 is pushed up by the knockout pins after the forming and positioned so as to protrude upward from the forming cavity 22 of the lower die 21 by a predetermined amount.

[0091] In the multistage forging device of this embodiment, conditions for performing the forging processing (forging conditions) are as follows. That is, the temperature of the workpiece W is set to 380 to 540 °C, the temperature of the upper die (punch) of each of the primary forming dies 1 and the secondary forming dies 2 is set to 100 to 250 °C, and the temperature of the lower die thereof is set to 150 to 370 °C. In this embodiment, the primary forming and the secondary forming are conducted continuously, and therefore it is preferable that the temperature of the workpiece is set to be higher at the primary forming. In details, it is preferable that the workpiece temperature during the primary forming is set to be lower than the solidus temperature of the workpiece W by 30 to 60 °C (i.e., -30 to -60 °C with respect to the solidus temperature of the workpiece W), and the temperature of the workpiece during the secondary forming is set to be lower than the temperature of the workpiece W during the primary forming by 20 to 60 °C (i.e., -20 to -60 °C with respect to the temperature of the workpiece W during the primary forming) by releasing heat to the dies. It is more preferable that the temperature of the workpiece during the secondary forming is set so as not to become 370 °C or lower.

[0092] A graphite series lubricant can be used as a lubricant for the workpiece W, and the lubricant can be applied by immersion treatment or Bonderizing treatment. As a lubricant for the dies, a soluble graphite series lubricant or a mixture of oil-based graphite series lubricant and aqueous graphite series lubricant can be used. The lubrication to the dies is conducted during both the primary forming and the secondary forming.

[0093] Next, the forging operation of the forging device of this embodiment is explained. In this device, the primary forming and the secondary forming are conducted in a simultaneous parallel manner, and a plurality of workpieces W are transferred in a simultaneous parallel manner. In the following explanation, however, for an easy understanding of the present invention, various operations to be consecutively performed against a forging member W0 will be explained in chronological order.

[0094] Initially, the pair of feed bars 41 and 41 is in an opened state at the retreated position. In this initial state, a forging member W0 is loaded on the introducing conveyer 56 from the outside and transferred to the workpiece introducing section 50. At that time, the axis of the forging member W0 is arranged in an up-and-down direction (i.e., vertical direction).

[0095] Next, the pair of feed bars 41 and 41 is approached (closed), so that the upper side portion of the forging member W0 arranged at the workpiece introducing section 50 is sandwiched and held from both sides thereof by and between the first pair (left end pair in Fig. 1) of claws 42 and 42.

[0096] After that, the pair of feed bars 41 and 41 is raised and then moved forward so that the forging member W0 sandwiched and held by and between the first pair of claws 42 and 42 is transferred to a position corresponding to the forming cavity 12 of the lower die 11 of the primary forming section 51.

[0097] Next, the pair of feed bars 41 and 41 is lowered.

At this time, the upper portion of the forging member W0 is sandwiched and held by and between the pair of claws 42 and 42, while the lower portion thereof is protruded downward. Consequently, when the feed bars 41 and 41 are lowered, the lower portion of the forging member W0 chucked with the pair of claws 42 and 42 is inserted into the upper portion of the forming cavity 12 of the lower die 11.

[0098] In this inserted state, the pair of feed bars 41 and 41 is opened to release the chucking state of the forging member W0, which in turn results in dropping of the forging member W0 in the forming cavity 12 of the lower die 11. In this embodiment, since chucking of the forging member W0 is released in a state in which the lower portion of the forging member W0 is inserted in the forming cavity 12, the forging member W0 can be accurately and assuredly accommodated in the forming cavity 12. This assuredly prevents occurrence of installation defects, such as, e.g., displacement of the forging member W0 at the time of the insertion or abnormal insertion with a posture different from a normal posture. Therefore, the die forming, which will be described, can be conducted smoothly with a high degree of accuracy.

[0099] In this embodiment, it is preferable that the upper portion of the forging member W0 is sandwiched and held by the pair of claws 42 and 42. In other words, if the lower portion of the forging member W0 is sandwiched and held by the pair of claws 42 and 42, the lower portion of the forging member W0 cannot be disposed in a state in which the lower portion is inserted in the forming cavity 12 because the pair of claws 42 and 42 interferes with the lower die 11 when the feed bars 41 and 41 are lowered. Furthermore, when the feed bars 41 and 41 are opened, there is a risk that it becomes difficult to drop the forging member W0 into the forming cavity 12 with a high degree of positional accuracy. For that reason, in this embodiment, the upper portion of the forging member W0 is sandwiched and held by the pair of claws 42 and 42. Therefore, when the feed bars 41 and 41 are lowered, the lower portion of the forging member W can be assuredly inserted into the forming cavity 12, and when the feed bars 41 and 41 are opened, the forging member W0 can be assuredly dropped into the forming cavity 12.

[0100] Next, the upper plate 20 is lowered to punch the punch 16 into the forming cavity 12 of the lower die 11, which causes pressing of the forging member W0 in each dented portion of the forming cavity 12. Thus, the forging member W0 is formed into a primary formed member W1.

[0101] As explained above, in addition to the main body portion 81, the skirt scheduled portions 82, the pin-boss scheduled portions 83, this primary formed member W1 has a positioning protrusion 85 protruded from one side portion of the outer circumferential surface of the main body portion 81 in the radially outward direction.

[0102] The dotted line shown in Fig. 8 indicates a lowermost position of the punch 16 when the punch 16 is lowered.

[0103] After completion of the punching operation by the punch 16, the upper plate 20 and the punch 16 are raised, and then the primary formed member W1 is pushed up by the knockout pins, so that the upper side portion of the primary formed member W1 is positioned so as to be protruded upward from the forming cavity 12.

[0104] During this forming process, the pair of feed bars 41 and 41 is taking the retreated initial position. When the primary formed member W1 is pushed up by the knockout pins as mentioned above, the pair of feed bars 41 and 41 are closed (approached), so that the upper portion of the primary formed member W1 in the primary forming section 51 is sandwiched and held by and between the second pair (the second pair from the left side in Fig. 1) of claws 42 and 42 from its both sides.

[0105] At this time, the positioning protrusion 85 formed on the primary formed member W1 is engaged with the positioning dented portion 45 of one of claws 42, thereby positioning the primary formed member W1 with respect to the transfer device 4.

[0106] At this time, even if the primary formed member W1 is slightly displaced when the primary formed member W1 is sandwiched and held by and between the claws 42 and 42, the displacement is corrected. In detail, as shown in Fig. 3, if the primary formed member W1 is displaced at the time of being sandwiched and held by and between the claws 42 and 42, the outer circumferential angular portion of the positioning protrusion 85 comes into contact with the guide portion 46 of the positioning dented portion 45 to be guided, or the opening edge portion of the positioning dented portion 45 comes into contact with the guide portion 86 of the positioning protrusion 85 to be guided. As a result, the primary formed member W1 is corrected in position while being moved slightly. When the positional displacement of the primary formed member W1 is absorbed and the primary formed member W1 is positioned accurately, the positioning protrusion 85 is fitted in the positioning dented portion 45. In a state in which the primary formed member W1 is positioned with a high degree of accuracy as mentioned above, the primary formed member W1 is sandwiched and held by and between the pair of claws 42 and 42 of the transfer device 4.

[0107] Next, the pair of feed bars 41 and 41 is raised and then moved forward, so that the primary formed member W1 sandwiched and held by and between the second pair of claws 42 and 42 is transferred to a position corresponding to a forming cavity 22 of the lower die 21 arranged at the secondary forming section 52.

[0108] Thereafter, as shown in Fig. 11, the pair of feed bars 41 and 41 is lowered, so that the lower portion of the primary formed member W1 held by the claws 42 and 42 is inserted into the upper portion of the forming cavity 22 of the lower die 21. Furthermore, the lower portion of the positioning protrusion 85 of the primary formed member W1 is inserted into the upper portion of the positioning protrusion fitting female die portion 23 of the forming cavity 22.

[0109] In this state, the pair of feed bars 41 and 41 is opened to release the chucking of the primary formed member W1, so that the primary formed member W1 is dropped in the forming cavity 22 with the positioning protrusion 85 fitted in the positioning protrusion fitting female die portion 23 of the forming cavity 22.

[0110] In this embodiment, at the time of dropping the primary formed member W1, the primary formed member W1 is dropped with a part of the primary formed member W1 (i.e., the lower portion of the primary formed member) fitted in the forming cavity 22, which enables assured accommodation of the primary formed member W1 in the forming cavity 22 with a high degree of positional accuracy. Furthermore, the primary formed member W1 is dropped in the forming cavity 22 in a state in which a part of the positioning protrusion 85 (lower portion of the positioning protrusion) is fitted in the positioning protrusion fitting female die portion 23 of the forming cavity 22, and therefore the primary formed member W1 can be positioned accurately in the axial rotational direction (i.e., in the circumferential direction). As a result, the primary formed member W1 can be set in the forming cavity 22 of the lower die 21 with a higher degree of positional accuracy.

[0111] In this embodiment, in the same manner as explained above, when the pair of feed bars 41 and 41 is lowered, the upper portion of the primary formed member W1 is sandwiched and held by and between the pair of claws 42 and 42 so that the primary formed member W1 can be arranged with the lower portion thereof inserted in the forming cavity 22.

[0112] In this embodiment, even if the primary formed member W1 is slightly displaced, when the primary formed member W1 is dropped in the forming cavity 22, the lower guide portion 87 formed at the lower side of the positioning protrusion 85 comes into contact with the opening edge portion of the positioning protrusion fitting female die portion 23 of the lower die 21 to be guided. Thus, the primary formed member W1 is assuredly accommodated in the forming cavity 22 of the lower die 21.

[0113] Thereafter, the punch 26 is pushed into the forming cavity 22 of the lower die 21 in accordance with the lowering operation of the upper plate 20, whereby the primary formed member W1 is pressed into each dented portion of the forming cavity 22. Thus, a secondary formed member W2 is formed. With this forming, the main body portion 81 is formed into a land portion 91, the skirt scheduled portion 82 is formed into a skirt portion 92, and the pin-boss scheduled portion 83 is formed into a pin-boss portion 93. Furthermore, the positioning protrusion 85 is pressed by and between the positioning protrusion fitting female die portion 23 of the lower die 21 and the positioning protrusion forming male die portion 27 of the punch 26 to be compressed in the axial direction, and formed into a positioning protrusion forming portion remaining 95 short in the axial direction.

[0114] The dotted line shown in Fig. 9 indicates a lowermost position of the punch 26 when the punch 26 is lowered.

[0115] After completion of the punching operation by the punch 26, the upper plate 20 and the punch 26 are raised, and then the secondary formed member W2 is pushed up by the knockout pins, so that the upper side portion of the secondary formed member W2 is positioned so as to be protruded upward from the forming cavity 22.

[0116] During this forming process, the pair of feed bars 41 and 41 is taking the retreated initial position. When the secondary formed member W2 is pushed up by the knockout pins as mentioned above, the pair of feed bars 41 and 41 are closed (approached), so that the upper portion of the secondary formed member W2 in the secondary forming section 52 is sandwiched and held by and between the third pair (the third pair from the left side in Fig. 1) of claws 42 and 42 from its both sides.

[0117] At this time, in the similar manner as in the aforementioned primary formed member W1, the positioning protrusion forming portion remaining 95 is engaged with the positioning dented portion 45 of one of claws 42 in a fitted manner, which enables accurate positioning of the secondary formed product W2.

[0118] Next, the pair of feed bars 41 and 41 is raised and moved forward, so that the secondary formed product W2 sandwiched and held by and between the third pair of claws 42 and 42 is transferred to a position corresponding to the workpiece discharging section 53.

[0119] Thereafter, the pair of feed bars 41 and 41 is lowered and then opened to release the chucking of the secondary formed member W2. Thus, the secondary formed member W2 is disposed on the workpiece discharging section 53.

[0120] The secondary formed member W2 disposed on the workpiece discharging section 53 is conveyed to a predetermined place by the discharging conveyer 57. In this way, a series of forging of the workpiece W is completed.

[0121] As explained above, in the multistage forging device of this embodiment, the primary forming and the secondary forming are conducted alongside. In other words, the workpieces W disposed on the workpiece introducing section 50 and forming sections 51 and 52 are each sandwiched and held simultaneously by the three pairs of claws 42 and 42 of the pair of feed bars 41 and 41, and transferred simultaneously to the forming sections 51 and 52 and workpiece discharging section 53. Next, each of the workpieces arranged at the forming sections 51 and 52, the primary forming and the secondary forming are conducted simultaneously. While, at the time of the forming, the workpiece (forging member) is conveyed to the workpiece introducing section 50 by the introducing conveyer 56, and the workpiece (secondary formed member W2) arranged at the workpiece discharging section 53 is discharged by the discharging conveyer 57. In this manner, the transferring operation of the workpieces W by the pair of feed bars 41 and 41 and the forming operation are repeated alternately. Thus, the pri-

mary forming and the secondary forming for a plurality of worwkpieces W are conducted in a simultaneous parallel manner, and the secondary formed members (forged products) are discharged sequentially.

[0122] The forged member W2 manufactured in this way is subjected to cutting processing as needed, the positioning protrusion forming portion remaining 95 and the like are removed. Thus, the forged member is formed into a forged product having a final shape.

[0123] As explained above, according to the forging method by the forging device of this embodiment, a positioning protrusion 85 is formed on the workpiece W by the primary forming, while the claw 42 is provided with a positioning dented portion 45 corresponding to the positioning protrusion 85. Therefore, at the time of chucking the primary formed member W1 with the claws 42 and 42, the positioning protrusion 85 and the positioning dented portion 45 are engaged with each other, enabling positioning of the primary formed member W1 with a high degree of accuracy, which in turn can transfer the primary formed member W1 to the secondary forming dies 2 with a high degree of accuracy. Therefore, with the secondary forming dies 2, the primary formed member W1 can be subjected to forming while maintaining a normal posture with no displacement, which in turn can assuredly obtain a high quality secondary formed member W2.

[0124] Furthermore, in this embodiment, the positioning protrusion 85 is formed on the workpiece W during the primary forming, which can eliminate a separate process for forming the positioning protrusion. This in turn can prevent the number of processing steps from being increased, which in turn can maintain high productivity.

[0125] Also, with the forging device of this embodiment, the use of the aforementioned transfer device 4 enables short-time transferring with a constant cycle time. As a result, temperature management, which is one of important conditions for forging, such as management of the die temperature or management of the workpiece temperature, can be conduced easily and stably. This in turn can attain excellent machining performance, which is effective for forging technology.

[0126] Furthermore, in this forging device of this embodiment, the use of the transfer device 4 can reduce transfer failures, resulting in stable forging operations. For example, changes in die temperature caused by operation interruptions due to transfer failures can be controlled, enabling easy and stable temperature management described above, which is more effective for forging technology.

[0127] As shown in Fig. 4, in the piston member W2 manufactured by the forging device of this embodiment, the center 93x of the pin-boss portion 93 is offset by a predetermined amount Δx toward the thrust side (toward one of the skirt portions) with respect to the center of the piston W2x. Therefore, the piston member W2 is formed with a volume valance in which the volume on the thrust side is slightly larger.

[0128] In this situation, in performing forging, especially closed-die forging of this embodiment, the volume balance should be adjusted at the stage of forming the secondary formed member W2 as a final finished product.

[0129] In this embodiment, the positioning protrusion 85 is formed by the primary forming at a position corresponding to the thrust side (one of the skirt portions) of the primary formed member W1, and the positioning protrusion 85 is pressed during the secondary forming to increase the volume on the thrust side. Thus, the volume balance can be adjusted accurately. In this volume balance adjusting method, the volume balance is adjusted by adjusting the amount of the protrusion 85 to be pressed during the secondary forming. Therefore, the primary formed member W1 can be manufactured by the primary forming without carefully considering the volume balance, and adjustment of the volume balance can be performed easily, which in turn can further enhance the productivity.

[0130] In this embodiment, in pressing the positioning protrusion 85 during the secondary forming, only a part of the positioning protrusion 85 is pressed to increase the thickness. In the present invention, however, the pressing amount of the positioning protrusion 85 is not specifically limited, and can be freely set as needed. For example, the positioning protrusion 85 can be entirely pressed to increase a thickness.

[0131] On the contrary, the volume balance can also be adjusted by forming a positioning protrusion 85 on a side opposite to a thrust side (anti-thrust side, the other skirt portion side) of the primary formed member W1 and cutting the positioning protrusion 85 after the secondary forming. In cases where the volume of the thrust side is made relatively larger by cutting the positioning protrusion 85 after the secondary forming, the volume balance of the primary formed member W1 can be set equal on the thrust side and on the anti-thrust side during the primary forming, which enables easy volume balance adjustment at the time of the primary forming.

[0132] As explained above, in this embodiment, the positioning protrusion 85 is formed on the skirt portion (thrust side or anti-thrust side), which enables easy adjustment of the volume balance of the forged product W2 by pressing or cutting the protrusion 85. In the present invention, however, it is not always required to form the positioning protrusion 85 on the skirt portion, and the positioning protrusion 85 can be formed on another portion.

[0133] In cases where the positioning protrusion 85 is not entirely pressed so that at least a part thereof remains, the protrusion remaining 95 is removed at a following cutting step. However, this protrusion remaining 95 can be used for positioning the workpiece at the cutting step, which enables smooth cutting operation.

[0134] Figs. 12A to 12C show a claw 42 of a feed bar 41 of a multistage forging device according to a modified embodiment of the present invention. As shown in these figures, in the same manner as in the aforementioned embodiment, this device is equipped with a workpiece introducing section, a primary forming section, a second-

ary forming section, and a workpiece discharging section, and configured to transfer the workpiece therebetween by a transfer device. The transfer device is equipped with a pair of feed bars 41 and 41, and the pair of feed bars 41 and 41 is provided with plural pairs of opposing claws 42 and 42 arranged along the transferring line at predetermine intervals.

[0135] The pair of claws 42 and 42 are each constituted by a flat board members each having a rectangular shape in a plan view. The opposed surfaces (tip end surfaces) of the pair of claws 42 and 42 are each constituted by a flat surface (vertical surface), and constituted as a positioning portion (engaging portion receiving portion).

[0136] On the other hand, as to the workpiece W to be processed by the forging device, similar to the aforementioned embodiment, the workpiece W has a cylindrical shape (disk shape).

[0137] Furthermore, as shown in Figs. 13 and 14A to 14C, the primary formed member W1 is integrally provided with a circular main body portion 81 and a pair of bin-boss scheduled portions 83 and 83 formed on both sides of one surface side (upper surface side) of the main body portion 81.

[0138] The pair of pin-boss scheduled portions 83 and 83 are to be formed into the pin-boss portions with secondary forming, and each has a rectangular cubic shape. The outer side surface of the pin-boss scheduled portion 83 and 83 is constituted by a perpendicular surface, and constituted as a positioning portion (engaging portion).

[0139] In this forging device, a pin-boss portion, a skirt portion, and side wall portions are formed on the upper surface side of the workpiece W. In detail, as shown in Fig. 15, in the primary forming die 1 of this forging device, a pin-boss scheduled portion forming dented portions 161 and 161 for forming the pin-boss scheduled portions 83 and 83 are formed on a punch 16 as an upper die. Furthermore, as shown in Fig. 16, in the secondary die 2, pin-boss portion forming dented portions 261 and 261 for forming the pin-boss portions are formed on the punch 26 as an upper die.

[0140] In this modified embodiment, since the other structures are similar to the aforementioned embodiment, duplicate explanations are omitted by allotting the same or corresponding symbols to the same or corresponding portions.

[0141] In this forging device, after forming the workpieces with the primary forming die 2, the pair of feed bars 41 and 41 are closed (approached). With this, as shown in Fig. 12, the tip end surfaces of the pair of claws 42 and 42 come into contact with both outside surfaces of the pin-boss scheduled portions 83 and 83 of the primary formed member W1, so that the primary formed member W1 is sandwiched and held by and between the pair of claws 42 and 42. At this time, the tip end surfaces of the pair of claws 42 and 42 are constituted by vertical flat surfaces, and the outer side surfaces of the bin-boss scheduled portions 83 and 83 of the primary formed member W1 to which the tip end surfaces of the pair of claws 42 and 42 contact are constituted by a vertical surface. Their face-to-face contact enables positioning of the primary formed member W1 with respect to the transfer device. In detail, if the primary formed member W1 is displaced at the time of being sandwiched and held by the claws 42 and 42, the outer circumferential edge of the tip end surface of the claw 42 and 42 comes into contact with the outside surface of the pin-boss scheduled portions 83 and 83 to guide the primary formed member W1, which corrects the position of the primary formed member W1 while being slightly moved. When the displacement of the primary formed member W1 is absorbed and the member W1 is correctly positioned, the tip end surfaces of the claws 42 and 42 come into face-to-face contact with the outside surfaces of the pin-boss scheduled portions 83 and 83. In this way, the primary formed member W1 is sandwiched and held by and between the pair of claws 42 and 42 of the transfer device in a positioned state with a high degree of accuracy.

[0142] Thereafter, in the same manner as mentioned above, in accordance with the movement of the pair of feed bars 41 and 41, the primary formed member W1 sandwiched and held with the pair of claws 42 and 42 is transferred to the secondary forming section, then the pair of feed bars 41 and 41 is opened at this position, so that the primary formed member W1 is dropped in the forming cavity 22 of the lower die 21 of the secondary forming die 2.

[0143] Thereafter, in the same manner as mentioned above, secondary forming is conducted, then the primary formed member W1 is transferred to the workpiece discharging section and then discharged.

[0144] Also in this variable example of the multistage forging device, similar to the above, similar functions and effects can be obtained.

[0145] Furthermore, in this modified embodiment, there is no need to form any particular forming portions on the primary formed member W1 for the purpose of positioning, and a primary formed member W1 of a simple shape is used, so the forging can be performed easily.

[0146] In this embodiment, the positioning protrusion 85 is formed on the workpiece W side, and the dented portion 45 is formed on the claw 42 side so as to be engaged with each other. The present invention, however, is not limited to that, and allows to form a positioning dented portion on the workpiece side and a protrusion on the claw side to be engaged with each other for the purpose of positioning.

[0147] Furthermore, in the aforementioned embodiments, the workpiece is formed at two forming sections, the primary forming section and the secondary forming section. The present invention, however, the number of forming sections is not limited two, and can be one or 3 or more. In addition, in the case of forming more than three forming sections, there is no need to conduct forging at all forming sections, and for example, forming, such as burr removing by pressing, other than forging can be employed.

[0148] This application claims priority to Japanese Patent Application No. 2008-308399 filed on December 3, 2008, and the entire disclosures of which are incorporated herein by reference in their entirety.

[0149] It should be understood that the terms and expressions used herein are used for explanation and have no intention to be used to construe in a limited manner, do not eliminate any equivalents of features shown and mentioned herein, and allow various modifications falling within the claimed scope of the present invention.

[0150] While the present invention may be embodied in many different forms, a number of illustrative embodiments are described herein with the understanding that the present disclosure is to be considered as providing examples of the principles of the invention and such examples are not intended to limit the invention to preferred embodiments described herein and/or illustrated herein.

[0151] While illustrative embodiments of the invention have been described herein, the present invention is not limited to the various preferred embodiments described herein, but includes any and all embodiments having equivalent elements, modifications, omissions, combinations (e.g., of aspects across various embodiments), adaptations and/or alterations as would be appreciated by those in the art based on the present disclosure. The limitations in the claims are to be interpreted broadly based on the language employed in the claims and not limited to examples described in the present specification or during the prosecution of the application, which examples are to be construed as non-exclusive.

INDUSTRIAL APPLICABILITY

[0152] The forging method of the present invention can be applied to forging technology for forging a workpiece to be transferred.

DESCRIPTION OF THE REFERENCE NUMERALS

[0153]

1	primary forming dies
2	secondary forming dies
4	transfer device
41	feed bar
42	claw
45	positioning dented portion (engaging portion receiving portion)
50	workpiece introducing section
51	primary forming section (primary workpiece processing section)
52	secondary forming section (secondary workpiece processing section)
54	workpiece discharging section
82	skirt scheduled portion
85	positioning protrusion (engaging portion)
86	guide portion
91	land portion
92	skirt portion
93	pin-boss portion
W	workpiece
M0	workpiece member
W1	primary formed member
W2	secondary formed member (piston member, forged product)

Claims

1. A forging method in which a workpiece disposed at a workpiece introducing section is sandwiched and held from both sides of the workpiece by and between a pair of claws provided to a pair of feed bars arranged on both sides of a transferring line by closing the feed bars, and transferred to a workpiece processing section by moving the feed bars forward with the workpiece held and then opening the feed bars, and the workpiece transferred to the workpiece processing section is subjected to forging,
wherein an engaging portion is formed on the workpiece and an engaging portion receiving portion is formed on one of the claws, and
wherein the workpiece is positioned by engaging the engaging portion with the engaging portion receiving portion at the time of sandwiching and holding the workpiece by and between the claws.

2. The forging method as recited in claim 1, wherein one of the engaging portion and the engaging portion receiving portion is constituted by a positioning protrusion and the other thereof is constituted by a positioning dented portion with which the engaging portion is engaged to thereby position the workpiece.

3. The forging method as recited in claim 1 or 2, wherein a workpiece discharging section is provided at a downstream side of the workpiece processing section along the transferring line, and plural pairs of claws are provided to the pair of feed bars,
wherein the pair of feed bars is closed to sandwich and hold the workpiece disposed at the workpiece introducing section and the workpiece disposed at the workpiece processing section by and between corresponding pair of claws, and
wherein the feed bars are moved forward with the workpieces sandwiched and held by and between the corresponding pair of claws, and opened to transfer the workpieces sandwiched and held by the corresponding pair of claws on the workpiece processing section and the workpiece discharging section, respectively.

4. The forging method as recited in claim 3, wherein the workpiece processing section includes a plurality of workpiece processing sections arranged along the transferring line,

wherein the pair of feed bars is closed to sandwich and hold the workpiece disposed at the workpiece introducing section and the workpiece disposed at the workpiece processing section by and between corresponding pair of claws, moved forward with the workpieces sandwiched and held by and between the corresponding pair of claws, and then opened to transfer the workpieces sandwiched and held by the corresponding pair of claws on the workpiece processing section and the workpiece discharging section respectively.

5. The forging method as recited in claim 3 or 4, wherein the workpiece processing section includes a primary workpiece processing section and a secondary workpiece processing section arranged at a downstream side of the primary workpiece processing section,
wherein the primary workpiece processing section is constituted as a primary forming section for obtaining a primary formed member by subjecting the workpiece to die-forging as primary forming, and
wherein the secondary workpiece processing section is constituted as a secondary forming section for obtaining a secondary formed member by subjecting the primary formed member to die-forging as secondary forming.

6. The forging method as recited in claim 5, wherein the engaging portion of the workpiece is formed by the primary forming.

7. The forging method as recited in claim 5 or 6, wherein the engaging portion to be formed on the primary formed member as the workpiece is constituted by a positioning protrusion,
wherein, after the primary forming, at least a part of the positioning protrusion is pressed to increase a thickness to thereby attain a volume balance of the secondary formed member.

8. The forging method as recited in claim 7, wherein the pressing of the at least a part of the positioning protrusion is performed by the secondary forming.

9. The forging method as recited in claim 5 or 6,
wherein the engaging portion formed on the primary formed member as the workpiece is constituted by a positional protrusion, and
wherein the positional protrusion is removed after the primary forming to attain a volume balance of the secondary formed member.

10. The forging method as recited in any one of claims 5 to 9, wherein a piston member integrally provided with a pair of skirt-portions and a pair of pin-boss portions on one surface side of a land portion is formed as the secondary formed member.

11. The forging method as recited in claim 10, wherein the engaging portion is formed on an outer peripheral surface of a skirt scheduled portion corresponding to the skirt portion of the primary formed member.

12. The forging method as recited in claim 2, wherein guide portions for guiding the positioning protrusion toward the positioning dented portion are formed on both sides of the positioning protrusion.

13. The forging method as recited in any one of claims 1 to 12, wherein the workpiece is made of aluminum or aluminum alloy.

14. A forging apparatus in which a workpiece disposed at a workpiece introducing section is sandwiched and held from both sides of the workpiece by and between a pair of claws provided to a pair of feed bars arranged on both sides of a transferring line by closing the feed bars, and transferred to a workpiece processing section by moving the feed bars forward with the workpiece held and then opening the feed bars, and the workpiece transferred to the workpiece processing section is subjected to forging,
wherein the workpiece is provided with an engaging portion and one of the claws is provided with an engaging portion receiving portion, and
wherein the workpiece is positioned by engaging the engaging portion with the engaging portion receiving portion at the time of sandwiching and holding the workpiece with the claws.

15. The forging device as recited in claim 14, wherein a workpiece discharging section is provided at a downstream side of the workpiece processing section along the transferring line,
wherein the workpiece processing section includes a primary workpiece processing section and a secondary workpiece processing section arranged at a downstream side of the primary workpiece processing section,
wherein the pair of feed bars are closed to sandwich and hold the workpiece disposed at the workpiece introducing section and the workpiece disposed at the workpiece processing section by and between corresponding pair of claws, the feed bars are moved forward with the workpieces sandwiched and held by and between the corresponding pair of claws, and opened to transfer the workpieces sandwiched and held by the corresponding pair of claws on the workpiece processing section and the workpiece discharging section respectively,
wherein the primary workpiece processing section includes first forming dies for obtaining a primary formed member by subjecting the workpiece to primary forming, and
wherein the secondary workpiece processing section includes second forming dies for obtaining a sec-

ondary formed member by subjecting the primary formed member to secondary forming.

16. A workpiece transferring method in which a workpiece disposed at a workpiece introducing section is sandwiched and held from both sides of the workpiece by and between a pair of claws provided to a pair of feed bars arranged on both sides of a transferring line by closing the feed bars, and transferred to a workpiece processing section by moving the feed bars forward with the workpiece held and then opening the feed bars,
wherein an engaging portion is formed on the workpiece and an engaging portion receiving portion is formed on one of the claws, and
wherein the workpiece is positioned by engaging the engaging portion with the engaging portion receiving portion at the time of sandwiching and holding the workpiece by and between the claws.

17. A workpiece transferring device in which a workpiece disposed at a workpiece introducing section is sandwiched and held from both sides of the workpiece by and between a pair of claws provided to a pair of feed bars arranged on both sides of a transferring line by closing the feed bars, and transferred to a workpiece processing section by moving the feed bars forward with the workpiece held and then opening the feed bars,
wherein the workpiece is provided with an engaging portion and one of the claws is provided with an engaging portion receiving portion, and
wherein the workpiece is positioned by engaging the engaging portion with the engaging portion receiving portion at the time of sandwiching and holding the workpiece with the claws.

Fig.1

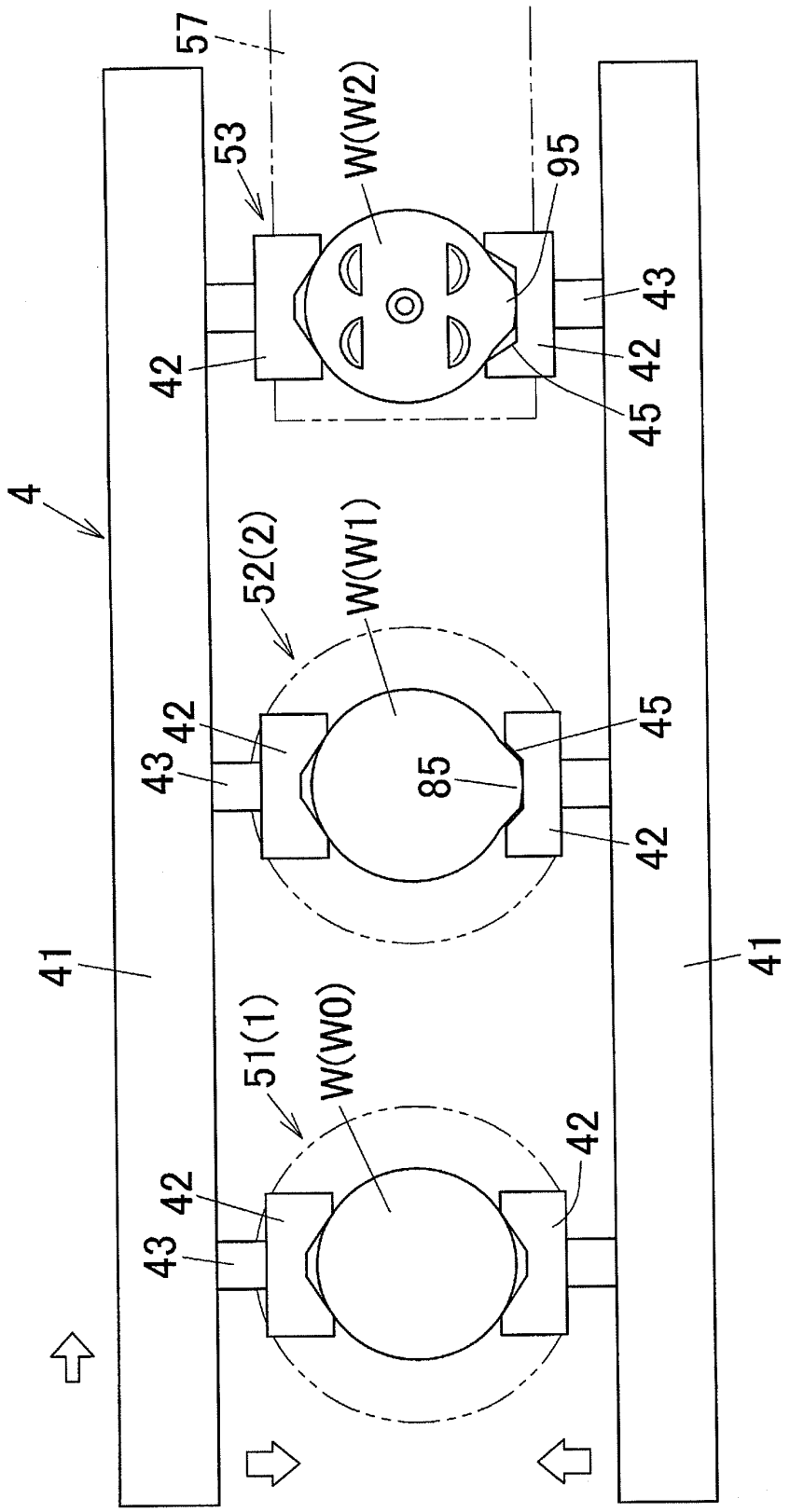

57
53
W(W2)
95
43
42
42
45
4
52(2)
W(W1)
42
45
43
85
42
41
41
51(1)
W(W0)
42
42
43

Fig. 2

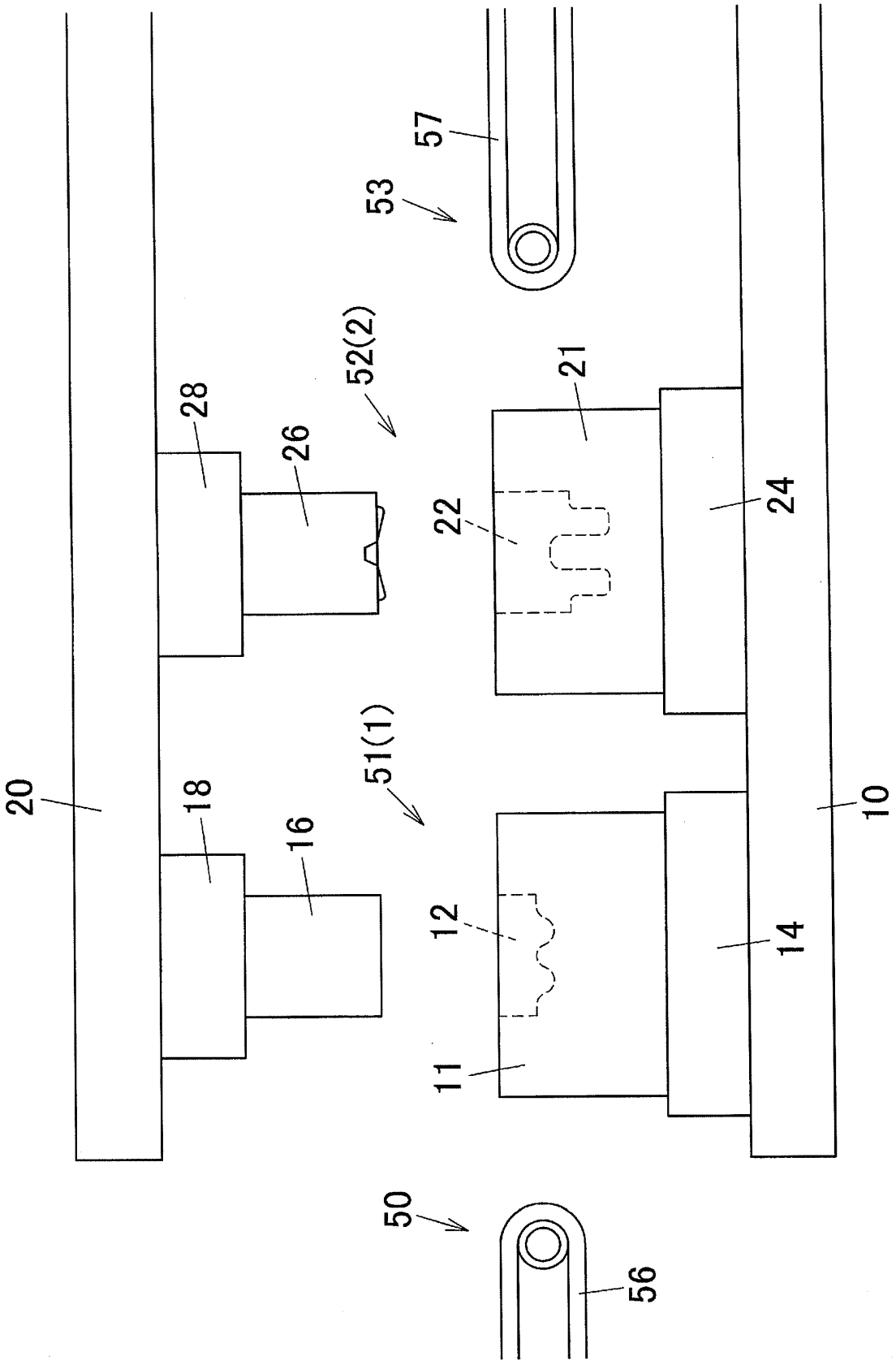


Fig.3

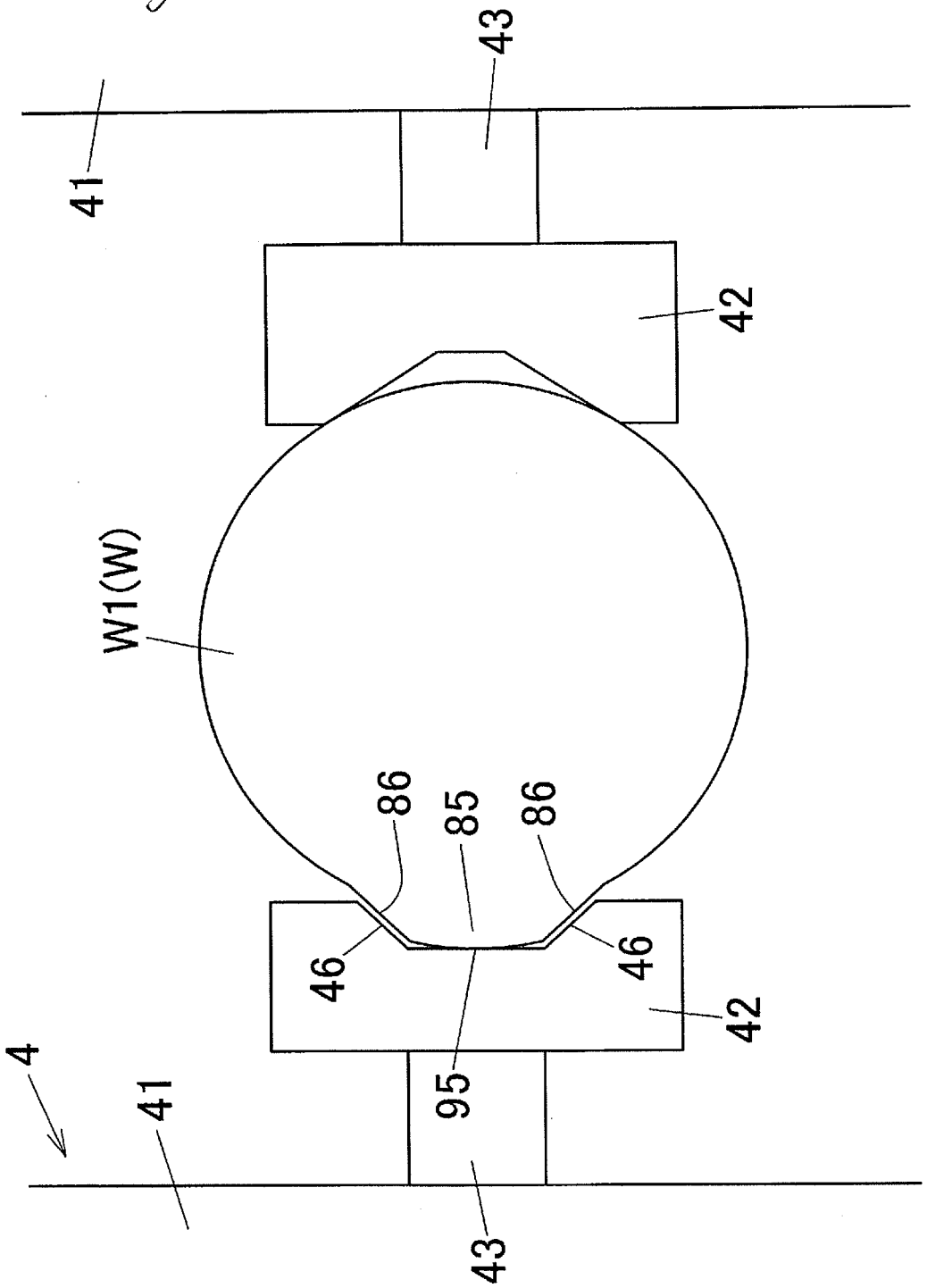


Fig. 4

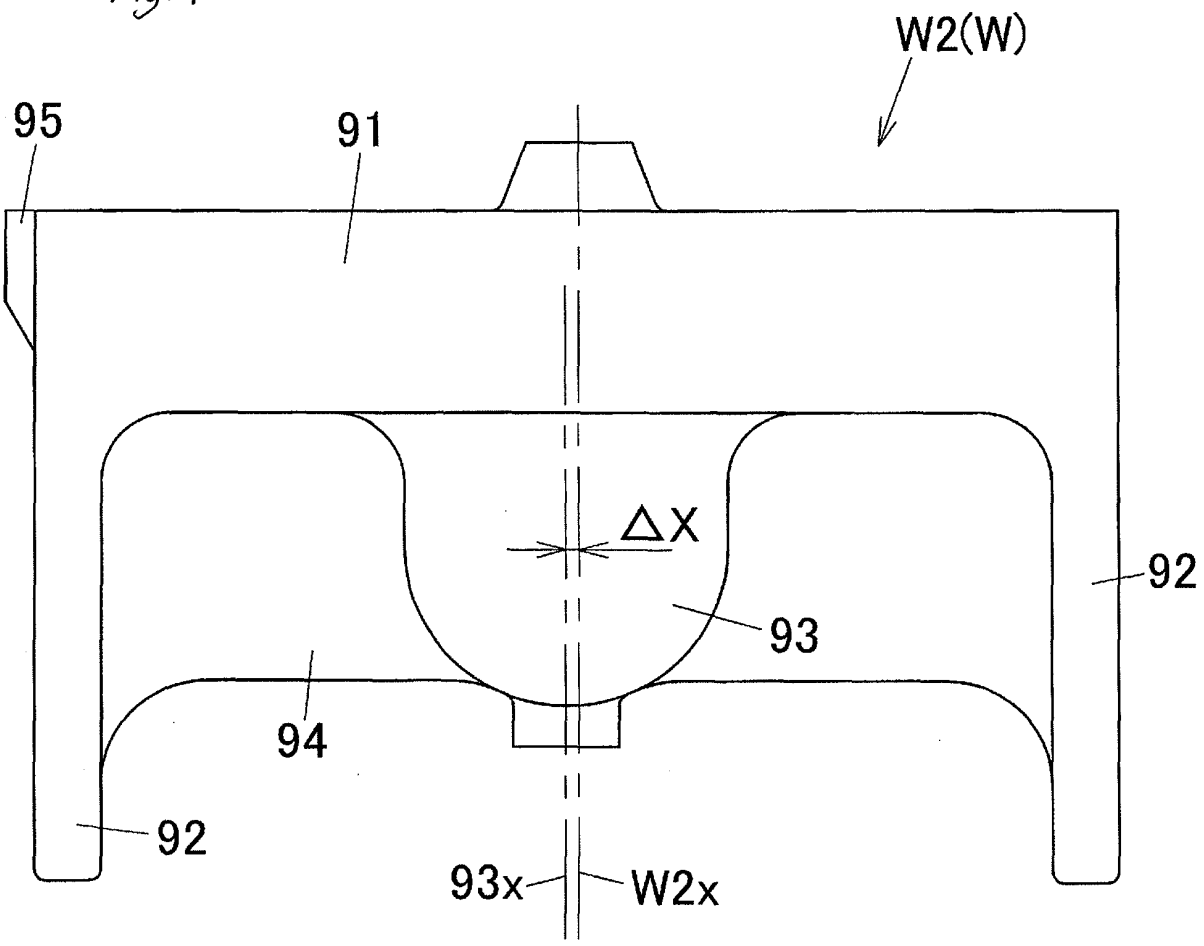


Fig. 5

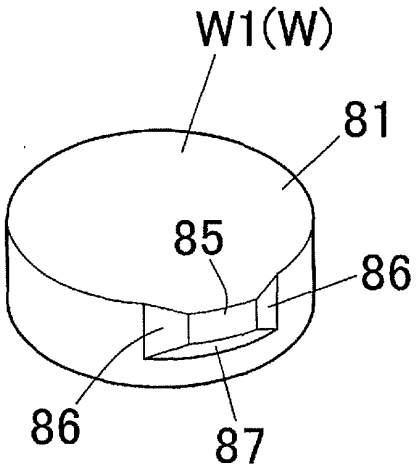


Fig. 6A

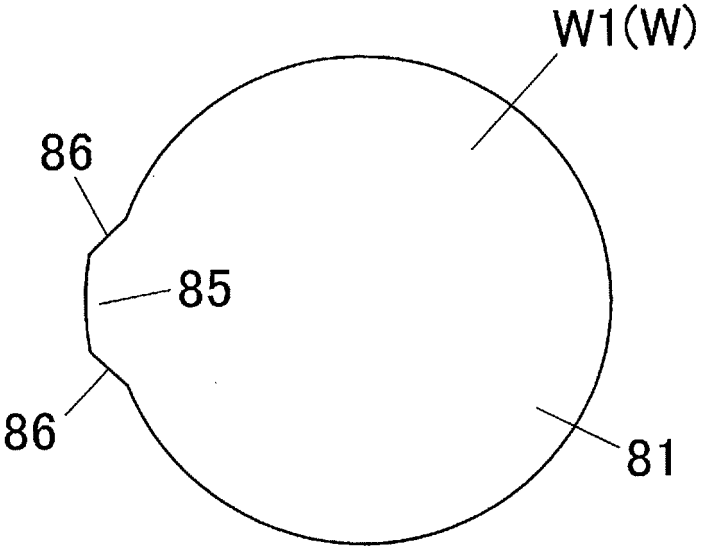


Fig. 6B

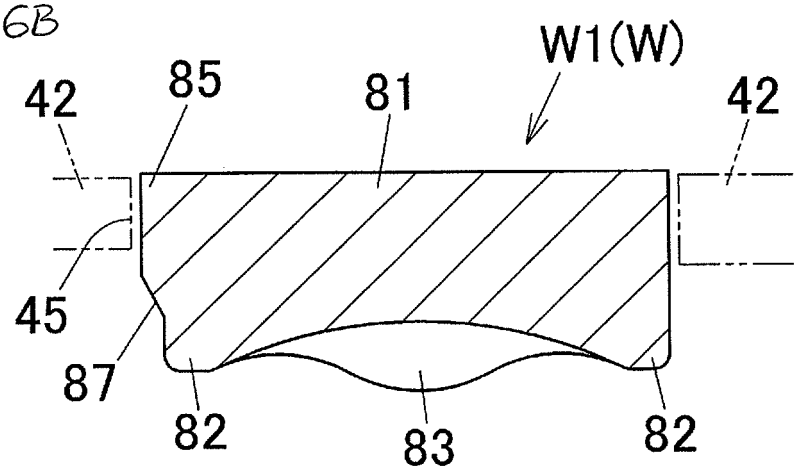


Fig. 6C

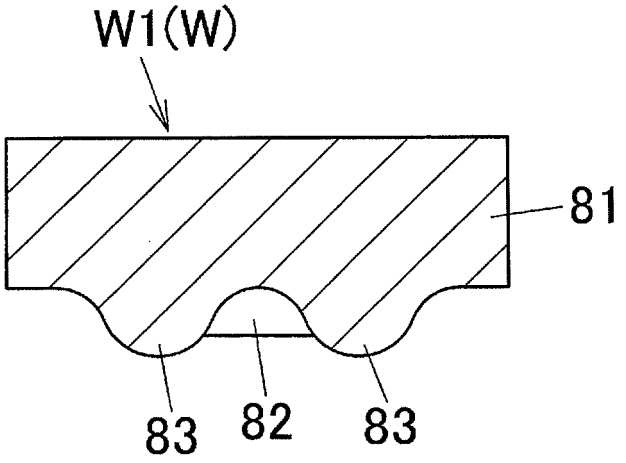


Fig. 7

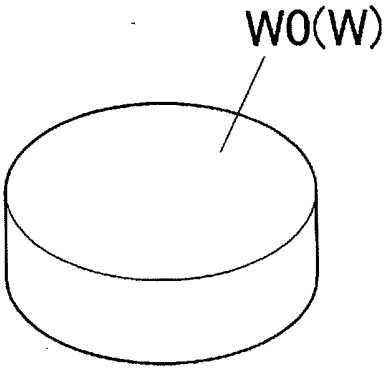


Fig. 8

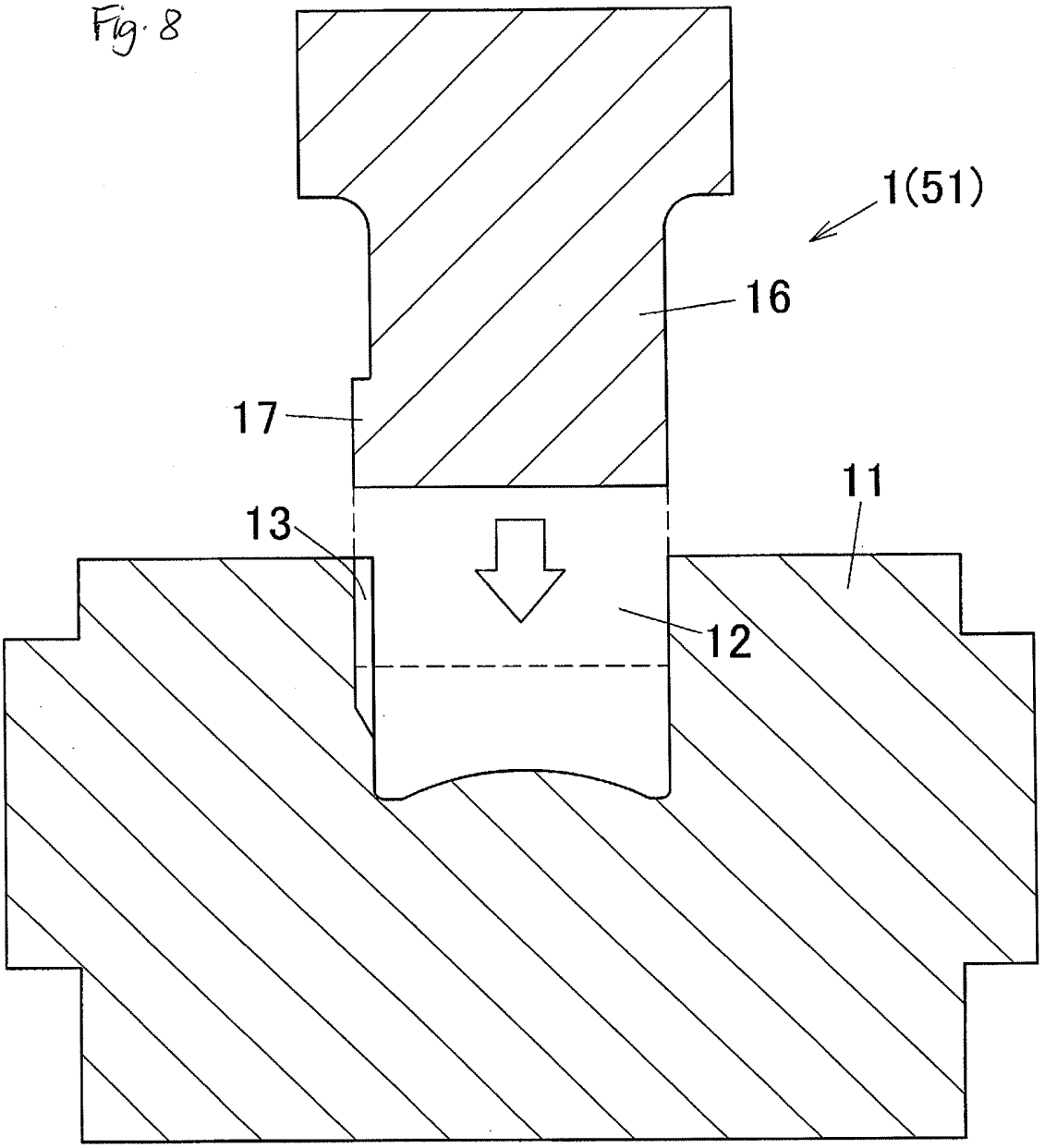


Fig. 9

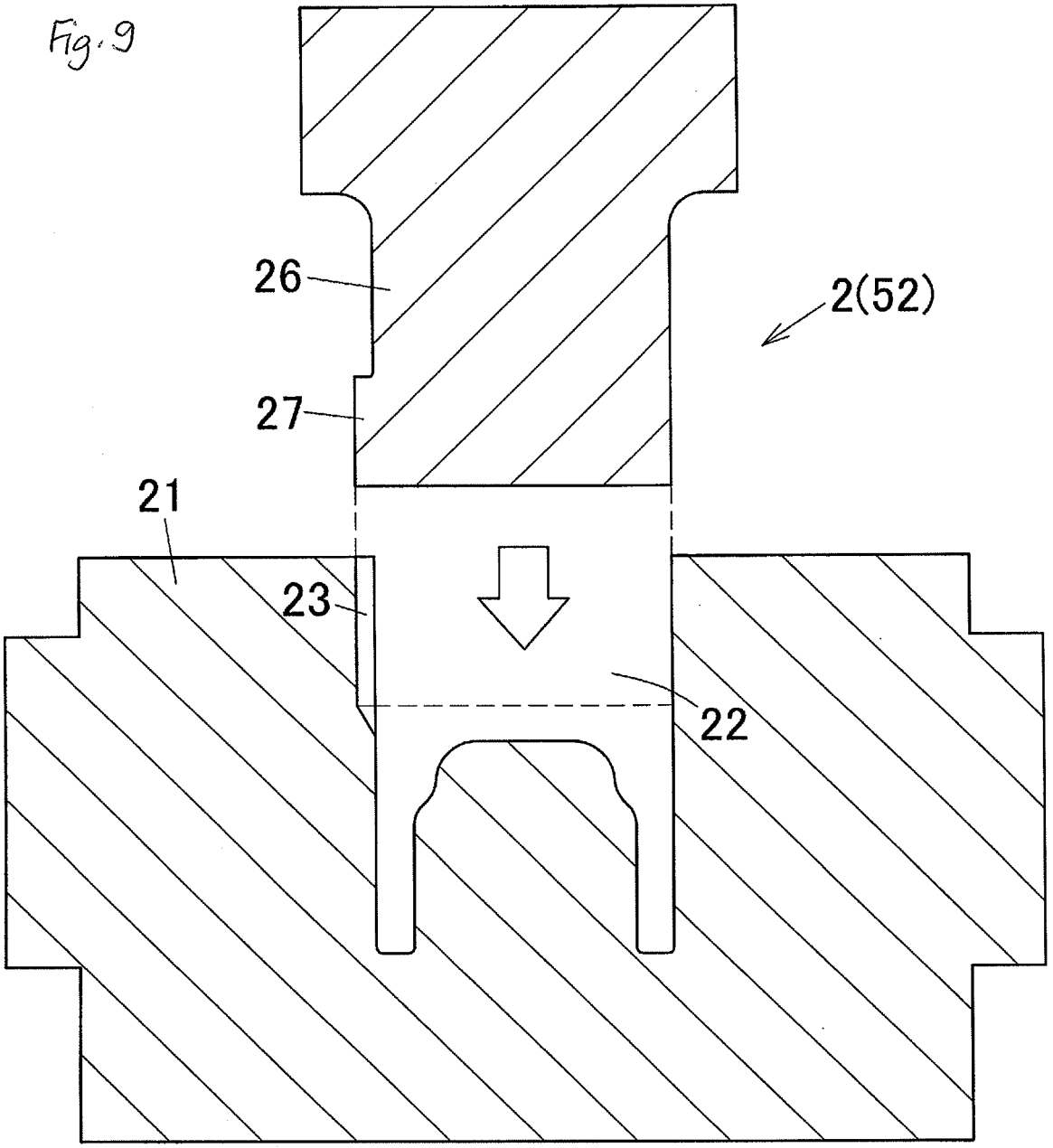


Fig. 10A

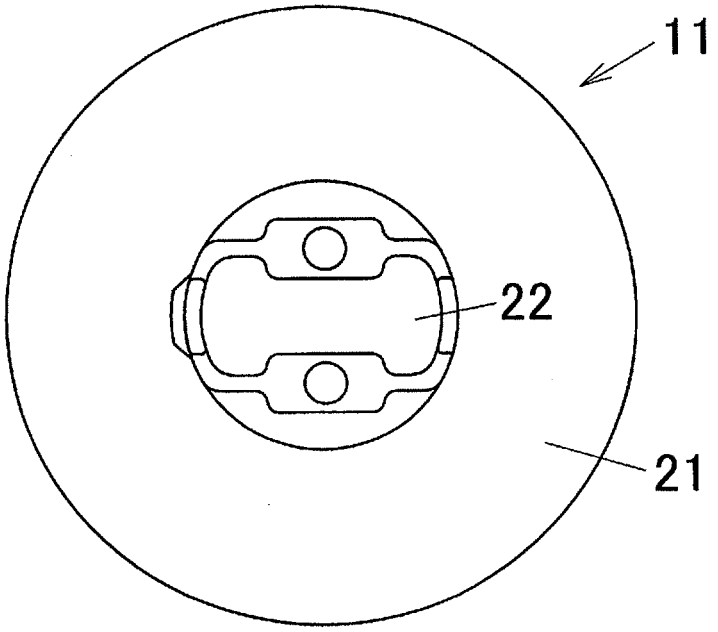


Fig. 10B

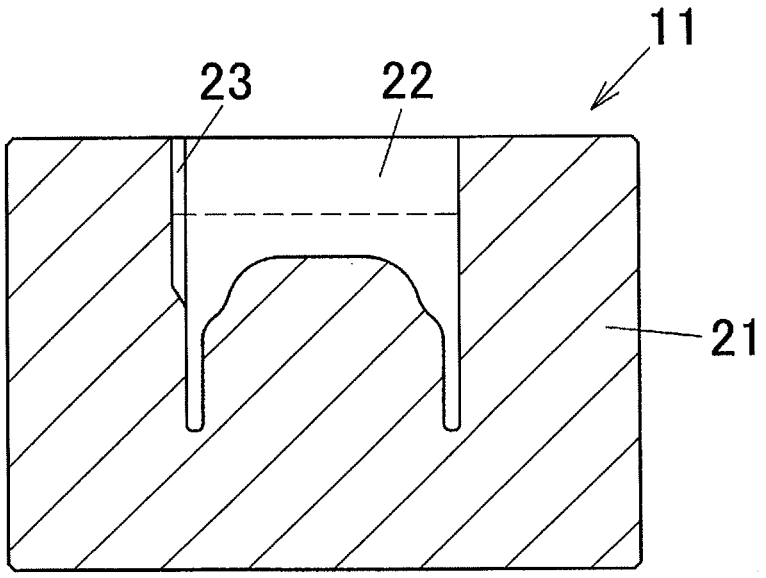


Fig. 10C

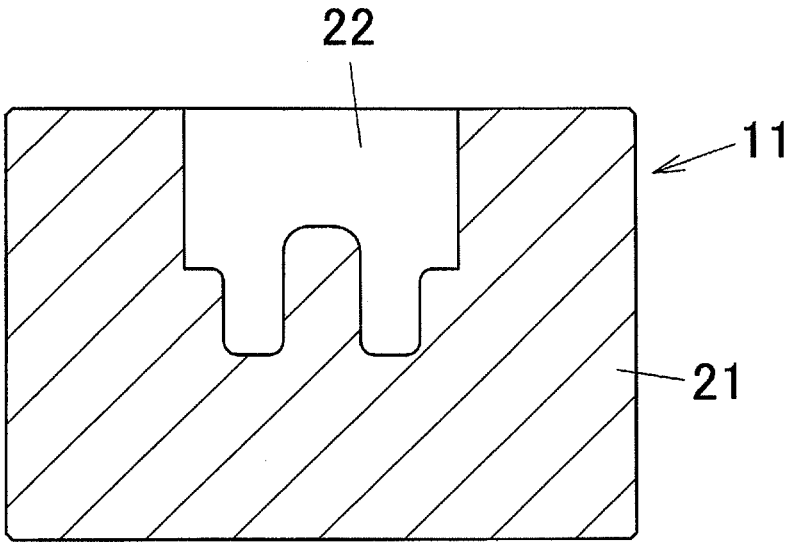


Fig. 11

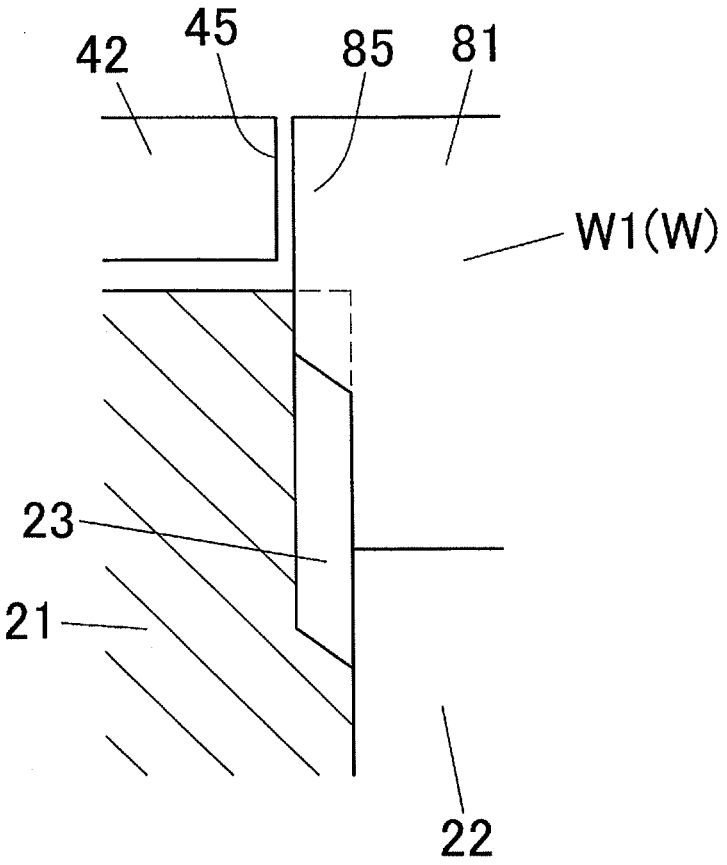


Fig. 12A

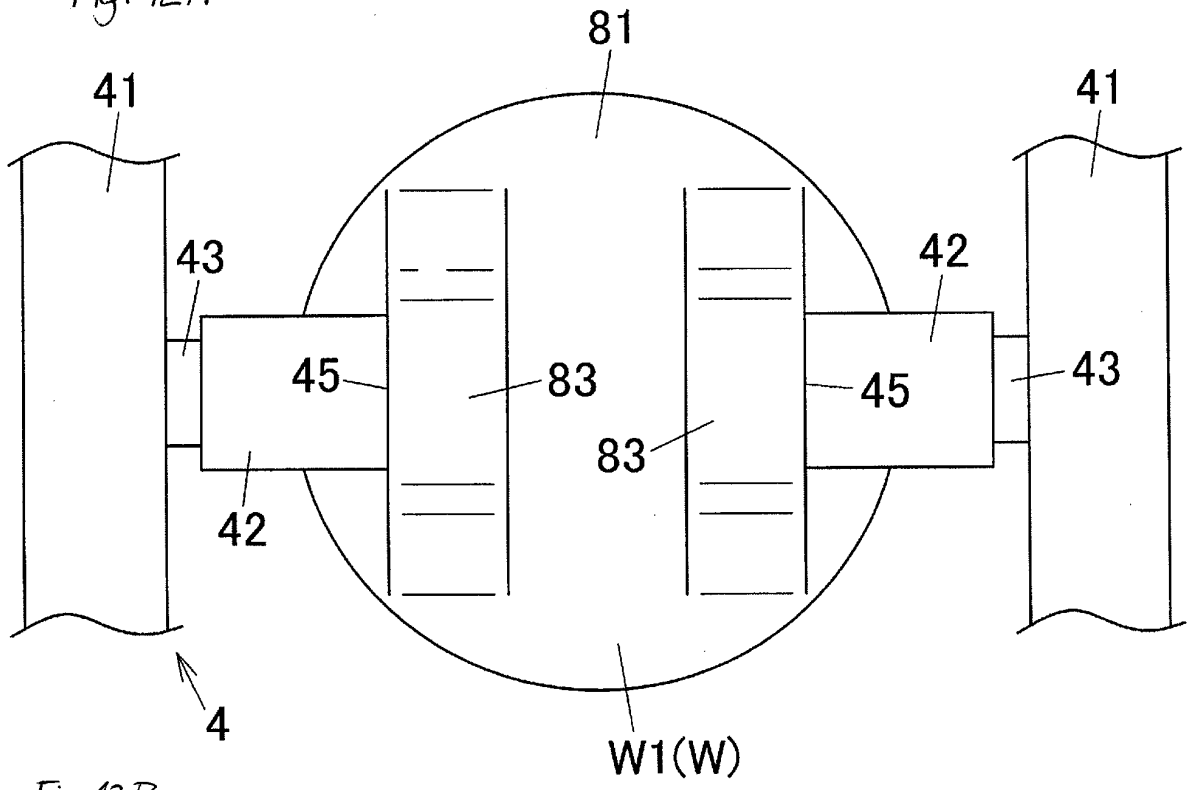


Fig. 12B

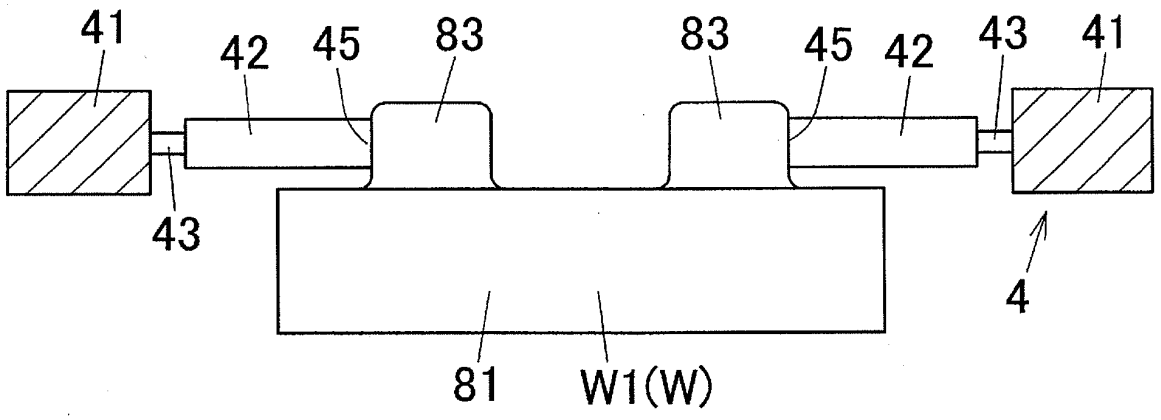


Fig. 13

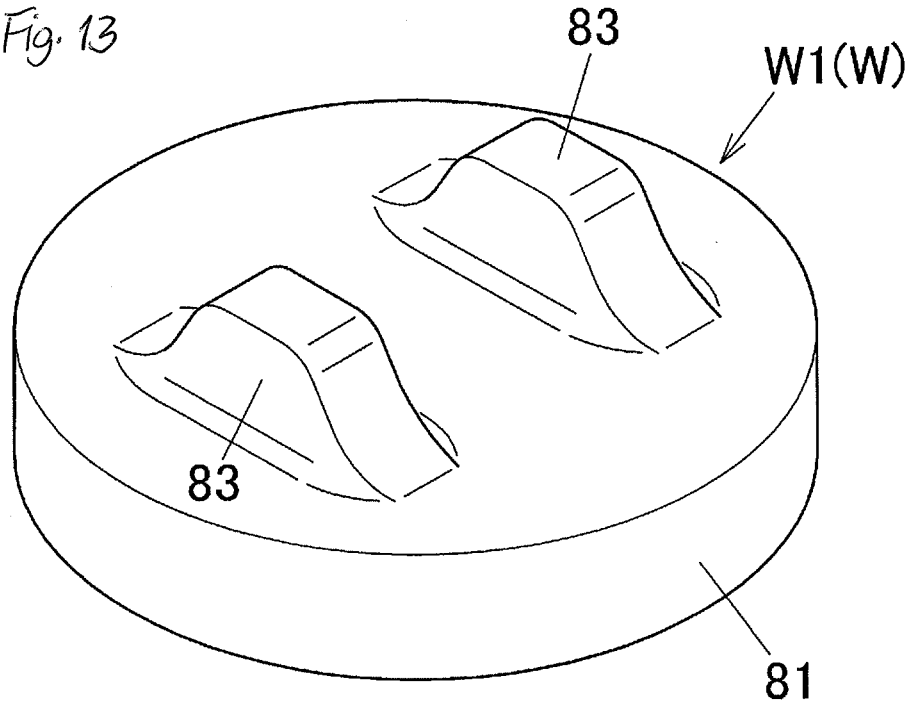


Fig. 14A

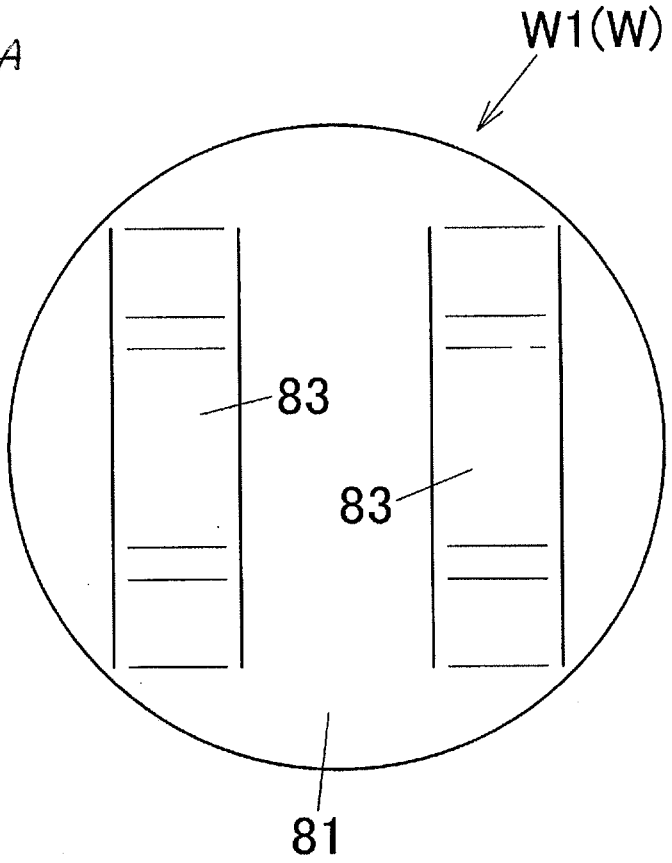


Fig. 14B

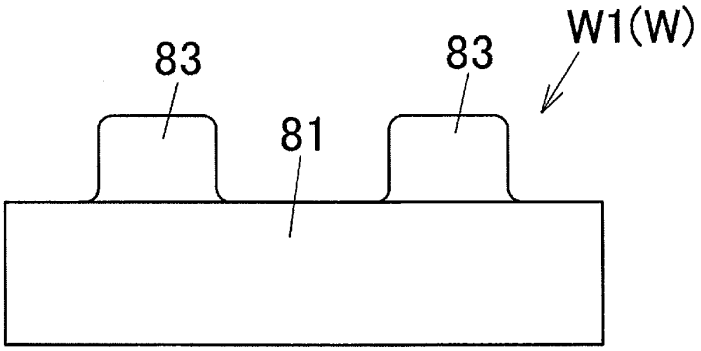


Fig. 14C

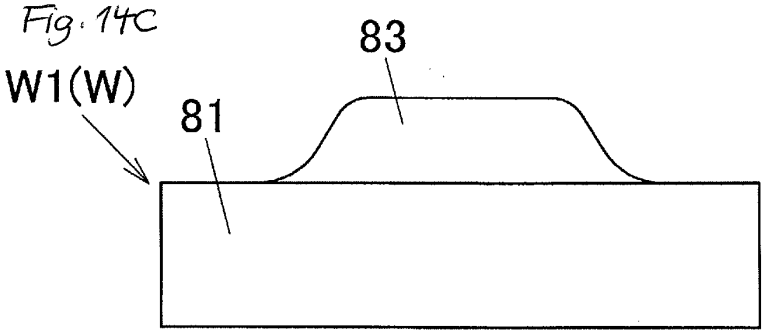


Fig. 15

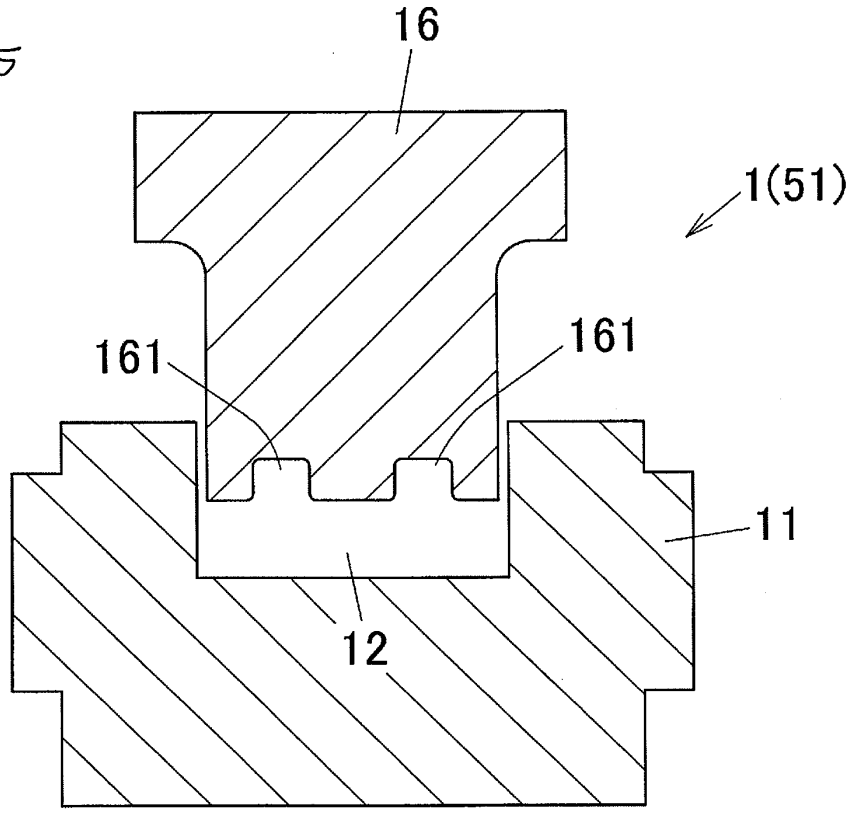
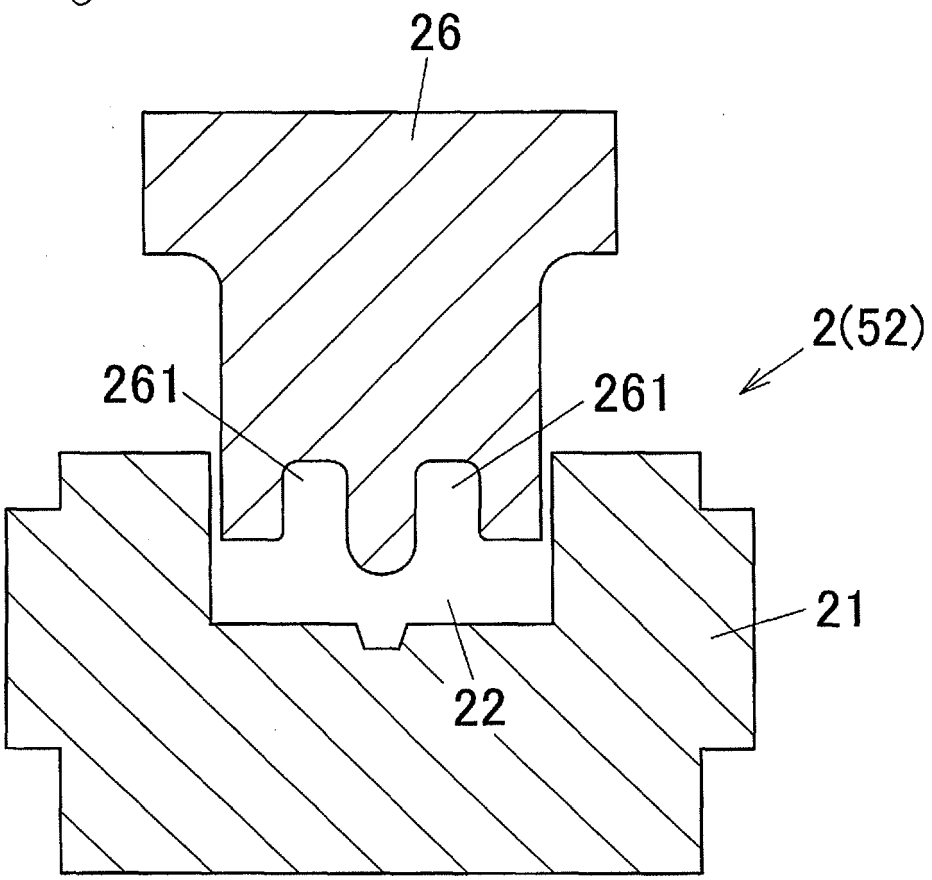


Fig. 16



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2009/070214

A. CLASSIFICATION OF SUBJECT MATTER
B21K27/00(2006.01)i, *B21J5/00*(2006.01)i, *B30B13/00*(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)
B21K27/00, B21J5/00, B30B13/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2010
Kokai Jitsuyo Shinan Koho 1971-2010 Toroku Jitsuyo Shinan Koho 1994-2010

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 51-736 B1 (Aida Engineering, Ltd.), 10 January 1976 (10.01.1976), entire text (Family: none)	1-6,9,10, 12-17 7,8,11
Y A	JP 2002-336929 A (Nissan Motor Co., Ltd.), 26 November 2002 (26.11.2002), entire text (Family: none)	1-6,10,12-17 7-9,11
Y A	JP 5-349 A (Nissan Motor Co., Ltd.), 08 January 1993 (08.01.1993), paragraph [0011]; fig. 1, 6 (Family: none)	1-6,9,10, 12-17 7,8,11

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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 January, 2010 (20.01.10)	02 February, 2010 (02.02.10)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2009/070214

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 63-130238 A (Honda Motor Co., Ltd.), 02 June 1988 (02.06.1988), entire text (Family: none)	10,13 1-9,11,12, 14-17
A	JP 2004-27922 A (Showa Denko Kabushiki Kaisha), 29 January 2004 (29.01.2004), entire text (Family: none)	1-17

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Patent documents cited in the description

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- JP 63281737 B **[0005]**
- JP 2007130680 A **[0005]**
- JP 2008308399 A **[0148]**