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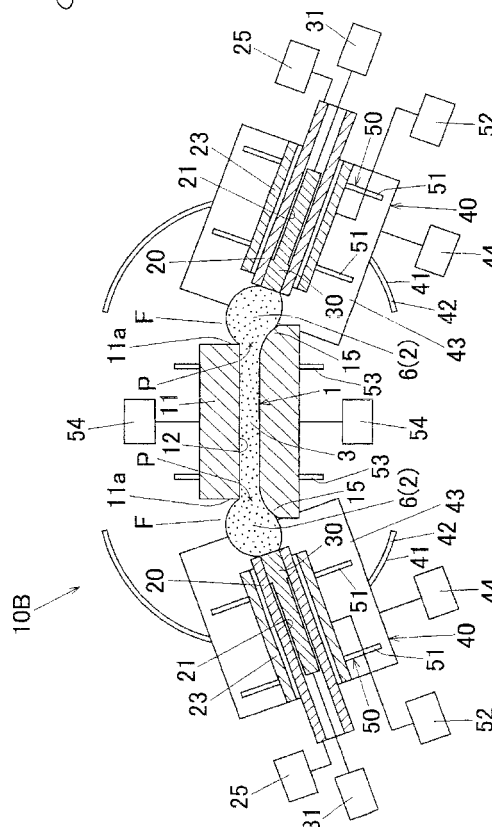
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(54) **UPSETTING METHOD AND UPSETTING DEVICE**

(57) An upsetting method capable of manufacturing an upsetting manufactured product having a bent expanded portion under a lighter load is provided. A bar-shaped raw material 1 is loaded to the receiving die 11 in an axial movement prevented state, and the expansion scheduled portion 2 of the raw material 1 is arranged in the insertion hole 21 for holding the expansion scheduled portion 2 of the raw material 1 in a buckling prevented state. Subsequently, the guide 20 is moved in a direction opposite to a moving direction of the punch 30 while pressurizing the expansion scheduled portion 2 of the raw material 1 with the punch 30 in an axial direction, to thereby radially outwardly expand the expansion scheduled portion 2 of the raw material 1 exposed between a tip end portion of the guide 20 and the receiving die 11. In this upsetting method, the expansion scheduled portion 2 is bent while expanding the expansion scheduled portion 2 of the raw material 1.

Fig. 6



Description

TECHNICAL FIELD

[0001] The present invention relates to an upsetting method and an upsetting apparatus used in manufacturing a product having a radially outwardly expanded portion, such as, e.g., an arm or a piston for vehicles (e.g., cars, railroad vehicles, etc.).

BACKGROUND ART

[0002] In general, in upsetting a bar-shaped raw material, if the material buckles during the upsetting, the obtained upsetting manufactured product becomes poor in shape, which causes degradation in value as a product. Therefore, in order to prevent the occurrence of such buckling, the following upsetting method has been conventionally proposed.

[0003] That is, in this method, a bar-shaped raw material is loaded to a receiving die in an axial movement prevented state, and the expansion scheduled portion (i.e., processing scheduled portion) of the raw material is inserted in the insertion hole formed in a guide and held therein in a buckling prevented state.

Subsequently, the guide is moved in a direction opposite to a punch moving direction while pressurizing the expansion scheduled portion of the raw material in the axial direction with a punch, to thereby radially outwardly expand the expansion scheduled portion of the raw material exposed between the tip end portion of the guide and the receiving die (see, e.g., Patent Documents 1 to 4).

[0004] According to this upsetting method, there is an advantage that buckling of the raw material can be prevented as mentioned above and further the expansion scheduled portion of the raw material can be expanded under a lighter load.

[0005] The upsetting manufactured product obtained by this upsetting method can be used as a preform for manufacturing a product, such as, e.g., an arm for vehicles.

Patent Document 1 Japanese Unexamined Laid-open Patent Publication No. H09-253782

Patent Document 2 Japanese translation of PCT international application No. H07-506768

Patent Document 3 Japanese Unexamined Laid-open Patent Publication No. 2005-59097

Patent Document 4 Japanese Unexamined Laid-open Patent Publication No. 2005-144554

DISCLOSURE OF THE INVENTION

PROBLEMS TO BE SOLVED

[0006] In the case of manufacturing a product having an expanded portion bent in shape among various types of products, it is preferable to use a preform preliminary formed into such a shape to improve the material yield

rate and reduce the number of manufacturing steps.

[0007] In the conventional upsetting method mentioned above, however, it was difficult to form a preform having an expanded portion bent with respect to the axis. On the other hand, after forming an expanded portion, to perform bending work of the expanded portion had a drawback that a heavy load was required to bend the expanded portion. Furthermore, there are such drawbacks that bending of an expanded portion results in bending of a neck portion between the expanded portion and the shank portion without causing the scheduled bending of the expanded portion, or results in poor surface quality due to wrinkles formed on a bending inner side surface of the expanded portion. Thus, it was very difficult to perform bending work of an expanded portion after forming it.

[0008] The preferred embodiments of the present invention have been developed in view of the above-mentioned and/or other problems in the related art. The preferred embodiments of the present invention can significantly improve upon existing methods and/or apparatuses.

[0009] The present invention was made in view of the aforementioned technical background, and aims to provide an upsetting method capable of manufacturing an upsetting manufactured product having an expanded portion bent in shape under as a lighter load as possible, an upsetting manufactured product obtained by the method, and an upsetting apparatus for use in the method.

[0010] Other objects and advantages of the present invention will be apparent from the following preferred embodiments.

MEANS TO SOLVE THE PROBLEMS

[0011] The present invention provides the following means. It should be noted that in this specification a bending direction of an expansion scheduled portion of a raw material denotes a width direction of the expansion scheduled portion of the raw material. That is, the expansion scheduled portion of the raw material is to be bent in the width direction.

[0012] [1] An upsetting method, comprising the steps of:

attaching a bar-shaped raw material to a receiving die in an axial movement prevented state, and arranging an expansion scheduled portion of the raw material in an insertion hole formed in a guide for holding the expansion scheduled portion of the raw material in a buckling prevented state; and then radially outwardly expanding the expansion scheduled portion of the raw material exposed between a tip end portion of the guide and the receiving die by moving the guide in a direction opposite to a moving direction of a punch while pressurizing the expansion scheduled portion of the raw material with the punch in an axial direction,

wherein the expansion scheduled portion is bent while expanding the expansion scheduled portion of the raw material.

[0013] [2] The upsetting method as recited in Item 1, wherein the expansion scheduled portion is bent in a state in which the expansion scheduled portion is supported by a supporting portion arranged at an expansion scheduled portion bending side with respect to the expansion scheduled portion of the raw material in a buckling prevented state.

[0014] [3] The upsetting method as recited in Item 1 or 2, wherein the expansion scheduled portion of the raw material is bent by pivotally moving at least one of the guide and the receiving die about a pivotal axis perpendicular to a plane including an axis of the raw material.

[0015] [4] An upsetting manufactured product obtained by the upsetting method as recited in any one of Items 1 to 3.

[0016] [5] An upsetting method, comprising the steps of:

attaching an axial intermediate portion of a bar-shaped raw material to a receiving die in an axial movement prevented state, and arranging expansion scheduled portions of axial both end portions of the raw material in an insertion hole for holding the expansion scheduled portion of the raw material formed in a guide in a buckling prevented state, respectively; and then

simultaneously expanding both the expansion scheduled portions of the raw material exposed between a tip end portion of each guide and the receiving die radially outwardly, respectively, by moving each guide in a direction opposite to a moving direction of a corresponding punch while simultaneously pressurizing both the expansion scheduled portions of the raw material with the punch in an axial direction, respectively,

wherein at least one of both the expansion scheduled portions of the raw material is bent while simultaneously expanding both the expansion scheduled portions of the raw material, respectively.

[0017] [6] The upsetting method as recited in Item 5, wherein the expansion scheduled portion is bent in a state in which the expansion scheduled portion is supported by a supporting portion arranged at an expansion scheduled portion bending side with respect to the expansion scheduled portion of the raw material in a buckling prevented state.

[0018] [7] The upsetting method as recited in Item 5 or 6, wherein the expansion scheduled portion of the raw material is bent by pivotally moving the guide about a pivotal axis perpendicular to a plane including a raw material axis.

[0019] [8] An upsetting manufactured product obtained by the upsetting method as recited in any one of Items 5 to 7.

[0020] [9] An upsetting apparatus, comprising:

a receiving die to which a bar-shaped raw material is attached in an axial movement prevented state;
a guide having an insertion hole for holding an expansion scheduled portion of the raw material in a buckling prevented state;
a punch for pressurizing the expansion scheduled portion of the raw material arranged in the insertion hole of the guide in an axial direction; and
a guide driving device for moving the guide in a direction opposite to a moving direction of the punch,

wherein the upsetting apparatus is configured to radially outwardly expand the expansion scheduled portion of the raw material exposed between a tip end portion of the guide and the receiving die, and wherein a bending device for bending the expansion scheduled portion of the raw material is provided.

[0021] [10] The upsetting apparatus as recited in Item 9, wherein the upsetting apparatus is configured to bend the expansion scheduled portion of the raw material by the bending device while expanding the expansion scheduled portion of the raw material.

[0022] [11] The upsetting apparatus as recited in Item 9 or 10, further comprising a supporting portion arranged at a bending side of the expansion scheduled portion of the raw material with respect to the expansion scheduled portion to support the expansion scheduled portion in a buckling prevented state.

[0023] [12] The upsetting apparatus as recited in any one of Items 9 to 11, wherein the bending device is configured to bend the expansion scheduled portion of the raw material by pivotally moving at least one of the guide and the receiving die about a pivotal axis perpendicular to a plane including a raw material axis.

[0024] [13] The upsetting apparatus as recited in Item 12, further comprising a change mechanism for changing a position of the pivotal axis.

[0025] [14] An upsetting apparatus, comprising:

a receiving die to which a bar-shaped raw material is attached in an axial movement prevented state;
two guides each having an insertion hole for holding each of axial both end expansion scheduled portions of the raw material in a buckling prevented state;
two punches each for pressurizing each expansion scheduled portion of the raw material arranged in the insertion hole of each guide in an axial direction; and
two guide driving devices each for moving each guide in a direction opposite to a moving direction of the corresponding punch,

wherein the upsetting apparatus is configured to radially outwardly expand both the expansion scheduled portions of the raw material each exposed between a tip end portion of the guide and the receiving die, and

wherein a bending device for bending at least one of the expansion scheduled portions of the raw material is provided.

[0026] [15] The upsetting apparatus as recited in Item 14, wherein the upsetting apparatus is configured to bend the expansion scheduled portion of the raw material by the bending device while expanding the expansion scheduled portion of the raw material.

[0027] [16] The upsetting apparatus as recited in Items 14 or 15, further comprising a supporting portion arranged at a bending side of the expansion scheduled portion of the raw material with respect to the expansion scheduled portion to support the expansion scheduled portion in a buckling prevented state.

[0028] [17] The upsetting apparatus as recited in any one of Items 14 to 16, wherein the bending device is configured to bend the expansion scheduled portion of the raw material by pivotally moving the guide about a pivotal axis perpendicular to a plane including a raw material axis.

[0029] [18] The upsetting apparatus as recited in Item 17, further comprising a changing mechanism for changing a position of the pivotal axis.

[0030] [19] An upsetting method, comprising:

a step of preparing an upsetting apparatus equipped with a receiving die having a receiving face and a holding hole for holding a non-expansion scheduled portion of a bar-shaped raw material in a buckling prevented state formed at the receiving face, a guide having an insertion hole for holding an expansion scheduled portion of the raw material in a buckling prevented state, and a punch, wherein an expansion preventing protruded portion integrally protruded at a tip end portion of the guide in an axial direction of the guide;

a step of arranging the expansion scheduled portion of the raw material in the insertion hole of the guide with the non-expansion scheduled portion held in the holding hole of the receiving die;

a step of radially outwardly expanding the expansion scheduled portion of the raw material exposed between a tip end portion of the guide and the receiving face of the receiving die in a state in which an expansion of a contacting portion of at least one of thickness side surfaces of the expansion scheduled portions in contact with the guide protruded portion is controlled by moving the guide in a direction opposite to a moving direction of the punch while pressurizing the expansion scheduled portion of the raw material with the punch in an axial direction after the step of arranging the expansion scheduled portion of the raw material; and

a step of bending the expansion scheduled portion of the raw material in its width direction while expanding the expansion scheduled portion of the raw material expand at the expansion step.

[0031] [20] The upsetting method as recited in Item 19, wherein an expansion preventing side wall portion is provided at the receiving face of the receiving die in a protruded manner, and wherein at the expansion step, the expansion scheduled portion of the raw material is expanded radially outwardly in a state in which an expansion of a contacting portion of at least one of thickness side surfaces of the expansion scheduled portion in contact with the guide protruded portion is controlled and also in a state in which a contacting portion of at least one of thickness side surfaces of the expansion scheduled portion in contact with the receiving die side wall portion is controlled.

[0032] [21] The upsetting method as recited in Item 20, wherein the receiving die side wall portion is protruded from the receiving face of the receiving die at each of thickness side surfaces of the expansion scheduled portion of the raw material.

[0033] [22] The upsetting method as recited in any one of Items 19 to 21, wherein the protruded portion of the guide is integrally provided at each of portions of a tip end portion of the guide opposed across the insertion hole.

[0034] [23] The upsetting method as recited in any one of Items 19 to 22, wherein the receiving face of the receiving die is formed into a forming face for forming at least a portion of at least one side surface among widthwise side surfaces of the expansion scheduled portion of the raw material.

[0035] [24] The upsetting method as recited in any one of Items 19 to 23, wherein at the bending step, the expansion scheduled portion of the raw material is bent in its widthwise direction by pivotally moving at least one of the guide and the receiving die about a pivotal axis parallel to a thickness direction of the expansion scheduled portion of the raw material.

[0036] [25] The upsetting method as recited in Item 24, wherein the tip end portion of the protruded portion of the guide is formed into an circular-arc-shape forwardly protruded along the widthwise direction of the expansion scheduled portion of the raw material.

[0037] [26] The upsetting method as recited in any one of Items 19 to 25, wherein at the bending step, the expansion scheduled portion of the raw material is bent in its widthwise direction in a state in which the expansion scheduled portion is supported by a supporting portion arranged at an expansion scheduled portion bending side with respect to the expansion scheduled portion of the raw material in a buckling prevented state.

[0038] [27] An upsetting manufactured product obtained by the upsetting method as recited in any one of Items 19 to 26.

[0039] [28] An upsetting method

a step of preparing an upsetting apparatus equipped with a receiving die having receiving faces at both axial end portions and a holding hole for holding a non-expansion scheduled portion of an axial central portion of a bar-shaped raw material in a buckling prevented state formed

so as to communicate both the receiving faces, two guides each having an insertion hole for holding an expansion scheduled portion of the raw material in a buckling prevented state, and two punches, wherein an expansion preventing protruded portion is protruded from a tip end portion of at least one of the guides in an axial direction thereof;

a step of arranging both the expansion scheduled portions of the raw material in a respective insertion hole of the guide with the non-expansion scheduled portion held in the holding hole of the receiving die;

a step of radially outwardly expanding the expansion scheduled portion of the raw material exposed between a tip end portion of each guide and the receiving face of the receiving die in a state in which an expansion of a contacting portion of at least one of thickness side surfaces of the expansion scheduled portions in contact with the guide protruded portion is controlled by moving each guide in a direction opposite to a moving direction of the corresponding punch while pressurizing both the expansion scheduled portions of the raw material with the punches in an axial direction after the step of arranging the expansion scheduled portion of the raw material; and a step of bending at least one of the expansion scheduled portions in its width direction while expanding both the expansion scheduled portions of the raw material in the expansion step.

[0040] [29] The upsetting method as recited in Item 28, wherein an expansion preventing side wall portion is provided at at least one of the receiving faces of the receiving die in a protruded manner, and

wherein at the expansion step, both the expansion scheduled portions of the raw material are simultaneously expanded radially outwardly in a state in which an expansion of a contacting portion of at least one of thickness side surfaces of the expansion scheduled portion in contact with the guide protruded portion is controlled and also in a state in which a contacting portion of at least one of thickness side surfaces of the expansion scheduled portion in contact with the receiving die side wall portion is controlled.

[0041] [30] The upsetting method as recited in Item 29, wherein the receiving die side wall portion is protruded from the receiving face of the receiving die at each of thickness side surfaces of the expansion scheduled portion of the raw material.

[0042] [31] The upsetting method as recited in any one of Items 28 to 30, wherein the protruded portion of the guide is integrally provided at each of portions of a tip end portion of the guide opposed across the insertion hole.

[0043] [32] The upsetting method as recited in any one of Items 28 to 31, wherein at least one of the receiving faces of the receiving die is formed into a forming face for forming at least a portion of at least one side surface among widthwise side surfaces of the expansion scheduled portion of the raw material.

[0044] [33] The upsetting method as recited in any one

of Items 28 to 32, wherein at the bending step, the expansion scheduled portion of the raw material is bent in its widthwise direction by pivotally moving the guide about a pivotal axis parallel to a thickness direction of the expansion scheduled portion of the raw material.

[0045] [34] The upsetting method as recited in Item 33, wherein the tip end portion of the protruded portion of the guide is formed into an circular-arc-shape forwardly protruded along the widthwise direction of the expansion scheduled portion of the raw material.

[0046] [35] The upsetting method as recited in any one of Items 28 to 34, wherein at the bending step, the expansion scheduled portion of the raw material is bent in its widthwise direction in a state in which the expansion scheduled portion is supported by a supporting portion arranged at an expansion scheduled portion bending side with respect to the expansion scheduled portion of the raw material in a buckling prevented state.

[0047] [36] An upsetting manufactured product obtained by the upsetting method as recited in any one of Items 28 to 35.

[0048] [37] An upsetting apparatus, comprising:

a receiving die having a receiving face and a holding hole for holding a non-expansion scheduled portion of a bar-shaped raw material in a buckling prevented state formed at the receiving face;

a guide having an insertion hole for holding an expansion scheduled portion of the raw material in a buckling prevented state;

a punch for pressurizing the expansion scheduled portion of the raw material arranged in the insertion hole of the guide in an axial direction; and

a guide driving device for moving the guide in a direction opposite to a moving direction of the punch,

wherein the upsetting apparatus is configured to radially outwardly expand the expansion scheduled portion of the raw material exposed between a tip end portion of the guide and the receiving face of the receiving die, wherein an expansion preventing protruded portion protruded in an axial direction of the guide is integrally provided at the tip end portion of the guide,

wherein the protruded portion of the guide is configured to control an expansion of a contacting portion of the expansion scheduled portion by a contact with at least one of thickness side surfaces of the expansion scheduled portion at the time of expanding the expansion scheduled portion of the raw material, and

wherein the upsetting apparatus further comprises a bending device for bending the expansion scheduled portion of the raw material in its width direction.

[0049] [38] The upsetting apparatus as recited in Item 37, wherein the bending device is configured to bend the expansion scheduled portion of the raw material in its width direction at the time of expanding the expansion scheduled portion of the raw material.

[0050] [39] The upsetting apparatus as recited in Item

37 or 38, wherein an expansion preventing side wall portion is provided at the receiving face of the receiving die in a protruded manner, and wherein the side wall portion of the receiving die controls expansion of a contacting portion of the expansion scheduled portion by a contact with at least one side surfaces among thickness side surfaces of the expansion scheduled portion at the time of expanding the expansion scheduled portion of the raw material.

[0051] [40] The upsetting apparatus as recited in Item 39, wherein the receiving die side wall portion is protruded from the receiving face of the receiving die at each of thickness side surfaces of the expansion scheduled portion of the raw material.

[0052] [41] The upsetting apparatus as recited in any one of Items 37 to 40, wherein the protruded portion of the guide is integrally provided at each of portions of a tip end portion of the guide opposed across the insertion hole.

[0053] [42] The upsetting apparatus as recited in any one of Items 37 to 41, wherein the receiving face of the receiving die is formed into a forming face for forming at least a portion of at least one side surface among widthwise side surfaces of the expansion scheduled portion of the raw material.

[0054] [43] The upsetting apparatus as recited in any one of Items 37 to 42, wherein the bending device is configured to bend the expansion scheduled portion of the raw material in its widthwise direction by pivotally moving at least one of the guide and the receiving die about a pivotal axis parallel to a thickness direction of the expansion scheduled portion of the raw material.

[0055] [44] The upsetting apparatus as recited in Item 43, wherein the tip end portion of the protruded portion of the guide is formed into an circular-arc-shape forwardly protruded along the widthwise direction of the expansion scheduled portion of the raw material.

[0056] [45] The upsetting apparatus as recited in Item 43 or 44, further comprising a change mechanism for changing a position of the pivotal axis.

[0057] [46] The upsetting apparatus as recited in any one of Items 37 to 45, further comprising a supporting portion arranged at a bending side of the expansion scheduled portion with respect to the expansion scheduled portion of the raw material to support the expansion scheduled portion in a buckling prevented state.

[0058] [47] An upsetting apparatus, comprising:

a receiving die having receiving faces at axial both end portions and a holding hole for holding a non-expansion scheduled portion of a bar-shaped raw material in a buckling prevented state formed so as to communicate both the receiving faces;
two guides each having an insertion hole for holding an expansion scheduled portion of the raw material in a buckling prevented state;
two punches each for pressurizing the expansion scheduled portion of the raw material arranged in

the insertion hole of each guide in an axial direction; and

two guide driving devices each for moving each guide in a direction opposite to a moving direction of the corresponding punch,

wherein the upsetting apparatus is configured to radially outwardly expand both the expansion scheduled portions of the raw material exposed between a tip end portion of each guide and the corresponding receiving face of the receiving die,

wherein an expansion preventing protruded portion protruded in an axial direction of the guide is provided at the tip end portion of at least one of the guides,

wherein the protruded portion of the guide is configured to control an expansion of a contacting portion of the expansion scheduled portion by a contact with at least one of thickness side surfaces of the expansion scheduled portion at the time of expanding the expansion scheduled portion of the raw material, and wherein the upsetting apparatus further comprises a bending device for bending at least one of the expansion scheduled portions of the raw material in a width direction.

[0059] [48] The upsetting apparatus as recited in Item 47, wherein the bending device is configured to bend the expansion scheduled portion of the raw material in its width direction at the time of expanding the expansion scheduled portion of the raw material.

[0060] [49] The upsetting apparatus as recited in Item 47 or 48, wherein expansion preventing side wall portion is provided at at least one of the receiving faces of the receiving die in a protruded manner, and

wherein the side wall portion of the receiving die controls an expansion of a contacting portion of the expansion scheduled portion by a contact with at least one side surfaces among thickness side surfaces of the expansion scheduled portion at the time of expanding the expansion scheduled portion of the raw material.

[0061] [50] The upsetting apparatus as recited in Item 49, wherein the receiving die side wall portion is protruded from the receiving face of the receiving die at each of thickness side surfaces of the expansion scheduled portion of the raw material.

[0062] [51] The upsetting apparatus as recited in any one of Items 47 to 50, wherein the protruded portions of the guide is integrally provided at each of portions of a tip end portion of the guide opposed across the insertion hole.

[0063] [52] The upsetting apparatus as recited in any one of Items 47 to 51, wherein at least one of the receiving faces of the receiving die is formed into a forming face for forming at least a portion of at least one side surface among widthwise side surfaces of the expansion scheduled portion of the raw material into a predetermined shape.

[0064] [53] The upsetting apparatus as recited in any one of Items 47 to 52, wherein the bending device is

configured to bend the expansion scheduled portion of the raw material in its widthwise direction by pivotally moving the guide about a pivotal axis parallel to a thickness direction of the expansion scheduled portion of the raw material.

[0065] [54] The upsetting apparatus as recited in Item 53, wherein the tip end portion of the protruded portion of the guide is formed into an circular-arc-shape forwardly protruded along the widthwise direction of the expansion scheduled portion of the raw material.

[0066] [55] The upsetting apparatus as recited in Item 53 or 54, further comprising a change mechanism for changing a position of the pivotal axis.

[0067] [56] The upsetting apparatus as recited in any one of Items 47 to 55, further comprising a supporting portion arranged at a bending side of the expansion scheduled portion with respect to the expansion scheduled portion of the raw material to support the expansion scheduled portion in a buckling prevented state.

EFFECTS OF THE INVENTION

[0068] The present invention has the following effects.

[0069] According to the invention [1], by moving the guide in a direction opposite to the moving direction of the punch while pressurizing the bar-shaped expansion scheduled portion with the punch to expand the expansion scheduled portion of the raw material exposed between the tip end portion of the guide and the receiving die radially outwardly, buckling of the raw material can be prevented, and the expansion of the expansion scheduled portion of the raw material can be performed under a lighter load. Furthermore, since the expansion scheduled portion is bent while expanding the expansion scheduled portion of the raw material, the expansion scheduled portion can be bent under a lighter load. That is, in the present invention, the expansion scheduled portion of the raw material can be expanded under a lighter load, and the expansion scheduled portion can also be bent under a lighter load. Therefore, an upsetting manufactured product with a bent expanded portion can be assuredly manufactured under as a lighter load as possible.

[0070] According to the invention [2], since the expansion scheduled portion is bent with the expansion scheduled portion supported by the supporting portion in a buckling prevented state, buckling of the expansion scheduled portion can be prevented assuredly.

[0071] According to the invention [3], the expansion scheduled portion can be bent assuredly.

[0072] According to the invention [4], an upsetting manufactured product having a bent expanded portion excellent in surface quality can be provided.

[0073] According to the invention [5], in the same manner as in the invention [1], buckling of the raw material can be prevented, and the expansion of each expansion scheduled portion of the raw material can be performed under a lighter load. Furthermore, since the expansion

of both the expansion scheduled portions of the raw material can be performed simultaneously, the upsetting-manufactured product in which the expanded portions are formed at both the axial end portions can be manufactured efficiently. Furthermore, since at least one of the expansion scheduled portions of both the expansion scheduled portions is bent while simultaneously expanding both the expansion scheduled portions of the raw material, a predetermined expansion scheduled portion can be bent under a lighter load. That is, in the present invention, the expansion of both the expansion scheduled portions of the raw material can be performed under a lighter load, and that a predetermined expansion scheduled portion can also be bent under a lighter load. Therefore, the upsetting manufactured product having a bent expanded portion can be assuredly formed under as a lighter load as possible.

[0074] According to the invention [6], buckling of the expansion scheduled portion can be prevented assuredly.

[0075] According to the invention [7], the expansion scheduled portion can be bent assuredly.

[0076] According to the invention [8], an upsetting manufactured product having a bent expanded portion excellent in surface quality can be provided.

[0077] According to the invention [9] to [12], an upsetting apparatus used suitably for the upsetting method according to any one of the inventions [1] to [4] can be provided.

[0078] According to the invention [13], the position of the pivotal axis can be arbitrarily changed depending on the bent shape of the expanded portion.

[0079] According to the invention [14] to [17], an upsetting apparatus used suitably for the upsetting method according to any one of the inventions [5] to [8] can be provided.

[0080] According to the invention [18], the position of the pivotal axis can be arbitrarily changed depending on the bent shape of the expanded portion.

[0081] According to the invention [19], at the expansion step, since the expansion scheduled portion of the raw material is expanded radially outwardly in a state in which an expansion of a contacting portion of at least one side surface among the thickness side surfaces of the expansion scheduled portion in contact with the guide protruded portion is controlled, an expanded portion in which the expansion of at least one of side surfaces among the thickness direction side surfaces is controlled can be formed.

[0082] Furthermore, at the bending step, since the expansion scheduled portion is bent in the width direction while expanding the expansion scheduled portion of the raw material, the expansion scheduled portion can be bent under a lighter load, and the expansion of the expansion scheduled portion can be further performed under a lighter load.

[0083] Therefore, according to this invention, as to a preform having an expanded portion bent with respect

to the axial direction in which the expansion of at least one surface of both the thickness side surfaces is controlled, a preform which is closer to a produce in shape can be manufactured under a lighter load.

[0084] According to invention of [20], at the expansion step, since the expansion scheduled portion of the raw material is expanded radially outwardly in a state in which the expansion of the contacting portion of at least one side surface of the expansion scheduled portion among the thickness side surfaces of the expansion scheduled portion in contact with the guide protruded portion is controlled and in the state in which the expansion of the contacting portion of at least one side of thickness side surfaces of the expansion scheduled portion among the thickness side surfaces of the expansion scheduled portion in contact with the receiving die is controlled, the expansion of at least one side surface of the thickness side surfaces of the expansion scheduled portion of the raw material can be prevented assuredly.

[0085] According to the invention [21], the expansion of the thickness side surfaces of the expansion scheduled portion of the raw material can be prevented.

[0086] According to the invention [22], the expansion of the thickness side surfaces of the expansion scheduled portion of the raw material can be prevented assuredly.

[0087] According to the invention [23], at least a part of at least one of the side surfaces among the widthwise both side surfaces of the expansion scheduled portion of the raw material can be formed into a product configuration or its closer configuration by the receiving face of the receiving die.

[0088] According to the invention [24], the expansion scheduled portion of the raw material can be assuredly bent in the width direction.

[0089] According to the invention [25], at the bending step, an interference of the tip end portion of the protruded portion of the guide to the receiving die can be prevented.

[0090] According to the invention [26], at the bending step, buckling of the expansion scheduled portion of the raw material can be prevented assuredly.

[0091] According to the invention [27], an upsetting manufactured product having an expanded portion in which the expansion of at least one side surface among the thickness side surfaces is controlled and the expanded portion itself is bent in the axial direction can be offered.

[0092] According to the invention [28], the same effects as in the invention [19] can be obtained. Furthermore, at the expansion step, since both the expansion scheduled portions of the raw material are simultaneously expanded radially outwardly, an upsetting manufactured product in which expanded portions are formed at the axial both end portions can be manufactured efficiently.

[0093] According to the invention [29] to [35], the same effect as in the invention [20] to [26] can be performed.

[0094] According to the invention [36], it is possible

to provide an upsetting manufactured product in which an expanded portion is formed at each of the axial both end portions, at least one of both the expanded portion, an expansion of at least one side surface among the thickness side surfaces is controlled, and the expanded portion itself is bent in the axial direction.

[0095] According to the invention [37] to [44], an upsetting apparatus used suitably for the upsetting method according to any one of the inventions [19] to [25] can be provided.

[0096] According to the invention [45], the position of the pivotal axis can be arbitrarily changed depending on the bent shape of the expanded portion.

[0097] According to the invention [46], an upsetting apparatus used suitably for the upsetting method according to any one of the invention [26] can be provided.

[0098] According to the invention [47] to [54], an upsetting apparatus used suitably for the upsetting method according to any one of the inventions [28] to [34] can be provided.

[0099] According to the invention [55], the position of the pivotal axis can be arbitrarily changed depending on the bent shape of the expanded portion.

[0100] According to the invention [56], an upsetting apparatus used suitably for the upsetting method according to any one of the invention [35] can be provided.

BRIEF DESCRIPTION OF THE DRAWINGS

[0101]

Fig. 1 is a partially cut-out perspective view of an upsetting apparatus according to a first embodiment of the present invention.

Fig. 2 is a cross-sectional view showing the upsetting apparatus in the state before expanding an expansion scheduled portion of a raw material.

Fig. 3 is a cross-sectional view of the upsetting apparatus in the state in the middle of expanding an expansion scheduled portion of a raw material.

Fig. 4 is a cross-sectional view of the upsetting apparatus in the state after expanding the expansion scheduled portion of the raw material.

Fig. 5 is a perspective view of an upsetting manufactured product produced by the upsetting apparatus.

Fig. 6 is a cross-sectional view of an upsetting apparatus according to a second embodiment of the present invention in the state after expanding an expansion scheduled portion of a raw material.

Fig. 7 is a partially cut-out perspective view of the upsetting apparatus according to a third embodiment of the present invention.

Fig. 8 is a perspective view of an end portion of a receiving die of the upsetting apparatus.

Fig. 9 is a perspective view of a guide of the upsetting apparatus.

Fig. 10 is a cross-sectional view of the upsetting ap-

paratus in the state before expanding an expansion scheduled portion of a raw material.

Fig. 11 is a cross-sectional view of the upsetting apparatus in the state in the middle of expanding the expansion scheduled portion of the raw material.

Fig. 12 is a cross-sectional view of the upsetting apparatus in the state after expanding the expansion scheduled portion of the raw material.

Fig. 13 is a perspective view of the upsetting manufactured product processed using the upsetting apparatus.

Fig. 14 is a cross-sectional view of the upsetting apparatus with a modified pivotal axis.

EXPLANATION OF THE NUMERALS

[0102]

1: raw material
 2: expansion scheduled portion
 3: axial intermediate portion (non-expansion scheduled portion)
 5: upsetting manufactured product
 6: expanded portion
 7: shank portion
 10A, 10B: upsetting apparatus
 11: receiving die
 12: holding hole (raw material mounting hole)
 15: supporting portion
 20: guide
 21: insertion hole
 23: guide holder
 25: guide driving device
 30: punch
 31: punch driving device
 40: bending device
 41: guide pivotally moving mechanism
 42: rail
 43: stage
 44: stage driving device
 50: change mechanism
 51: guide holder moving rail
 52: guide holder driving device
 53: receiving die moving rail
 54: receiving die driving device
 F: free expanding space
 P: pivotal axis
 101: raw material
 102: expansion scheduled portion
 103: non-expansion scheduled portion (axial intermediate portion)
 105: upsetting manufactured product (preform)
 106: expanded portion
 107: shank portion
 110: upsetting apparatus
 111: receiving die
 112: holding hole
 113: receiving face

114: expansion preventing side wall portion
 115: supporting portion
 119: dividing plane
 120: guide
 121: insertion hole
 122: expansion preventing protruded portion
 122b: tip end portion
 125: guide driving device
 130: punch
 131: punch driving device
 140: bending device
 141: guide pivotally moving mechanism
 142: circular arc-shaped rail
 143: stage
 144: stage driving device
 150: change mechanism
 151: guide holder moving rail
 152: guide holder driving device
 153: receiving die moving rail
 154: receiving die driving device
 E: expanding space
 P: pivotal axis

BEST MODE FOR CARRYING OUT THE INVENTION

[0103] Next, some embodiments of the present invention will be explained below with reference to the attached drawings.

[0104] Figs. 1 to 5 are drawings for explaining a first embodiment of the present invention.

[0105] In Fig. 1, the reference numeral 10A denotes an upsetting apparatus according to the first embodiment. Specifically, this upsetting apparatus 10A is a free upsetting apparatus. The reference numeral 1 denotes a bar-shaped raw material.

[0106] In Fig. 5, the reference numeral 5 denotes an upsetting manufactured product produced by the upsetting apparatus 10A. This upsetting manufactured product 5 has a straight shank portion 7 and expanded portions 6 (diameter expanded portions) radially outwardly expanded (enlarged in diameter) along the entire periphery formed at both ends of the shank portion 7. Each expanded portion 6 is bent with respect to the axial direction. Specifically, the expanded portion 6 itself is bent, and the expanded portion 6 is unevenly expanded in the peripheral direction. More specifically, the expanded amount of the expanded portion 6 at the side opposite to the bent side is larger than the expanded amount of the expanded portion 6 at the bent side, in other words, the expanded portion 6 is expanded to the side opposite to the bent side of the expanded portion 6 greater than to the bent side. This upsetting manufactured product 5 is used as a preform for manufacturing an arm for vehicles such as, e.g., cars and railroad vehicles. Each expanded portion 6 of this upsetting manufactured product 5 is a portion to be processed at a post-step into a connecting portion (for example, a bush mounting portion, a yoke portion, a ball joint portion) to be connected with another component.

[0107] As shown in Figs. 1 and 2, the raw material 1 has expansion scheduled portions 2 and 2 at both the axial end portions and a non-expansion scheduled portion at the axial intermediate portion 3. The axial intermediate portion 3 of the raw material 1 will be served as a shank portion 7 of the upsetting manufactured product 5 after the upsetting.

[0108] This raw material 1 is a straight solid round bar having a predetermined length, and made of metal material, specifically, aluminum or aluminum alloy material. The raw material 1 is round in cross-section and constant in diameter in the axial direction.

[0109] In the present invention, the material of the raw-material 1 is not limited to aluminum or aluminum alloy, and can be metal, such as, e.g., brass, copper (including its alloy), and stainless steel. It also can be plastic. It is especially preferable that it is aluminum or aluminum alloy. Moreover, the cross-sectional configuration of the raw material 1 is not limited to a circular shape, and can be a polygon, such as, e.g., a square, or a hexagon. Furthermore, the raw material 1 can be an extruded material, a continuously cast rolled material manufactured by a Properzi method, or a material manufactured by another method.

[0110] The diameter of the raw material 1 is 10 to 20 mm for example (specifically, 16 mm). In the upsetting manufactured product 5, for example, the maximum diameter of each expanded portion 6 is 50 to 70 mm (specifically, 60 mm), the length of each expanded portion 6 is 65 to 80 mm (specifically, 72 mm), and the length of the shank portion 7 is 150 to 250 (specifically, 220 mm). In the present invention, however, the diameter of the raw material 1 and the dimension of each portion of the upsetting manufactured product 5 are not limited to the above-mentioned dimensions. For example, the diameter of the raw material 1 and the dimension of each portion of the upsetting manufactured product 5 can be set so that the purpose of the present invention can be attained depending on the manufacturing of the desired product, such as, e.g., an arm, a connecting rod, or a piston for vehicles.

[0111] The upsetting apparatus 10A is equipped with a receiving die 11, two guides 20 and 20, two guide driving devices 25 and 25, two punches 30 and 30, two punch driving devices 31 and 31, and two bending devices 40 and 40.

[0112] The receiving die 11 is for receiving an expanded portion 6 formed by expanding the expansion scheduled portion 2 of the raw material, and has axial both end portions of the receiving die 11 each served as a receiving face 11a (hereinafter may also referred to as "receiving portion"). This receiving die 11 is provided with a holding hole 12 (hereinafter may also be referred to as "mounting hole") communicating both the receiving faces 11a and 11a. Therefore, end openings of the holding hole 12 are formed at both receiving faces 11a and 11a of the receiving die 11. The holding hole 12 is extended straightly in the axial direction of the receiving die 11. This holding

hole 12 holds the axial intermediate portion 3 of the raw material 1 as a non-expansion scheduled portion in a buckling prevented state and in an axial movement prevented state. The axial intermediate portion 3 of the raw material 1 is fitted in the holding hole 12 in an axial movement prevented state and in a buckling prevented state. Thereby, the axial intermediate portion 3 of the raw material 1 is attached to the receiving die 11. Furthermore, this receiving die 11 is divided into two pieces by the dividing plane cutting the holding hole 12 longitudinally.

[0113] The two guides 20 and 20 are the same in structure. Each guide 20 has an insertion hole 21 for holding the corresponding expansion scheduled portion 2 of the raw material 1 in a buckling prevented state. This insertion hole 21 penetrates the guide 20 in the axial direction thereof. The outlet opening of the insertion hole 21 is provided at the tip end portion of the guide 20. The cross-sectional configuration of the insertion hole 21 is the same as the cross-sectional configuration of the expansion scheduled portion 2 of the raw material 1, and the expansion scheduled portion 2 of the raw material 1 is fittedly inserted in the insertion hole 21 in the axially slidable manner. And the raw material 1 is inserted into the insertion hole 21 with the expansion scheduled portion 2 of the raw material 1 disposed in the insertion hole 21, whereby the expansion scheduled portion 2 of the raw material 1 is held in the insertion hole 21 in a buckling prevented state.

[0114] Each guide 20 is accommodated in and held by the guide holder 23 in an axially slidable manner. The reference numeral 24 denotes a spacer disposed between the guide 20 and the guide holder 23 to reduce the slide frictional force between them.

[0115] The two punches 30 and 30 are the same in structure. Each punch 30 is for pressurizing the corresponding expansion scheduled portion 2 of the raw material 1 in the axial direction. Both the guides 20 and 20 are arranged at both axial sides of the raw material 1.

[0116] The two punch driving devices 31 and 31 are the same in structure. Each punch driving device 31 is for moving the punch 30 in the axial direction of the raw material 1. This punch driving device 31 is connected to each punch 30. Thus, by operating the punch driving device 30, the expansion scheduled portion 2 of the raw material 1 is pressurized in the axial direction thereof with the punch 30. As a driving source of the punch driving device 31, for example, a fluid pressure cylinder (e.g., a hydraulic cylinder or a gas cylinder) can be used.

[0117] The two guide driving devices 25 and 25 are the same in structure. Each guide driving device 25 is for moving the guide 20 in a direction opposite to the moving direction of the corresponding punch 30 (i.e., the pressurizing direction to the raw material expansion scheduled portion 2 by the punch 30). As a driving source of this driving device 25, for example, a fluid pressure cylinder (e.g., a hydraulic cylinder, a gas cylinder) can be used. The movement of the guide 20 with the guide driving device 25 causes a free expanding space F between

the tip end portion of the guide 20 and the receiving die 11 (specifically, the receiving face 11a of the receiving die 11). This free expanding space F is a space in which the expansion scheduled portion 2 of the raw material 1 can be expanded radially outwardly. Since the expansion scheduled portion 2 of the raw material 1 is expanded in this free expanding space F, this upsetting method is in the category of an upsetting method not using a closed-die with a closed cavity, i.e., a free upsetting method.

[0118] The two bending devices 40 and 40 are the same in structure. Each bending device 40 is for bending each expansion scheduled portion 2 of the raw material 1. In this embodiment, the bending device 40 is for bending the expansion scheduled portion 2 into a circular-arc-shape, etc., by pivotally moving the guide 20 about an axis perpendicular to a plane including the axis of the raw material (this axis will be referred to as a "pivotal axis P").

[0119] In this embodiment, the raw material 1 is arranged horizontally, and therefore the axis of the raw material is also arranged horizontally. The plane including the axis of the raw material is a horizontal plane, and therefore the pivotal axis P extends in a vertical direction.

[0120] Each bending device 40 is equipped with a guide pivotally moving mechanism 41 for pivotally moving the guide 20 about the pivotal axis P.

[0121] Each guide pivotally moving mechanism 41 is provided with a rail 42 extending in a circular arc manner centered on the pivotal axis P, a stage 43 capable of moving along the rail 42, and a stage driving device 44 for moving the stage 43 along the rail 42. As a driving source of the stage driving device 44, for example, a fluid pressure cylinder (e.g., a hydraulic cylinder or a gas cylinder) is connected to the stage 43. On the stage 43, the guide holder 23 is installed via guide holder moving rails 51 and 51 which will be mentioned later. As mentioned above, the guide 20 is accommodated in the guide holder 23.

[0122] In this guide pivotally moving mechanism 41, by operating the stage driving device 44, the guide 20 is pivotally moved along the circular-arc-shaped rail 42 together with the stage 43, i.e., the guide 20 is pivotally moved about the pivotal axis P. Thus, the pivotal movement of the guide 20 causes bending of the expansion scheduled portion 2 of the raw material 1 during the expansion process.

[0123] In the present invention, the guide pivotally moving mechanism 41 is not limited to the aforementioned mechanism, and can be, for example, a gear mechanism.

[0124] Furthermore, this upsetting apparatus 10A is equipped with two change mechanisms 50 and 50 each for changing the position of the pivotal axis P of each guide 20.

[0125] Both the change mechanisms 50 are 50 are the same in structure. Each change mechanism 50 has guide holder moving rails 51 and 51 laid on the stage 43, a guide holder driving device 52 for moving the guide holder

23 on the rails 51 and 51, receiving die moving rails 53 and 53, and receiving die driving devices 54 and 54 for moving the receiving die 11 on the rails 53 and 53. The guide holder moving rail 51 and the receiving die moving rail 53 extend in a direction perpendicular to the material axis. As a driving source of the guide holder driving device 52, for example, a fluid-pressure cylinder is connected to the guide holder 23. Furthermore, as a driving source of the receiving die driving device 54, for example, a fluid-pressure cylinder is connected to the receiving die 11. This receiving die driving device 54 is also used as a driving device for opening and closing the receiving die 11.

[0126] In this change mechanism 50, by operating the guide holder driving device 52, the guide 20 is moved on the rails 51 together with the guide holder 23 with respect to the stage 43. By further operating the receiving die driving device 54, the receiving die 11 is moved along the rails 53. By moving the guide 20 and the receiving die 11 in the same direction, the position of the pivotal axis P can be changed.

[0127] Next, the upsetting method using the above-mentioned upsetting apparatus 10A will be explained below.

[0128] First, as shown in Figs. 1 and 2, the axial intermediate portion 3 of the raw material 1 as a non-expansion scheduled portion is fitted in the holding hole 12 of the receiving die 11. Thus, the axial intermediate portion 3 of the raw material 1 is attached to the receiving die 11 in a state in which the axial intermediate portion is held in the holding hole 12 in a buckling prevented state and in an axial movement prevented state.

[0129] Furthermore, each of the expansion scheduled portions 2 and 2 of the raw material 1 is arranged in the corresponding insertion hole 21 of the guide 20. [Arrangement Step of Raw Material Expansion Scheduled Portion] Thereby, each expansion scheduled portion 2 of the raw material 1 is held within the insertion hole 21 in a buckling prevented state.

[0130] Subsequently, the guides 20 are simultaneously moved in respective directions opposite to the respective moving directions of the corresponding punch 30 with the guide driving devices 25 while simultaneously pressurizing both the expansion scheduled portions 2 and 2 of the raw material 1 with corresponding punches 30 in the axial direction. By this, both the expansion scheduled portions 2 and 2 of the raw material 1 each exposed in a free expanding space F formed between the tip end portion of each guide 20 and the receiving die 11 (more specifically, the receiving face 11a of the receiving die 11) are simultaneously expanded in the respective free expanding spaces F radially outwardly [Expansion Step].

[0131] Furthermore, as shown in Fig. 3, both the expansion scheduled portions 2 and 2 are simultaneously bent with the bending devices 40 and 40 while being simultaneously expanded. [Bending Step].

[0132] The bending method using the bending device 40 will be explained as follows.

[0133] That is, the position of the receiving die 11 is fixed. Then, the stage driving devices 44 and 44 of both the bending devices 40 and 40 are operated simultaneously while simultaneously expanding both the expansion scheduled portions 2 and 2 of the raw material 1. Then, each guide 20 is moved together with the stage 43 along the rail 42 with a part of the expansion scheduled portion 2 of the raw material 1 remained in the insertion hole 21 of the guide 20, whereby each guide 20 pivotally moves about the pivotal axis P. In accordance with the pivotal movement of the guide 20 as mentioned above, the expansion scheduled portion 2 is bent into a circular-arc-shape while being expanded.

[0134] The traveling speed of the stage 43, namely, the speed of bending the expansion scheduled portion 2 of the raw material 1, is set depending on the bend shape of the expanded portion 6.

[0135] As shown in Fig. 4, when each expansion scheduled portion 2 of the raw material 1 is expanded into a predetermined shape, the movement of the punch 30, that of the guide 20, and that of the stage 43 are stopped simultaneously.

[0136] Subsequently, the raw material 1 is taken out of the receiving die 11 to obtain a desired upsetting manufactured product 5.

[0137] The expanded portion of the obtained upsetting manufactured product 5 is used as a preform, and the expanded portion 6 thereof is processed at a post-process into a predetermined configuration to obtain a desired arm for vehicles.

[0138] According to this upsetting method, in manufacturing a preform for manufacturing a product in which an expanded portion is bent, a preform closer to a product in configuration can be manufactured.

[0139] According to the upsetting method of the aforementioned first embodiment, by moving the guide 20 in a direction opposite to the moving direction of the punch 30 while pressurizing the expansion scheduled portion 2 of the raw material 1 with the punch 30 in the axial direction, the expansion scheduled portion 2 of the raw material 1 exposed between the tip end portion of the guide 20 and the receiving die 11 is expanded radially outwardly. Therefore, buckling of the raw material 1, which may sometimes occur at the time of upsetting, can be prevented. Furthermore, each expansion scheduled portion 2 of the raw material 1 can be expanded under a lighter load. Namely, by bending the expansion scheduled portion 2 while pressurizing the expansion scheduled portion 2 of the raw material 1 in the axial direction, since the expansion scheduled portion 2 is deformed while being expanded radially outwardly by the same principle as stretch forming, the expansion scheduled portion 2 can be expanded under a lighter load. Furthermore, since both the expansion scheduled portions 2 and 2 of the raw material 1 are expanded simultaneously, an upsetting manufactured product 5 with expanded portions 6 at the axial end portions can be manufactured efficiently.

[0140] Furthermore, since each expansion scheduled

portion 2 of the raw material 1 is bent while being expanded, each expansion scheduled portion 2 can be bent under a lighter load.

[0141] That is, in this upsetting method, each expansion scheduled portion 2 of the raw material 1 can be expanded under a lighter load, and the expansion scheduled portion 2 can also be bent under a lighter load. Furthermore, it is possible to prevent occurring of wrinkles on the inner bent side surface portion of the expanded portion 6. Therefore, an upsetting manufactured product 5 having a bent expanded portion 6 can be manufactured assuredly under a lighter load without causing wrinkles.

[0142] Originally, in this upsetting method, since a blockade die having a closed-cavity is not used, it is possible to perform processing at low cost.

[0143] Furthermore, the expansion scheduled portion 2 of the raw material 1 can be assuredly bent by pivotally moving the guide 20 about an axis (i.e., pivotal axis P) perpendicular to a plane including the axis of the raw material.

[0144] In the aforementioned upsetting apparatus 10A, the positional changing of the pivotal axis P of the guide 20 can be performed by operating the guide holder driving device 52 of the change mechanism 50 to thereby move the guide 20 together with the guide holder 23 with respect to the stage 43 along the rail 51. Furthermore, the receiving die 11 is moved along the rail 53 by operating the receiving die driving device 54. In this way, the position of pivotal axis P can be changed by moving the guide 20 and the receiving die 11 in the same direction.

[0145] Therefore, according to this upsetting apparatus 10A, the position of the pivotal axis P can be arbitrarily changed depending on the bent shape of the expanded portion 6.

[0146] Fig. 6 is a figure for explaining a second embodiment of the present invention.

[0147] The upsetting apparatus 10B according to the second embodiment is equipped with two supporting portions 15 and 15 for supporting each expansion scheduled portion 2 of the raw material 1 in a buckling prevented state. Both the supporting portions 15 and 15 are the same in structure. Each supporting portion 15 is arranged at the bending side of the expansion scheduled portion 2 of the raw material 1. In this embodiment, each supporting portion 15 is integrally provided at the receiving die 11. In the present invention, the supporting portion 15 can be separated from the receiving die 11, i.e., the supporting portion 15 can be a separated supporting member.

[0148] Other structures of this upsetting apparatus 10B are the same as those of the upsetting apparatus 10A of the aforementioned first embodiment.

[0149] In the upsetting method using this upsetting apparatus 10B, each expansion scheduled portion 2 of the raw material 1 is bent with the expansion scheduled portion 2 supported by the supporting portion 15 in a buckling prevented state while expanding the expansion scheduled portion 2. This assuredly prevents buckling of the

expansion scheduled portion 2.

[0150] Although some embodiments of the present invention were explained above, the present invention is not limited to the aforementioned embodiments and allows various modifications.

[0151] For example, in the aforementioned embodiment, although both the expansion scheduled portions 2 and 2 of the raw material 1 are bent simultaneously, in the present invention, only one of the expansion scheduled portions 2 and 2 of the raw material 1 can be bent.

[0152] Moreover, in the aforementioned embodiment, the number of expansion scheduled portions 2 of the raw material 1 is two. In the present invention, however, the expansion scheduled portion 2 of the raw material 1 can be only one portion, such as, e.g., an axial one end portion of the raw material 1, or an axial intermediate portion thereof. Moreover, in the present invention, in cases where only one expansion scheduled portion 2 of the raw material 1 is bent, the guide 20 can be pivotally moved about the pivotal axis P, the receiving die 11 can be pivotally moved about the pivotal axis P, or the guide 20 and the receiving die 11 can be pivotally moved in the reverse directions about the pivotal axis P.

[0153] Moreover, in the present invention, the expansion can be completed with a part of the expansion scheduled portion 2 of the raw material 1 remained in the insertion hole 21 of the guide 20 at the expansion step, or the expansion can be completed immediately after extruding the entire expansion scheduled portion 2 out of the insertion hole 21 of the guide 20.

[0154] Moreover, in the present invention, the raw material 1 can be in a heated state or in a non-heated state at the time of the processing. That is, in the present invention, the processing temperature conditions of the raw material 1 are not limited.

[0155] Needless to say, the upsetting apparatus and the upsetting method according to the present invention are not limited to an apparatus or a method for manufacturing a preform for forming an arm for vehicles, and can be used in manufacturing various preforms for industrial products, such as, e.g., a reform for shafts, a preform for frames, a preform for connecting rods, or a preform for pistons for use in compressors.

[0156] Figs. 7 to 14 are figures for explaining a third embodiment of the present invention. This third embodiment is made in view of the aforementioned prior art background described in the column of "Background Art," and further in view of the technical background mentioned below.

[0157] In a conventional upsetting method, in general, an expansion scheduled portion of a raw material is evenly expanded radially outwardly around the entire periphery thereof.

[0158] Thus, a conventional upsetting method is used to mainly manufacture a preform for manufacturing an industrial product. However, among industrial products, for example, in the case of an eyeglass-frame-shaped arm for automobiles, although a connecting portion to be

connected to another component is formed at the end portion of the shank portion, this connecting portion is expanded only in the width directions but almost not in the thickness direction. In the case of manufacturing a preform for such a product, there were the following difficulties.

[0159] That is, in the aforementioned upsetting method, the expansion scheduled portion of the raw material is expanded radially outwardly in a uniform manner along the entire periphery thereof as mentioned above. Therefore, after the upsetting, it was necessary to subject the expanded portion to a further processing (i.e., secondary processing), such as, e.g., pressurizing the expanded portion into a connecting portion having a flat shape, or cutting the expanded portion. Consequently, there were such drawbacks that the number of manufacturing steps increases or the rate of the material yield deteriorates.

[0160] On the other hand, in the case of manufacturing a preform by an upsetting method using a forming die having a closed-cavity, i.e., by a restricted upsetting method, a heavy load is needed at the time of pressurizing the expansion scheduled portion of the raw material arranged in the closed-cavity of the forming die. This requires a punch driving device capable of generating a heavy load, resulting in an increased purchase cost of an upsetting apparatus.

[0161] Furthermore, generally, when manufacturing a product having a shape in which an expanded portion is bent with respect to the axial direction among products of various kinds, it is preferable to use a preform previously formed into such a shape to reduce the number of manufacturing steps and improve the rate of material yield.

[0162] In a conventional upsetting method, however, it was difficult to form a preform having a shape in which the expanded portion is bent with respect to the axial direction. On the other hand, it can be proposed a method in which an expanded portion is formed and then this expanded portion is subjected to a bending process. However, this method has a drawback that a heavy load is required to bent the expanded portion. Furthermore, in this proposal method, in the case of bending the expanded portion, there are drawbacks that the expanded portion itself is not bent but the neck portion between the expanded portion and the shank portion is bent, and/or wrinkles are generated at the inner bending side surface of the expanded portion, resulting in deteriorated surface quality. Under the circumstances, it was very difficult to bend an expanded portion after forming the expanded portion.

[0163] The third embodiment of the present invention was made in view of the conventional technical background described in the above-mentioned column of [Background Art] and the aforementioned technical background. Other than the aforementioned purposes, another purpose is to provide an upsetting method capable of expanding an expansion scheduled portion of a raw material radially outwardly in a state in which a peripheral

prescribed portion of the expansion scheduled portion is restricted to be expanded and also capable of manufacturing an upsetting manufactured product having a shape in which the expanded portion is bent with respect to the axial direction under a lighter load. Still another purpose is to provide an upsetting manufactured product obtained by the method, and an upsetting apparatus used for the method.

[0164] Another objects and advantages of the present invention will be apparent from the following preferable embodiments.

[0165] In Fig. 7, the reference numeral "110" denotes an upsetting apparatus according to a third embodiment of the present invention. "101" denotes a bar-shaped raw material.

[0166] In Fig. 7, the reference numeral "105" denotes an upsetting manufactured product processed by the upsetting apparatus 110. The upsetting manufactured product 105 has expanded portions 106 unevenly expanded radially outwardly at each end of the cylindrical shank portion 107. The shank portion 107 is straight. Both the expanded portions 106 and 106 are the same in configuration. The expanded state of each expanded portion 106 will be detailed. Each expanded portion 106 is expanded in its widthwise side into an approximately circular-arc-shape and not expanded or almost not expanded in its thickness side. Therefore, each expanded portion 106 is formed into a slightly distorted circular disc shape with a thickness approximately the same as the diameter of the shank portion 107. Furthermore, the expanded portion 106 is bent in the width direction with respect to the axial direction. More specifically, the expanded amount of the expanded portion 106 opposite to the widthwise bent side of the expanded portion 106 is larger than the expanded amount of the widthwise bent side of the expanded portion 106. That is, the expanded portion 106 is expanded more than the side opposite to the bent side. Thus, the expanded portion 106 is unevenly expanded in the peripheral direction.

[0167] This upsetting manufactured product 105 is used as a preform for manufacturing a predetermined product. Therefore, in the present invention, the upsetting apparatus 110 can be regarded as a manufacturing apparatus for a preform, and the upsetting method can be regarded as a manufacturing method of a preform.

[0168] In this embodiment, this upsetting manufactured product 105 can be used as a preform for manufacturing an arm for use in vehicles, such as, e.g., cars or railroad vehicles. Each expanded portion 106 of this upsetting manufactured product 105 is a portion to be processed at a post-step into a connecting portion (for example, bush mounting portion) to be connected to another component. As a process to be performed at the post-step, a hole punching for making a holding hole for mounting a bush in the expanded portion 106 can be exemplified.

[0169] As shown in Figs. 7 and 10, this raw material 101 has an axial intermediate portion as a non-expansion

scheduled portion 103 and axial both end portions as expansion scheduled portions 102. The non-expansion scheduled portion 103 of the raw material 101 corresponds to a shank portion 107 of the upsetting manufactured product 105 after the upsetting.

[0170] This rawmaterial 101 is a straight solid round bar having a predetermined length, and made of metal, more specifically, aluminum or aluminum alloy. The raw material 101 is circular in cross-section, and has a diameter constant along the axial direction.

[0171] In the present invention, the substance of the raw material 101 is not limited to aluminum or aluminum alloy, and can be any metal, such as, e.g., brass, copper (including its alloy), or stainless steel, or can be any plastic. Among other things, it is preferable that it is aluminum or aluminum alloy. Moreover, the cross-sectional shape of the raw material 101 is not limited to a circular shape, and can be a polygon, such as, e.g., a square or a hexagon. Moreover, the raw material 101 can be, for example, an extruded material, or a continuously cast rolled material manufactured by a Properzi method, or a material manufactured by any other method.

[0172] The diameter of the raw material 101 is, e.g., 10 to 30 mm (more specifically, 16 mm). For example, in the upsetting manufactured product 105, the diameter of the expanded portion 106 is 30 to 100 mm (more specifically, 50 mm or the like), the thickness of the expanded portion 106 is from a diameter of the raw material 101 to a diameter of the raw material 101 plus(+) 30 mm (more specifically, 26 mm or the like), and the length of the shank portion 107 is 20 to 300 mm (more specifically, 160 mm). In the present invention, however, the diameter of the raw material 101 and the dimension of each portion of the upsetting manufactured product 105 are not limited to the aforementioned dimension. For example, for the purpose of attaining the object of the present invention in accordance with the manufacturing of a desired product such as an arm for vehicles, the diameter of the raw material 101 and the dimension of each portion of the upsetting manufactured product 105 can be set up.

[0173] This upsetting apparatus 110 is equipped with a receiving die 111, two guides 120 and 120, two guide driving devices 125 and 125, two punches 130 and 130, two punch driving devices 131 and 131, and two bending devices 140 and 140.

[0174] The receiving die 111 is configured to hold the material of the expansion scheduled portion 102 at the time of expanding each expansion scheduled portion 102 of the raw material 101, and has a receiving face 113 at each of the axial both end portions of the receiving die 111. Furthermore, this receiving die 111 is provided with a holding hole 112 straightly extended in the axial direction so as to communicate both the receiving faces 113 and 113. Therefore, as shown in Fig. 8, an end opening of the holding hole 112 is formed at each of the receiving faces 113 and 113 of the receiving die 111.

[0175] The holding hole 112 of the receiving die 111 is configured to hold the non-expansion scheduled por-

tion 103 of the rawmaterial 101 in a buckling prevented state and in an axial movement prevented state. This holding hole 112 can also be regarded as a raw material mounting hole for attaching the raw material 101 in the receiving die 111. The cross-sectional shape of the holding hole 112 is a shape corresponding to the cross-sectional shape of the non-expansion scheduled portion 103 of the raw material 101, i.e., a circular shape. Furthermore, the diameter of this holding hole 112 is set to be slightly smaller than the diameter of the non-expansion scheduled portion 103 of the raw material 101. The receiving die 111 is divided into two members by a dividing plane 119 crossing the holding hole 112. The non-expansion scheduled portion 103 of the raw material 101 is fitted in between the divided grooves of the holding hole 112 formed by the divided members of the receiving die 111, and then both the divided members are integrally combined. Thereby, the non-expansion scheduled portion 103 of the raw material 101 is immovably held in the holding hole 112 in a buckling prevented state and in an axial movement prevented state.

[0176] Both the receiving faces 113 and 113 of the receiving die 111 are the same in structure. As shown in Fig. 8, each receiving face 113 of the receiving die 111 is formed into a concave surface having a circular arc cross-sectional shape in the widthwise direction of the expansion scheduled portion 102 of the raw material 101. Thus, each receiving face 113 is formed into a die surface for forming a part of each widthwise side of the expansion scheduled portion 102 of the raw material 101 into a pre-

determined shape (that is, circular-arc-shape). **[0177]** Furthermore, at the portions of each receiving face 113 of the receiving die 111 opposed with each other crossing the holding hole 112 and located at both thickness direction sides of the expansion scheduled portion 102 of the raw material 101, an expansion preventing side wall portion 114 is integrally formed at the receiving die 111 die so as to protrude in the axial direction of the receiving die 111 (i.e., in the axial direction of the raw material 101), respectively. Both these side wall portions 114 and 114 are extended along the receiving faces 113 and arranged in an opposed manner. These side wall portions 114 and 114 control the expansion of the contacting portion of the expansion scheduled portion 102 by coming into contact with the thickness direction both side surfaces of the expansion scheduled portion 102 at the time of expanding the expansion scheduled portion 102 of the raw material 101.

[0178] Furthermore, the side portion of each receiving face 113 of the receiving die 111 for bending the expansion scheduled portion 102 constitutes a supporting portion 115 for supporting the expansion scheduled portion 102 of the raw material 101 in a buckling prevented state.

[0179] Two guides 120 and 120 are the same in structure. As shown in Fig. 9, each guide 120 has an insertion hole 121 for inserting and holding the corresponding expansion scheduled portion 102 of the raw material 101 in buckling prevented state. This insertion hole 121 pen-

etrates the guide 120 along its axial direction. The inlet opening of the insertion hole 121 is formed at the basal end portion of the guide 120, while the outlet opening of the insertion hole 121 is formed at the tip end portion of the guide 120. The cross-sectional shape of the insertion hole 121 is the same as the cross-sectional shape of the expansion scheduled portion 102 of the raw material 101, so that the expansion scheduled portion 102 of the raw material 101 is axially slidably fitted in the insertion hole 121. The raw material 101 is inserted in the insertion hole 121 with the expansion scheduled portions 102 of the raw material 101 arranged in the insertion holes 121, and the expansion scheduled portions 102 of the raw material 101 is held within the insertion hole 121 in a buckling prevented state.

[0180] Furthermore, at portions of the tip end portion of each guide 120 opposed with each other crossing the insertion hole 121 and located at the thickness direction both sides of the expansion scheduled portion 102 of the rawmaterial 101, an expansion preventing protruded portion 122 protruded in the axial direction of the guide 120 is integrally formed at the guide 120. Both these protruded portions 122 and 122 are arranged so as to oppose each other. The tip end portion 122b of each protruded portion 122 is formed into a generally circular-arc-shape protruded toward the tip end and extended in the widthwise direction of the expansion scheduled portion 102 of the raw material 101. Both the protruded portions 122 and 122 control expansion of contacting portions of the expansion scheduled portion 102 by coming into contact with the thickness both side surfaces of the expansion scheduled portion 102 at the time of expanding the expansion scheduled portion 102 of the raw material 101.

[0181] On the other hand, as shown in Fig. 8, at portions near each receiving face 113 of the receiving die 111, a supporting wall portion 116 which comes into contact with the outside surface of one of the protruded portions 122 and 122 of the guide 120 to support the protruded portion 122 is formed at the receiving die 111 so as to protrude in the axial direction of the receiving die 111.

[0182] Moreover, as shown in Figs. 7 and 10, each guide 120 is accommodated and held in a guide holder 123 in an axially slidable manner. In addition, in Fig. 7, the reference numeral "124" denotes a spacer disposed between the guide 120 and the guide holder 123 to reduce the slide frictional force therebetween.

[0183] Two punches 130 and 130 are the same in structure. Each punch 130 is for pressurizing the corresponding expansion scheduled portion 102 of the raw material 101 in the axial direction thereof. Both the punches 130 and 130 are arranged so as to be opposed each other at both sides of the axial direction of the raw material 101.

[0184] Two punch driving devices 131 and 131 are the same in structure. Each punch driving device 131 is for moving the corresponding punch 130 in the axial direction of the raw material 101. This punch driving device

31 is connected to the corresponding punch 130. By operating the punch driving device 131, the punch 130 is moved to pressurize the expansion scheduled portion 102 of the raw material 101 in the axial direction. As a driving source of the punch driving device 131, for example, a fluid-pressure cylinder (e.g., a hydraulic cylinder, or a gas cylinder) can be used.

[0185] Two guide driving devices 125 and 125 are the same in structure. Each guide driving device 125 is for moving the guide 120 in a direction opposite to the moving direction of the corresponding punch 130 (i.e., in the pressurizing direction to the rawmaterial expansion scheduled portion 102 by the corresponding punch 130). As the driving source of this driving device 125, for example, a fluid-pressure cylinder (e.g., a hydraulic cylinder, or a gas cylinder) can be used. By moving the guide 120 with this driving device 125, an expansion space E will be formed between the tip end portion of the guide 120 and the receiving face 113 of the receiving die 111 (see Fig. 11). This expansion space E is a space in which the expansion scheduled portion 102 of the raw material 101 is radially outwardly expanded. In other words, in this expansion space E, the expansion scheduled portion 102 of the raw material 101 is expanded.

[0186] Two bending devices 140 and 140 are the same in structure. Each bending device 140 is for bending the expansion scheduled portion 102 in the width direction at the time of expanding each expansion scheduled portion 102 of the raw material 101. In this embodiment, the bending device 140 is configured to bend the expansion scheduled portion 102 of the raw material 101 in its width direction into a circular-arc-shape by pivotally moving the guide 120 about an axis parallel to the thickness direction of the expansion scheduled portion 102 of the raw material 101 (hereinafter referred to as "pivotal axis P") as a pivotal axis perpendicular to a plane including the axis of the raw material 101.

[0187] In this embodiment, the raw material 101 is arranged horizontally, while the thickness direction of the expansion scheduled portion 102 of the raw material 101 coincides with the up-and-down direction. Therefore, the pivotal axis P of the guide 120 extends in the up-and-down direction.

[0188] Each bending device 140 is equipped with a guide pivotally moving mechanism 141 which causes a pivotal movement of the guide 120 about the pivotal axis P.

[0189] Each guide pivotally moving mechanism 141 is provided with a rail 142 extending in a circular arc manner centered on the pivotal axis P and arranged on a horizontal floor (not shown), a stage 143 capable of moving along the circular arc-shaped rail 142, and a stage driving device 144 for moving the stage 143 along the circular-arc-shaped rail 142. As a driving source of the stage driving device 144, for example, a fluid pressure cylinder (e.g., a hydraulic cylinder, or a gas cylinder) is connected to the stage 143. On the stage 143, a guide holder 123 is installed via guide holder moving rails 151 and 151

which will be mentioned later. As mentioned above, the guide 120 is accommodated in the guide holder 123.

[0190] In this guide pivotally moving mechanism 141, by operating the stage driving device 144, as shown in Figs. 11 and 12, the guide 120 is moved along the circular-arc-shaped rail 142 together with the stage 143, whereby the guide 120 is pivotally moved about the pivotal axis P. Thus, the pivotal movement of the guide 120 causes bending of the expansion scheduled portion 102 of the raw material 101 in the width wise direction during the expansion process.

[0191] In the present invention, the guide pivotally moving mechanism 141 is not limited to the aforementioned mechanism utilizing an circular-arc-shaped rail 142, and can be, for example, a gear mechanism.

[0192] Furthermore, this upsetting apparatus 110 is equipped with two change mechanisms 150 and 150 each for changing the position of the pivotal axis P of each guide 20.

[0193] Both the change mechanisms 150 are 150 are the same in structure. As shown in Figs. 7 and 10, each change mechanism 150 has guide holder moving rails 151 and 151 laid on the stage 143, a guide holder driving device 152 for moving the guide holder 123 on the rails 151 and 151, receiving die moving rails 153 and 153, and receiving die driving devices 154 and 154 for moving the receiving die 111 on the rails 153 and 153. The receiving die 111 is moved by the driving force of the receiving die driving devices 154 and 154 along the receiving die moving rails 153 and 153. The guide holder moving rail 151 and the receiving die moving rail 153 are laid on a horizontal floor surface (not shown) so as to extend in a direction perpendicular to the material axis and in a horizontal direction. As a driving source of the guide holder driving device 154, for example, a fluid-pressure cylinder is connected to the receiving die 111. Moreover, for example, a fluid-pressure cylinder is connected to the guide holder 123 as a driving source of the guide holder driving device 152.

[0194] In this change mechanism 150, as shown in Fig. 14, the guide 120 is moved together with the entire guide holder 123 relative to the stage 143 along the rails 151 by operating the guide holder driving device 152. At the same time, the receiving die 111 is moved along the rails 153 by operating the receiving die driving device 154. The moving direction of the guide 120 and the receiving die 111 is, for example, a width direction of the expansion scheduled portion 102 of the raw material 101. Thus, the position of pivotal axis P can be changed by moving both the guide 120 and the receiving die 111 in the same direction.

[0195] The position of the pivotal axis P can be on the axis of the raw material 101 as shown in Fig. 10, and can also be a position distant from the axis of the raw material 101 as shown in Fig. 14. That is, in the present invention, the position of the pivotal axis P can be variously changed under the conditions that the receiving die 111 and the guide 120 do not interfere at the time of the bending step.

[0196] Next, an upsetting method using the aforementioned upsetting apparatus 110 will be explained below.

[0197] First, as shown in Figs. 7 and 10, the non-expansion scheduled portion 103 of the raw material 101 is disposed in the holding hole 112 of the receiving die 111. Thus, the non-expansion scheduled portion 103 of the raw material 101 is held in the holding hole 112 in a buckling prevented state and in an axial movement prevented state.

[0198] Furthermore, both the expansion scheduled portions 102 and 102 of the raw material 101 are disposed in the corresponding insertion hole 121 of the guide 120 [Arrangement Step of a raw material expansion scheduled portion]. Thereby, each expansion scheduled portion 102 of the raw material 101 is held within the insertion hole 121 in a buckling prevented state. In this state, the supporting wall portion 116 is in contact with one of the protruded portions 122 and 122 of the guide 120, whereby the protruded portion 122 is supported by the supporting wall portion 116.

[0199] Subsequently, the guides 120 are simultaneously each moved in a direction opposite to the moving direction of the corresponding punch 130 by the corresponding guide driving device 125 while simultaneously pressurizing both the expansion scheduled portions 102 and 102 of the raw material 101 in the axial direction by the corresponding punch 130. With this, as shown in Fig. 11, both the expansion scheduled portions 102 and 102 of the raw material 101 exposed between the tip end portion of each guide 120 and the corresponding receiving face 113 of the receiving die 111 are simultaneously expanded radially outwardly, respectively, in a state in which expansion of both the thickness side contacting portions of each expansion scheduled portion 102 in contact with both the protruded portions 122 and 122 of the guide 120 are controlled and also in a state in which expansion of both the thickness side contacting portions of each expansion scheduled portion 102 in contact with both the wall portions 114 and 114 of the receiving die 111 is controlled [Expansion Step].

[0200] Now, a portion of the expansion scheduled portion 102 of the raw material 101 which will be expanded radially outwardly at this expansion step will be detailed below. The portion denotes a portion other than the contacting portions of the expansion scheduled portion 102 in contact with both the protruded portions 122 and 122 of the guide 120, and a portion other than the contacting portions of the expansion scheduled portion 102 in contact with both the side wall portions 114 and 114 of the receiving die 111. That is, the expansion scheduled portion 102 will be expanded radially outwardly such that the non-contacting portion not in contact with both the protruded portions 122 and 122 of the guide 120 and both the side wall portions 114 and 114 of the receiving die 111 will be expanded radially outwardly.

[0201] Furthermore, as shown in Fig. 11, in this expansion step, both the expansion scheduled portions 102 and 102 are simultaneously bent in the width direction

thereof with the corresponding bending device 140 while simultaneously expanding both the expansion scheduled portions 102 and 102 of the raw material 101 [Bending Step].

[0202] The bending method by this bending device 140 will be explained as follows.

[0203] That is, in a state in which the position of the receiving die 111 is fixed, both the stage driving devices 144 and 144 of both the bending devices 140 and 140 are operated simultaneously while simultaneously expanding both the expansion scheduled portions 102 and 102 of the raw material 101 at the expansion step. As a result, in a state in which a part of the expansion scheduled portion 102 of the raw material 101 remains in the insertion hole 121 of each guide 120, each guide 120 is pivotally moved about the pivotal axis P together with the entire stage 143 along the circular-arc-shaped rail 142. As the guide 120 is pivotally moved as mentioned above while expanding the expansion scheduled portion 102 of the raw material 101, the expansion scheduled portion 102 of the raw material 101 is bent in the width direction with the expansion scheduled portion 102 supported by the supporting portion 115 in a buckling prevented state. At the time of this expansion, the material of the expansion scheduled portion 102 can be received by the receiving face 113 of the receiving die 111.

[0204] The traveling speed of the stage 143, namely, the speed for bending the expansion scheduled portion 102 of the raw material 101, can be arbitrarily set depending on the desired shape of the expanded portion 106.

[0205] In this embodiment, although the stage driving devices 144 and 144 of both the bending devices 140 and 40 are operated simultaneously, the present invention does not necessarily require such simultaneous operation. That is, in the present invention, it is not necessary to bend both the expansion scheduled portions 102 and 102 simultaneously. One of the expansion scheduled portions 102 and 102 can be first bent, and thereafter the other expansion scheduled portion 102 can be bent.

[0206] Then, as shown in Fig. 12, when each expansion scheduled portion 102 of the raw material 101 has been expanded into a predetermined shape, the movement of the stage 143 and the punch 130 will be stopped. At the same time, the movement of the guide 120 will be stopped.

[0207] Subsequently, the raw material 101 is taken out from the holding hole 112 of the receiving die 111 to obtain a desired upsetting manufactured product 105 shown in Fig. 13.

[0208] The upsetting manufactured product 105 obtained as mentioned above is used as a preform, and the expanded portion 106 is subjected to a post-process as needed. As such post-process, hole punching for opening a holding hole for holding a bush in the expanded portion 106 can be exemplified.

[0209] In this upsetting method, at the time of the initiation of pressurizing the expansion scheduled portion

102 of the raw material 101 by the punch 130, i.e., at the time of the initiation of expanding the expansion scheduled portion 102 of the raw material 101, the length of the expansion scheduled portion 102 of the raw material 101 exposed between the tip end portion of the guide 120 and the receiving face 113 of the receiving die 111 is set to be not larger than the buckling limit length (preferably below the buckling limit length) of the expansion scheduled portion 102.

[0210] A time lag can be set between the initiation of pressurizing the raw material expansion scheduled portion 102 by the punch 130 and the initiation of moving the guide 120. This increases the cross-sectional area of the expansion scheduled portion 102 at the early stage of the expansion, resulting in more assured prevention of the buckling.

[0211] With this upsetting method, in manufacturing a preform for a product having an expanded portion 106 expanded in the widthwise direction with the thickness side expansion prevented and bent with respect to the axial direction, a preform having a shape more closer to a product can be manufactured.

[0212] In this upsetting method, at both the expansion step and the bending step, the raw material 101 is not rotated about its axis, i.e., the raw material 101 is not self-axially rotated. Therefore, the expansion scheduled portion 102 of the raw material 101 can be expanded unevenly in the peripheral direction. On the other hand, in the case of bending the expansion scheduled portion 102 of the raw material 101 while self-axially rotating the raw material 101, the expansion scheduled portion 102 will be expanded evenly in the peripheral direction, and therefore uneven expansion cannot be attained.

[0213] According to the upsetting method of the aforementioned third embodiment, by moving the guide 120 in a direction opposite to the moving direction of the punch 130 while pressurizing the expansion scheduled portion 102 of the raw material 101 with the punch 130 in the axial direction, the expansion scheduled portion 102 of the raw material 101 exposed between the tip end portion of the guide 120 and the receiving face 113 of the receiving die 111 will be expanded radially outwardly. Therefore, buckling of the raw material 101, which may occur at the time of upsetting, can be prevented.

[0214] Furthermore, at the expansion step, since the expansion scheduled portion 102 is bent in the width direction while expanding the expansion scheduled portion 102 of the raw material 101, the expansion scheduled portion 102 can be bent under a lighter load, and it is possible to prevent occurrence of wrinkles at the bending inner side surface portion of the expanded portion 106.

[0215] Furthermore, since the expansion scheduled portion 102 is bent in the width direction while expanding the expansion scheduled portion 102 of the raw material 101, the expansion of the expansion scheduled portion 102 can be performed under a lighter load. That is, when the expansion scheduled portion 102 is bent while pressurizing the expansion scheduled portion 102 in the axial

direction in order to expand the expansion scheduled portion 102 of the raw material 101, the expansion scheduled portion 102 is deformed so as to be expanded toward the side opposite to the bending side of the expansion scheduled portion 102 by the same principle as stretch forming. Therefore, as compared with the case in which the expansion scheduled portion 102 is expanded without bending the expansion scheduled portion 102, the expansion of the expansion scheduled portion 102 can be performed under a lighter load.

[0216] Furthermore, the expansion scheduled portion 102 of the raw material 101 is expanded radially outwardly in a state in which the expansion of the contacting portion of the thickness direction both sides of the expansion scheduled portion 102 in contact with both the protruded portions 122 and 122 of the guide 120 is controlled and in the state in which the expansion of the contacting portion of the thickness direction both side surfaces of the expansion scheduled portion 102 in contact with both the side wall portions 114 and 114 of the receiving die 111 is controlled. Therefore, the expansion of the thickness direction both sides of the expansion scheduled portion 102 can be controlled assuredly. As a result, an expanded portion 106 in which the expansion of the thickness direction both sides is controlled assuredly can be formed.

[0217] Furthermore, at the expansion step, since both the expansion scheduled portions 102 and 102 of the raw material 101 are simultaneously expanded radially outwardly, an upsetting manufactured product 105 having expanded portions 106 and 106 formed at the axial end portions can be manufactured efficiently.

[0218] Moreover, since each receiving face 113 of the receiving die 111 is formed into a die surface for forming a part of the width direction both sides of the expansion scheduled portion 102 of the raw material 101 into a predetermined shape, the width direction both sides of the expansion scheduled portion 102 of the raw material 101 can be formed into a shape close to a product shape, respectively.

[0219] Moreover, at the bending step, the expansion scheduled portion 102 of the raw material 101 can be assuredly bent into the width direction by pivotally turning the guide 120 about the pivotal axis P parallel to the thickness direction of the expansion scheduled portion 102 of the raw material 101.

[0220] Moreover, since the tip end portion of each protruded portion 122 of the guide 120 is formed into a convex circular-arc-shape curved along the widthwise direction of the expansion scheduled portion 102 of the raw material 101, the interference of the tip end portion 122b of the protruded portion 122 of the guide 120 to the receiving die 111 can be prevented at the bending step.

[0221] Naturally, in this upsetting method, since a forming die having a closed-cavity is not used, processing can be performed at low cost.

[0222] Furthermore, since this upsetting apparatus 110 is equipped with the change mechanism 150 for

changing the position of the pivotal axis P of the guide 120, the position of the pivotal axis P can be changed in accordance with the bent shape of the desired expanded portion 106. Therefore, the bent shape of the expanded portion 106 can be changed variously.

[0223] Furthermore, since the expansion scheduled portion 102 is bent with the expansion scheduled portion 102 of the raw material 101 supported in a buckling prevented state by the supporting portion 115, buckling of the expansion scheduled portion 102 can be assuredly prevented at the time of the bending step.

[0224] Although some embodiments of the present invention were explained above, the present invention is not limited to the aforementioned embodiments, and various changes can be applied.

[0225] For example, in the aforementioned embodiment, both the expansion scheduled portions 102 and 102 of the raw material 101 are bent. In the present invention, however, other than the above, only one of the expansion scheduled portions 102 and 102 of the raw material 101 can be bent.

[0226] In the aforementioned embodiment, the raw material 101 has two expansion scheduled portions 102. In the present invention, however, only one portion of the raw material 101, such as, e.g., one of the axial side portions of the expansion scheduled portion 102 of the raw material 101, or an axial intermediate portion, can be bent. Moreover, in the present invention, in cases where the number of the expansion scheduled portion 102 of the raw material 101 is one, the guide 120 can be pivotally moved about the pivotal axis P as shown in the aforementioned embodiment, or the receiving die 111 can be pivotally moved about the pivotal axis P without moving the guide 120 with the position of the guide 120 fixed. Furthermore, both the guide 120 and the receiving die 111 can be pivotally moved about the pivotal axis P.

[0227] Furthermore, in the aforementioned embodiment, the number of the protruded portions 122 of each guide 120 is two. In the present invention, however, the number of the protruded portions 122 can be one.

[0228] Furthermore, in the aforementioned embodiment, the number of the side wall portions 114 of each receiving face 113 of the receiving die 111 is two. In the present invention, however, the number of the side wall portions 114 can be one.

[0229] Furthermore, in the aforementioned embodiment, at the tip end portion of each of two guides 120 and 120, a protruded portion 122 is provided. In the present invention, however, for example, the protruded portion 122 can be provided only at the tip end portion of one of the two guides 120 and 120.

[0230] Furthermore, in the aforementioned embodiment, at both the receiving faces 113 and 113 of the receiving die 111, the side wall portions 114 are provided. In the present invention, however, for example, the side wall portion 114 can be provided only at one of the receiving faces 113 and 113 among both the receiving faces 113 and 113 of the receiving die 111.

[0231] Moreover, in the present invention, at the expansion step, the expansion can be completed with a part of the expansion scheduled portion 102 of the raw material 101 remained in the insertion hole 121 of the guide 120, or the expansion can be completed immediately after the pushing of the entire expansion scheduled portion 102t out of the insertion hole 121 of the guide 120.

[0232] Moreover, in the present invention, at the time of the expansion step and the bending step, the raw material 101 can be heated or not heated. That is, in the present invention, the processing temperature conditions of the raw material 101 are not limited.

[0233] Naturally, the upsetting method and the upsetting apparatus according to the present invention are not limited to a method or apparatus for manufacturing a preform for manufacturing an arm for vehicles. They can be used to manufacture various preforms for industrial products, such as, e.g., a preform for shafts, a preform for frames, a preform for connecting rods, or a preform for pistons of a compressor.

[0234] This application claims priority to Japanese Patent Application No. 2005-262192 filed on September 9, 2005, U.S. Provisional Application No. 60/716,520 filed on September 14, 2005, Japanese Patent Application No. 2005-307849 filed on October 21, 2005, and U.S. Provisional Application No. 60/730,366 filed on October 27, 2005, the entire disclosures of which are incorporated herein by reference in their entireties.

[0235] 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.

[0236] 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.

[0237] 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

[0238] The present invention can be applied to an up-

setting method and an upsetting apparatus used in manufacturing a product having an expanded portion expanded radially outwardly, such as, e.g., an arm or a connecting rod for vehicles (cars, rail road vehicles, etc.).

Claims

1. An upsetting method, comprising the steps of:

attaching a bar-shaped raw material to a receiving die in an axial movement prevented state, and arranging an expansion scheduled portion of the raw material in an insertion hole formed in a guide for holding the expansion scheduled portion of the raw material in a buckling prevented state; and then radially outwardly expanding the expansion scheduled portion of the raw material exposed between a tip end portion of the guide and the receiving die by moving the guide in a direction opposite to a moving direction of a punch while pressurizing the expansion scheduled portion of the raw material with the punch in an axial direction,

wherein the expansion scheduled portion is bent while expanding the expansion scheduled portion of the raw material.

2. The upsetting method as recited in claim 1, wherein the expansion scheduled portion is bent in a state in which the expansion scheduled portion is supported by a supporting portion arranged at an expansion scheduled portion bending side with respect to the expansion scheduled portion of the raw material in a buckling prevented state.
3. The upsetting method as recited in claim 1 or 2, wherein the expansion scheduled portion of the raw material is bent by pivotally moving at least one of the guide and the receiving die about a pivotal axis perpendicular to a plane including an axis of the raw material.
4. An upsetting manufactured product obtained by the upsetting method as recited in claim 1.

5. An upsetting method, comprising the steps of:

attaching an axial intermediate portion of a bar-shaped raw material to a receiving die in an axial movement prevented state, and arranging expansion scheduled portions of axial both end portions of the raw material in an insertion hole for holding the expansion scheduled portion of the raw material formed in a guide in a buckling prevented state, respectively; and then

simultaneously expanding both the expansion scheduled portions of the raw material exposed between a tip end portion of each guide and the receiving die radially outwardly, respectively, by moving each guide in a direction opposite to a moving direction of a corresponding punch while simultaneously pressurizing both the expansion scheduled portions of the raw material with the punch in an axial direction, respectively,

wherein at least one of both the expansion scheduled portions of the raw material is bent while simultaneously expanding both the expansion scheduled portions of the raw material, respectively.

6. The upsetting method as recited in claim 5, wherein the expansion scheduled portion is bent in a state in which the expansion scheduled portion is supported by a supporting portion arranged at an expansion scheduled portion bending side with respect to the expansion scheduled portion of the raw material in a buckling prevented state.
7. The upsetting method as recited in claim 5 or 6, wherein the expansion scheduled portion of the raw material is bent by pivotally moving the guide about a pivotal axis perpendicular to a plane including a raw material axis.
8. An upsetting manufactured product obtained by the upsetting method as recited in claim 5.
9. An upsetting apparatus, comprising:
- a receiving die to which a bar-shaped raw material is attached in an axial movement prevented state;
- a guide having an insertion hole for holding an expansion scheduled portion of the raw material in a buckling prevented state;
- a punch for pressurizing the expansion scheduled portion of the raw material arranged in the insertion hole of the guide in an axial direction; and
- a guide driving device for moving the guide in a direction opposite to a moving direction of the punch,
- wherein the upsetting apparatus is configured to radially outwardly expand the expansion scheduled portion of the raw material exposed between a tip end portion of the guide and the receiving die, and wherein a bending device for bending the expansion scheduled portion of the raw material is provided.
10. The upsetting apparatus as recited in claim 9, wherein the upsetting apparatus is configured to bend the expansion scheduled portion of the raw material by

the bending device while expanding the expansion scheduled portion of the raw material.

11. The upsetting apparatus as recited in claim 9 or 10, further comprising a supporting portion arranged at a bending side of the expansion scheduled portion of the raw material with respect to the expansion scheduled portion to support the expansion scheduled portion in a buckling prevented state. 5
12. The upsetting apparatus as recited in claim 9, wherein the bending device is configured to bend the expansion scheduled portion of the raw material by pivotally moving at least one of the guide and the receiving die about a pivotal axis perpendicular to a plane including a raw material axis. 10
13. The upsetting apparatus as recited in claim 12, further comprising a change mechanism for changing a position of the pivotal axis. 15
14. An upsetting apparatus, comprising:

a receiving die to which a bar-shaped raw material is attached in an axial movement prevented state; 25
two guides each having an insertion hole for holding each of axial both end expansion scheduled portions of the raw material in a buckling prevented state; 30
two punches each for pressurizing each expansion scheduled portion of the raw material arranged in the insertion hole of each guide in an axial direction; and
two guide driving devices each for moving each guide in a direction opposite to a moving direction of the corresponding punch, 35

wherein the upsetting apparatus is configured to radially outwardly expand both the expansion scheduled portions of the raw material each exposed between a tip end portion of the guide and the receiving die, and 40
wherein a bending device for bending at least one of the expansion scheduled portions of the raw material is provided. 45
15. The upsetting apparatus as recited in claim 14, wherein the upsetting apparatus is configured to bend the expansion scheduled portion of the raw material by the bending device while expanding the expansion scheduled portion of the raw material. 50
16. The upsetting apparatus as recited in claim 14 or 15, further comprising a supporting portion arranged at a bending side of the expansion scheduled portion of the raw material with respect to the expansion scheduled portion to support the expansion sched- 55

uled portion in a buckling prevented state.

17. The upsetting apparatus as recited in claim 14, wherein the bending device is configured to bend the expansion scheduled portion of the raw material by pivotally moving the guide about a pivotal axis perpendicular to a plane including a raw material axis. 5
18. The upsetting apparatus as recited in claim 17, further comprising a changing mechanism for changing a position of the pivotal axis. 10
19. An upsetting method, comprising:

a step of preparing an upsetting apparatus equipped with a receiving die having a receiving face and a holding hole for holding a non-expansion scheduled portion of a bar-shaped raw material in a buckling prevented state formed at the receiving face, a guide having an insertion hole for holding an expansion scheduled portion of the raw material in a buckling prevented state, and a punch, wherein an expansion preventing protruded portion integrally protruded at a tip end portion of the guide in an axial direction of the guide; 15
a step of arranging the expansion scheduled portion of the raw material in the insertion hole of the guide with the non-expansion scheduled portion held in the holding hole of the receiving die; 20
a step of radially outwardly expanding the expansion scheduled portion of the raw material exposed between a tip end portion of the guide and the receiving face of the receiving die in a state in which an expansion of a contacting portion of at least one of thickness side surfaces of the expansion scheduled portions in contact with the guide protruded portion is controlled by moving the guide in a direction opposite to a moving direction of the punch while pressurizing the expansion scheduled portion of the raw material with the punch in an axial direction after the step of arranging the expansion scheduled portion of the raw material; and 25
a step of bending the expansion scheduled portion of the raw material in its width direction while expanding the expansion scheduled portion of the raw material expand at the expansion step. 30
20. The upsetting method as recited in claim 19, wherein an expansion preventing side wall portion is provided at the receiving face of the receiving die in a protruded manner, and wherein at the expansion step, the expansion scheduled portion of the raw material is expanded radially outwardly in a state in which an expansion of a contacting portion of at least one of 35

thickness side surfaces of the expansion scheduled portion in contact with the guide protruded portion is controlled and also in a state in which a contacting portion of at least one of thickness side surfaces of the expansion scheduled portion in contact with the receiving die side wall portion is controlled.

21. The upsetting method as recited in claim 20, wherein the receiving die side wall portion is protruded from the receiving face of the receiving die at each of thickness side surfaces of the expansion scheduled portion of the raw material.

22. The upsetting method as recited in claim 19, wherein the protruded portion of the guide is integrally provided at each of portions of a tip end portion of the guide opposed across the insertion hole.

23. The upsetting method as recited in claim 19, wherein the receiving face of the receiving die is formed into a forming face for forming at least a portion of at least one side surface among widthwise side surfaces of the expansion scheduled portion of the raw material.

24. The upsetting method as recited in claim 19, wherein at the bending step, the expansion scheduled portion of the raw material is bent in its widthwise direction by pivotally moving at least one of the guide and the receiving die about a pivotal axis parallel to a thickness direction of the expansion scheduled portion of the raw material.

25. The upsetting method as recited in claim 24, wherein the tip end portion of the protruded portion of the guide is formed into an circular-arc-shape forwardly protruded along the widthwise direction of the expansion scheduled portion of the raw material.

26. The upsetting method as recited in claim 19, wherein at the bending step, the expansion scheduled portion of the raw material is bent in its widthwise direction in a state in which the expansion scheduled portion is supported by a supporting portion arranged at an expansion scheduled portion bending side with respect to the expansion scheduled portion of the raw material in a buckling prevented state.

27. An upsetting manufactured product obtained by the upsetting method as recited in claim 19.

28. An upsetting method
a step of preparing an upsetting apparatus equipped with a receiving die having receiving faces at both axial end portions and a holding hole for holding a non-expansion scheduled portion of an axial central portion of a bar-shaped raw material in a buckling prevented state formed so as to communicate both the receiving faces, two guides each having an in-

sertion hole for holding an expansion scheduled portion of the raw material in a buckling prevented state, and two punches, wherein an expansion preventing protruded portion is protruded from a tip end portion of at least one of the guides in an axial direction thereof;

a step of arranging both the expansion scheduled portions of the raw material in a respective insertion hole of the guide with the non-expansion scheduled portion held in the holding hole of the receiving die; a step of radially outwardly expanding the expansion scheduled portion of the raw material exposed between a tip end portion of each guide and the receiving face of the receiving die in a state in which an expansion of a contacting portion of at least one of thickness side surfaces of the expansion scheduled portions in contact with the guide protruded portion is controlled by moving each guide in a direction opposite to a moving direction of the corresponding punch while pressurizing both the expansion scheduled portions of the raw material with the punches in an axial direction after the step of arranging the expansion scheduled portion of the raw material; and a step of bending at least one of the expansion scheduled portions in its width direction while expanding both the expansion scheduled portions of the raw material in the expansion step.

29. The upsetting method as recited in claim 28, wherein an expansion preventing side wall portion is provided at at least one of the receiving faces of the receiving die in a protruded manner, and wherein at the expansion step, both the expansion scheduled portions of the raw material are simultaneously expanded radially outwardly in a state in which an expansion of a contacting portion of at least one of thickness side surfaces of the expansion scheduled portion in contact with the guide protruded portion is controlled and also in a state in which a contacting portion of at least one of thickness side surfaces of the expansion scheduled portion in contact with the receiving die side wall portion is controlled.

30. The upsetting method as recited in claim 29, wherein the receiving die side wall portion is protruded from the receiving face of the receiving die at each of thickness side surfaces of the expansion scheduled portion of the raw material.

31. The upsetting method as recited in claim 28, wherein the protruded portion of the guide is integrally provided at each of portions of a tip end portion of the guide opposed across the insertion hole.

32. The upsetting method as recited in claim 28, wherein at least one of the receiving faces of the receiving die is formed into a forming face for forming at least

a portion of at least one side among widthwise side surfaces of the expansion scheduled portion of the raw material.

33. The upsetting method as recited in claim 28, wherein at the bending step, the expansion scheduled portion of the raw material is bent in its widthwise direction by pivotally moving the guide about a pivotal axis parallel to a thickness direction of the expansion scheduled portion of the raw material. 5
34. The upsetting method as recited in claim 33, wherein the tip end portion of the protruded portion of the guide is formed into an circular-arc-shape forwardly protruded along the widthwise direction of the expansion scheduled portion of the raw material. 10
35. The upsetting method as recited in claim 28, wherein at the bending step, the expansion scheduled portion of the raw material is bent in its widthwise direction in a state in which the expansion scheduled portion is supported by a supporting portion arranged at an expansion scheduled portion bending side with respect to the expansion scheduled portion of the raw material in a buckling prevented state. 20 25
36. An upsetting manufactured product obtained by the upsetting method as recited in claim 28.
37. An upsetting apparatus, comprising: 30
- a receiving die having a receiving face and a holding hole for holding a non-expansion scheduled portion of a bar-shaped raw material in a buckling prevented state formed at the receiving face;
 - a guide having an insertion hole for holding an expansion scheduled portion of the raw material in a buckling prevented state;
 - a punch for pressurizing the expansion scheduled portion of the raw material arranged in the insertion hole of the guide in an axial direction; and
 - a guide driving device for moving the guide in a direction opposite to a moving direction of the punch, 45
- wherein the upsetting apparatus is configured to radially outwardly expand the expansion scheduled portion of the raw material exposed between a tip end portion of the guide and the receiving face of the receiving die, 50
- wherein an expansion preventing protruded portion protruded in an axial direction of the guide is integrally provided at the tip end portion of the guide, 55
- wherein the protruded portion of the guide is configured to control an expansion of a contacting portion of the expansion scheduled portion by a contact with

at least one of thickness side surfaces of the expansion scheduled portion at the time of expanding the expansion scheduled portion of the raw material, and wherein the upsetting apparatus further comprises a bending device for bending the expansion scheduled portion of the raw material in its width direction.

38. The upsetting apparatus as recited in claim 37, wherein the bending device is configured to bend the expansion scheduled portion of the raw material in its width direction at the time of expanding the expansion scheduled portion of the raw material.
39. The upsetting apparatus as recited in claim 37, wherein an expansion preventing side wall portion is provided at the receiving face of the receiving die in a protruded manner, and wherein the side wall portion of the receiving die controls expansion of a contacting portion of the expansion scheduled portion by a contact with at least one side surfaces among thickness side surfaces of the expansion scheduled portion at the time of expanding the expansion scheduled portion of the raw material.
40. The upsetting apparatus as recited in claim 39, wherein the receiving die side wall portion is protruded from the receiving face of the receiving die at each of thickness side surfaces of the expansion scheduled portion of the raw material.
41. The upsetting apparatus as recited in claim 37, wherein the protruded portion of the guide is integrally provided at each of portions of a tip end portion of the guide opposed across the insertion hole. 35
42. The upsetting apparatus as recited in claim 37, wherein the receiving face of the receiving die is formed into a forming face for forming at least a portion of at least one side surface among widthwise side surfaces of the expansion scheduled portion of the raw material. 40
43. The upsetting apparatus as recited in claim 37, wherein the bending device is configured to bend the expansion scheduled portion of the raw material in its widthwise direction by pivotally moving at least one of the guide and the receiving die about a pivotal axis parallel to a thickness direction of the expansion scheduled portion of the raw material. 45
44. The upsetting apparatus as recited in claim 43, wherein the tip end portion of the protruded portion of the guide is formed into an circular-arc-shape forwardly protruded along the widthwise direction of the expansion scheduled portion of the raw material. 55
45. The upsetting apparatus as recited in claim 43, fur-

ther comprising a change mechanism for changing a position of the pivotal axis.

46. The upsetting apparatus as recited in claim 37, further comprising a supporting portion arranged at a bending side of the expansion scheduled portion with respect to the expansion scheduled portion of the raw material to support the expansion scheduled portion in a buckling prevented state.

47. An upsetting apparatus, comprising:

a receiving die having receiving faces at axial both end portions and a holding hole for holding a non-expansion scheduled portion of a bar-shaped raw material in a buckling prevented state formed so as to communicate both the receiving faces;
two guides each having an insertion hole for holding an expansion scheduled portion of the raw material in a buckling prevented state;
two punches each for pressurizing the expansion scheduled portion of the raw material arranged in the insertion hole of each guide in an axial direction; and
two guide driving devices each for moving each guide in a direction opposite to a moving direction of the corresponding punch,

wherein the upsetting apparatus is configured to radially outwardly expand both the expansion scheduled portions of the raw material exposed between a tip end portion of each guide and the corresponding receiving face of the receiving die,
wherein an expansion preventing protruded portion protruded in an axial direction of the guide is provided at the tip end portion of at least one of the guides,
wherein the protruded portion of the guide is configured to control an expansion of a contacting portion of the expansion scheduled portion by a contact with at least one of thickness side surfaces of the expansion scheduled portion at the time of expanding the expansion scheduled portion of the raw material, and
wherein the upsetting apparatus further comprises a bending device for bending at least one of the expansion scheduled portions of the raw material in a width direction.

48. The upsetting apparatus as recited in claim 47, wherein the bending device is configured to bend the expansion scheduled portion of the raw material in its width direction at the time of expanding the expansion scheduled portion of the raw material.

49. The upsetting apparatus as recited in claim 47, wherein expansion preventing side wall portion is provided at at least one of the receiving faces of the receiving die in a protruded manner, and

wherein the side wall portion of the receiving die controls an expansion of a contacting portion of the expansion scheduled portion by a contact with at least one side surfaces among thickness side surfaces of the expansion scheduled portion at the time of expanding the expansion scheduled portion of the raw material.

50. The upsetting apparatus as recited in claim 49, wherein the receiving die side wall portion is protruded from the receiving face of the receiving die at each of thickness side surfaces of the expansion scheduled portion of the raw material.

51. The upsetting apparatus as recited in claim 47, wherein the protruded portions of the guide is integrally provided at each of portions of a tip end portion of the guide opposed across the insertion hole.

52. The upsetting apparatus as recited in claim 47, wherein at least one of the receiving faces of the receiving die is formed into a forming face for forming at least a portion of at least one side surface among widthwise side surfaces of the expansion scheduled portion of the raw material into a predetermined shape.

53. The upsetting apparatus as recited in claim 47, wherein the bending device is configured to bend the expansion scheduled portion of the raw material in its widthwise direction by pivotally moving the guide about a pivotal axis parallel to a thickness direction of the expansion scheduled portion of the raw material.

54. The upsetting apparatus as recited in claim 53, wherein the tip end portion of the protruded portion of the guide is formed into an circular-arc-shape forwardly protruded along the widthwise direction of the expansion scheduled portion of the raw material.

55. The upsetting apparatus as recited in claim 53, further comprising a change mechanism for changing a position of the pivotal axis.

56. The upsetting apparatus as recited in claim 47, further comprising a supporting portion arranged at a bending side of the expansion scheduled portion with respect to the expansion scheduled portion of the raw material to support the expansion scheduled portion in a buckling prevented state.

Fig. 1

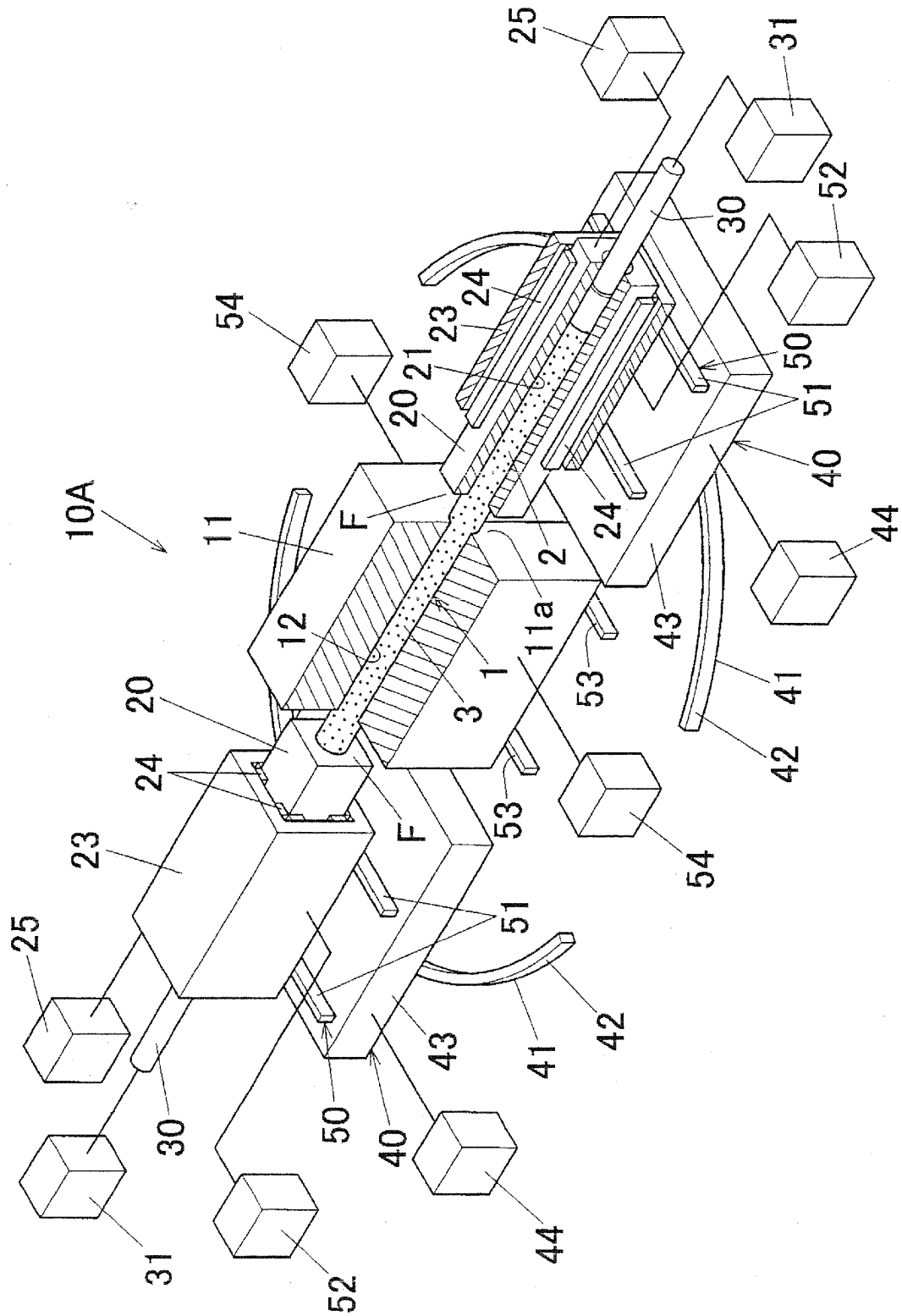


Fig. 2

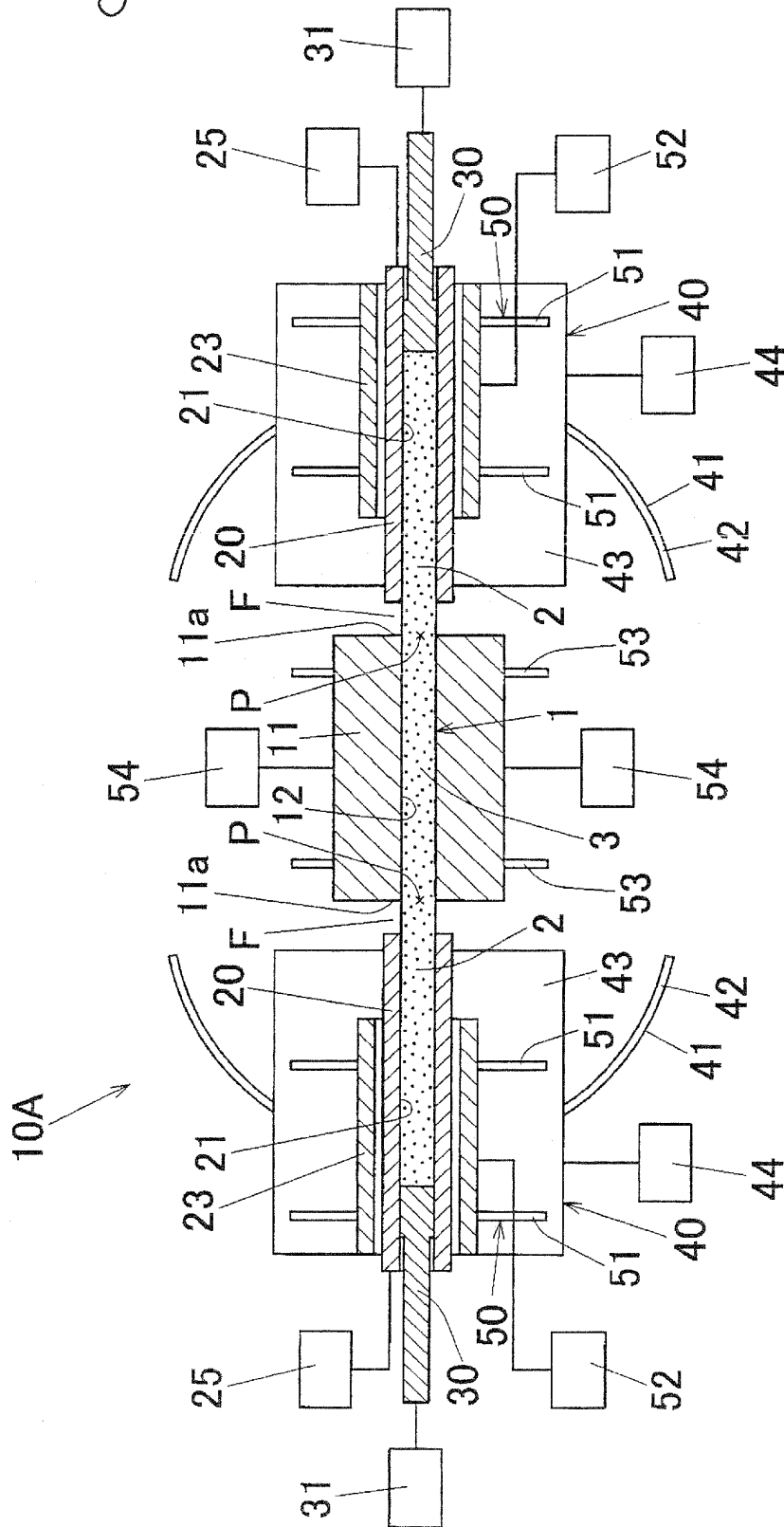


Fig. 3

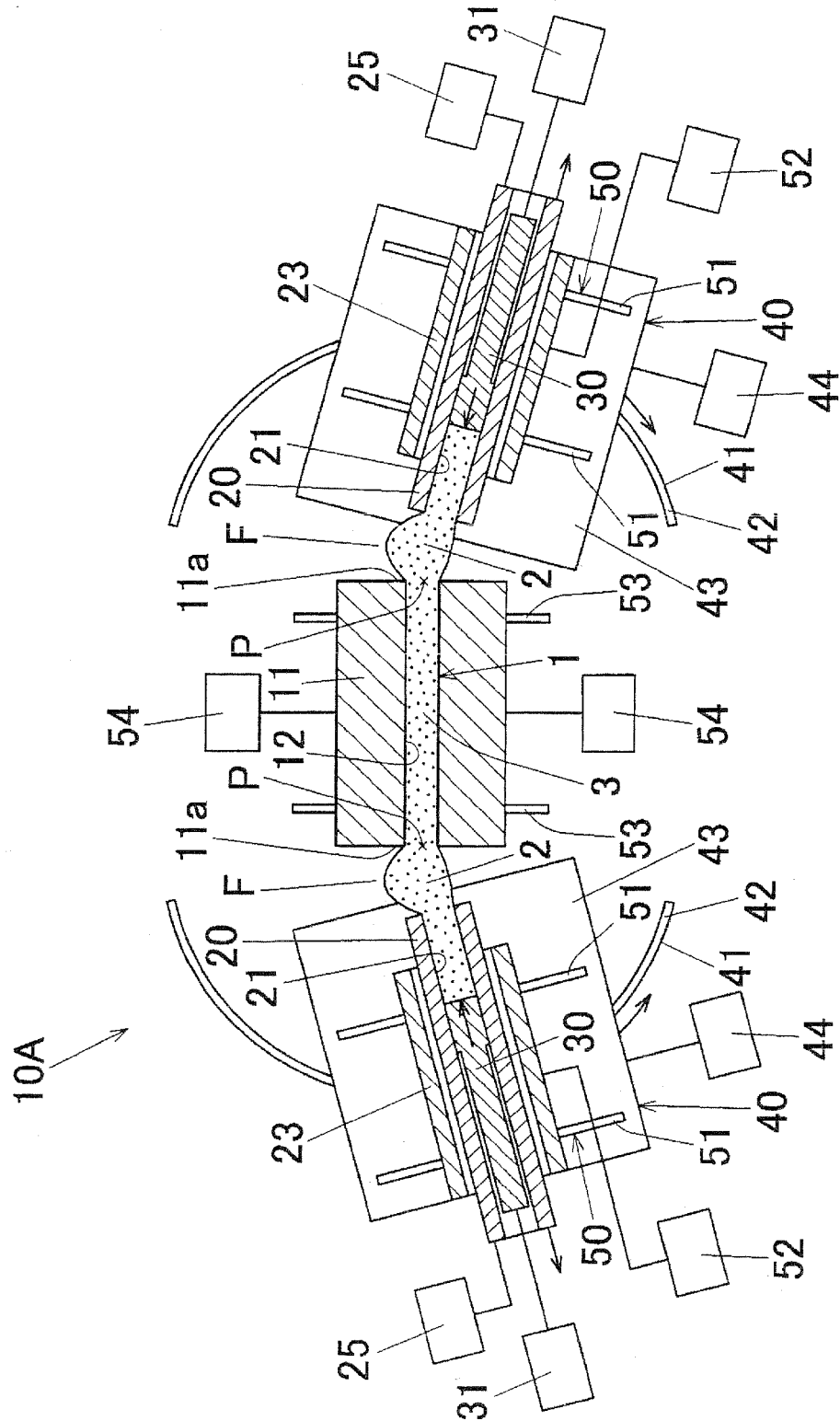


Fig. 4

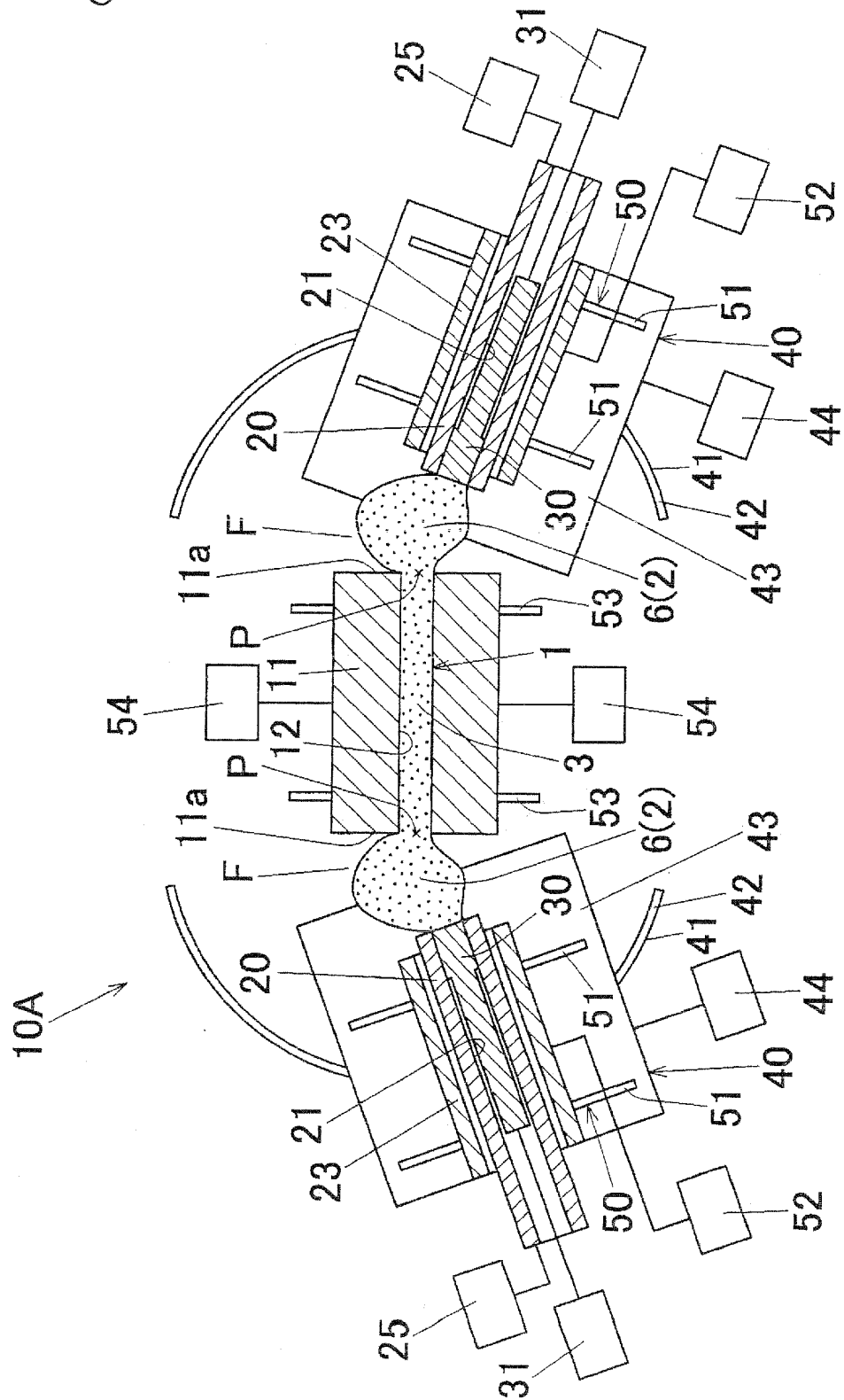


Fig. 5

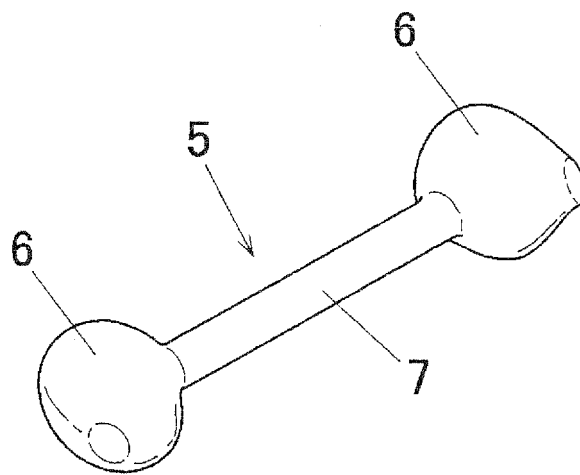


Fig. 6

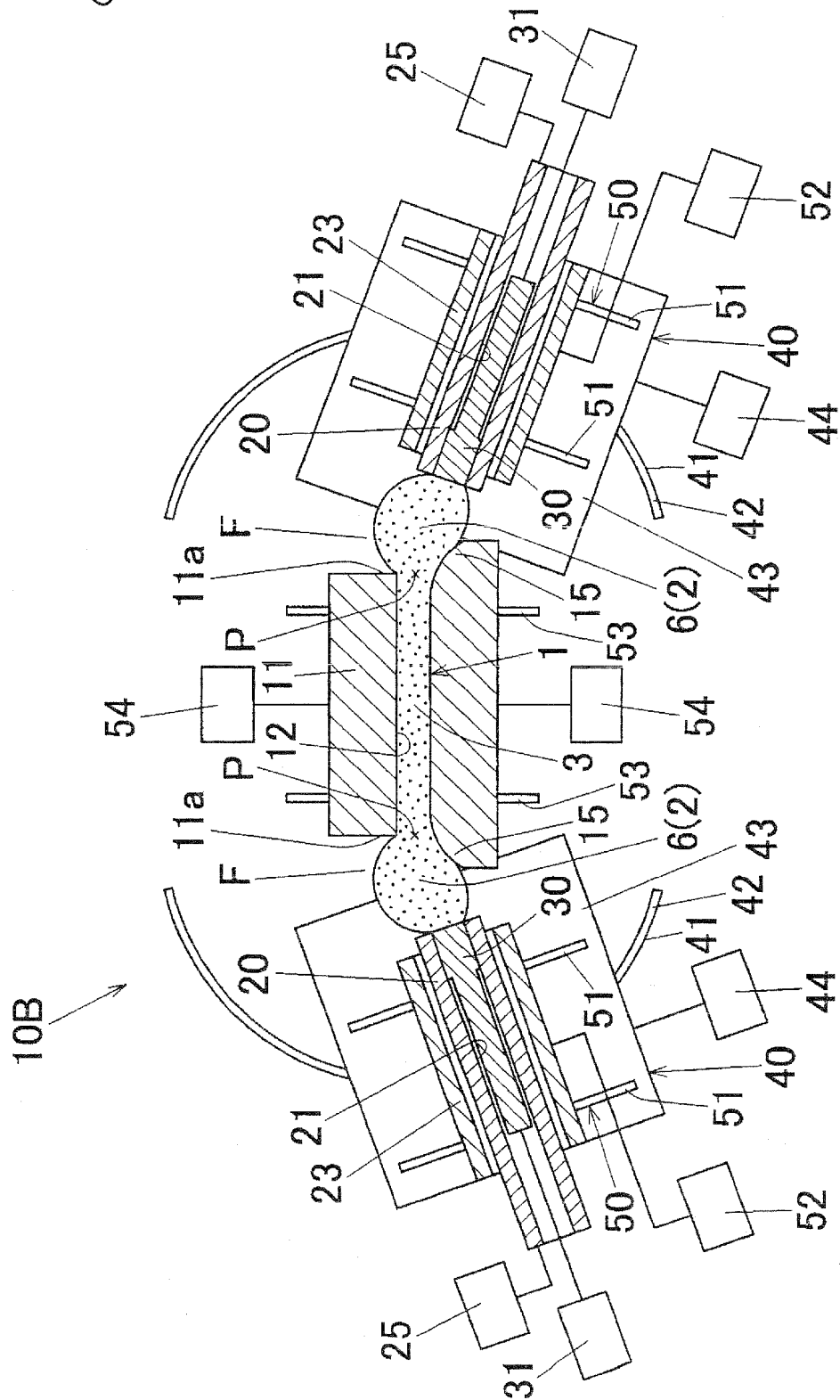


Fig. 7

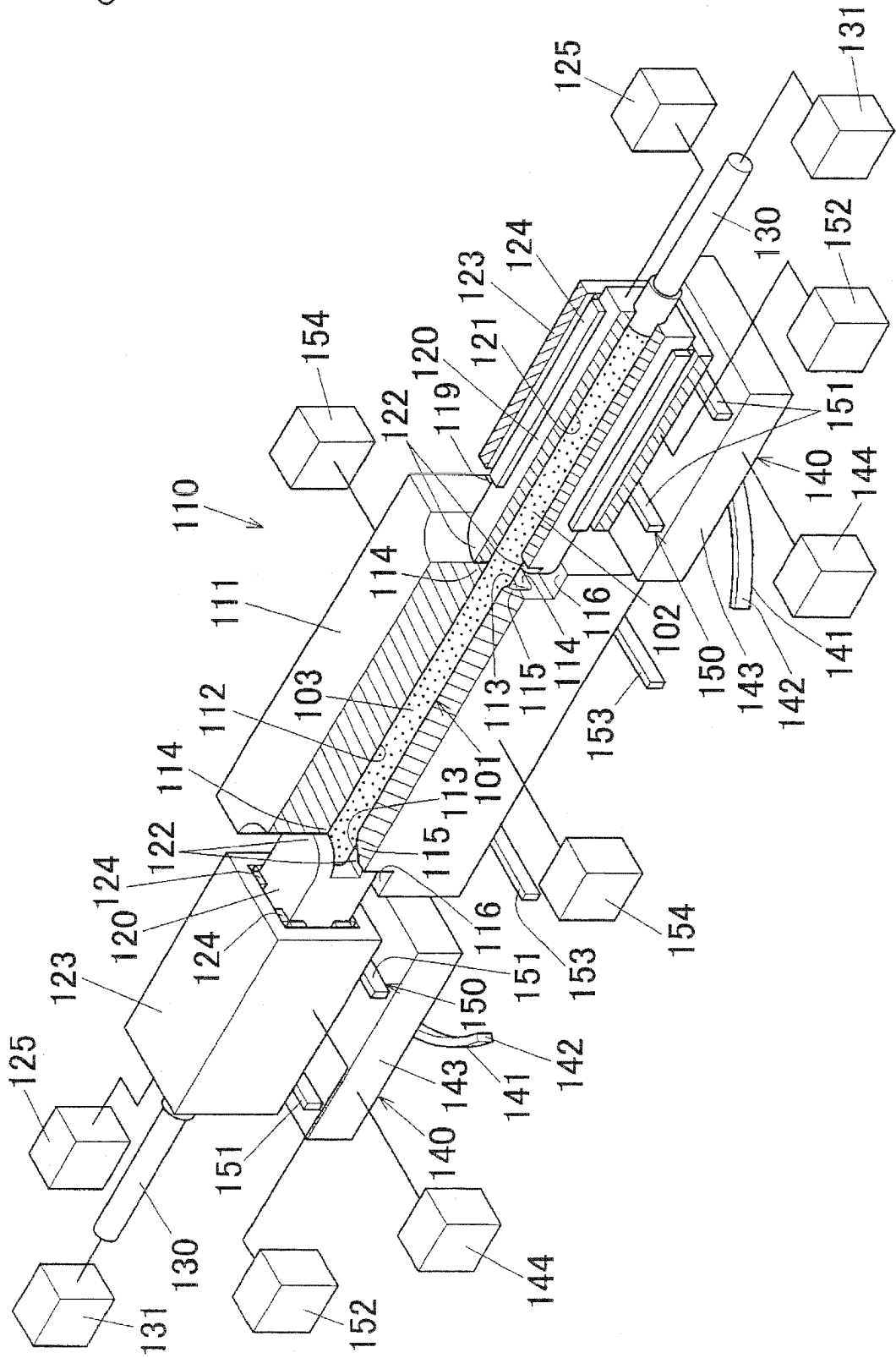


Fig. 8

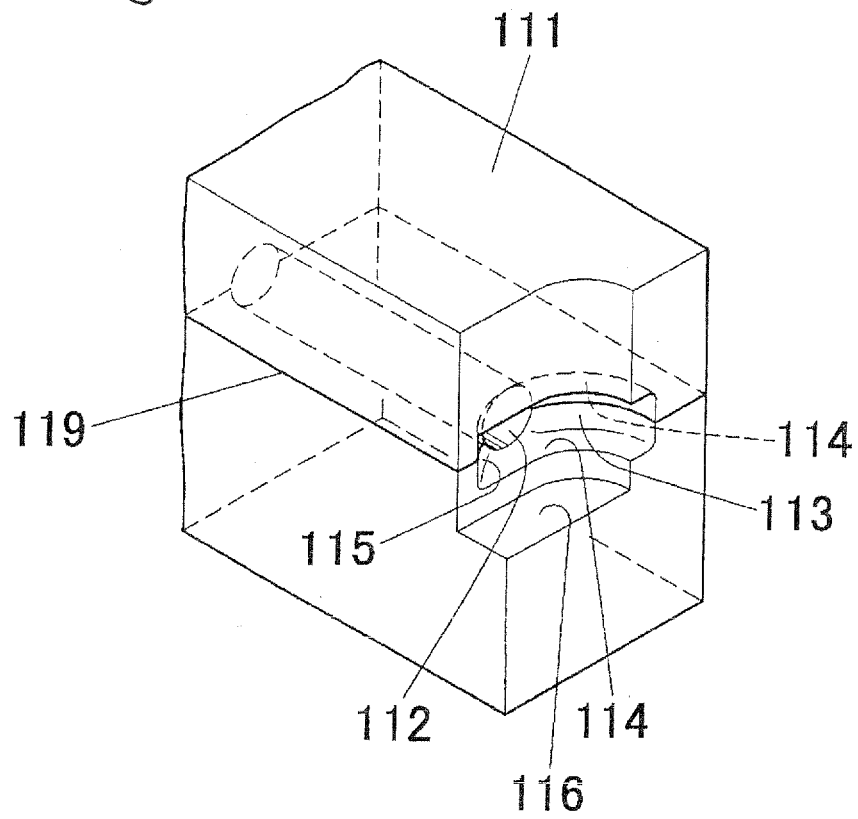


Fig. 9

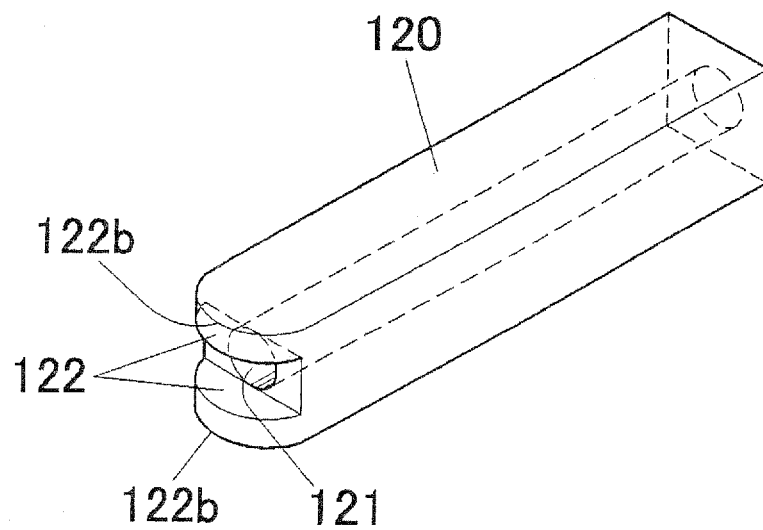


Fig. 10

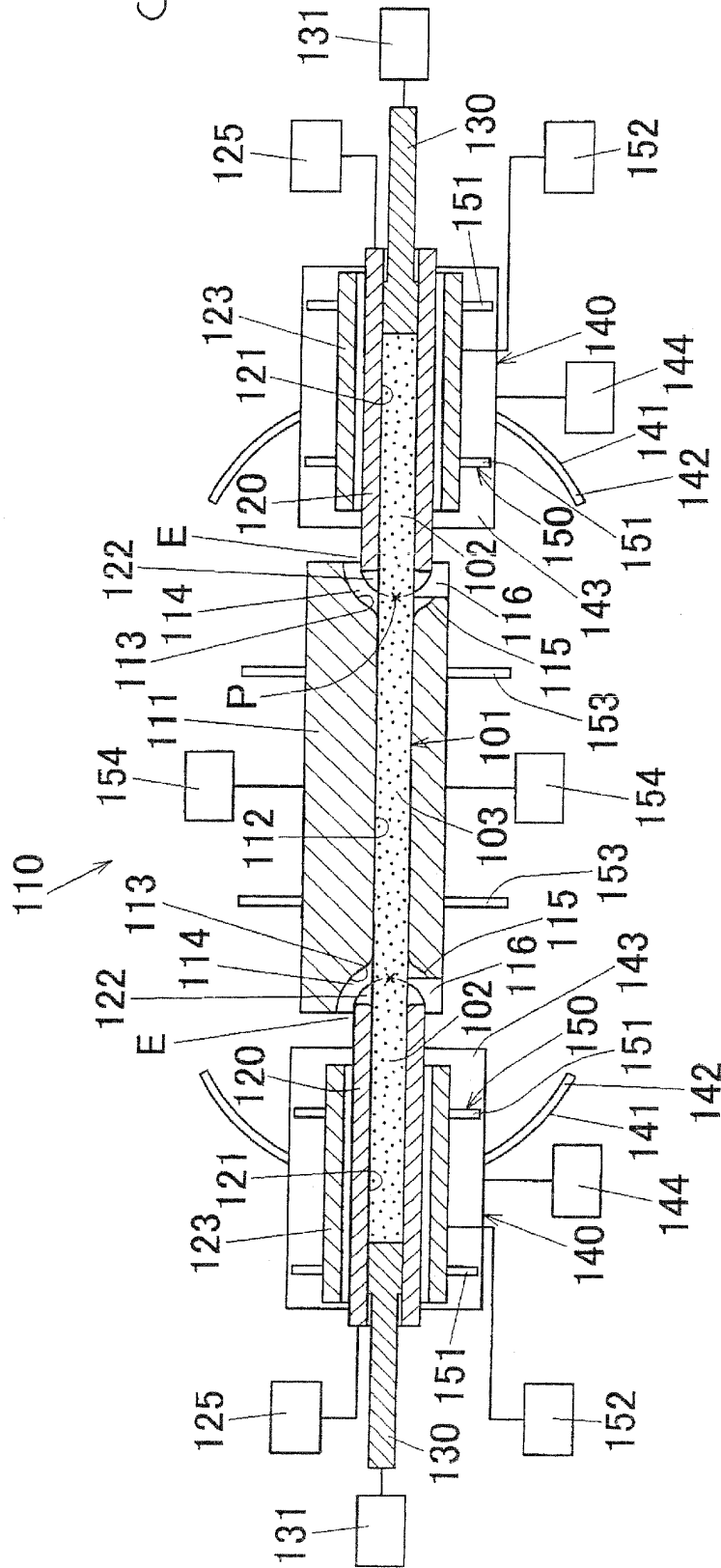


Fig. 11

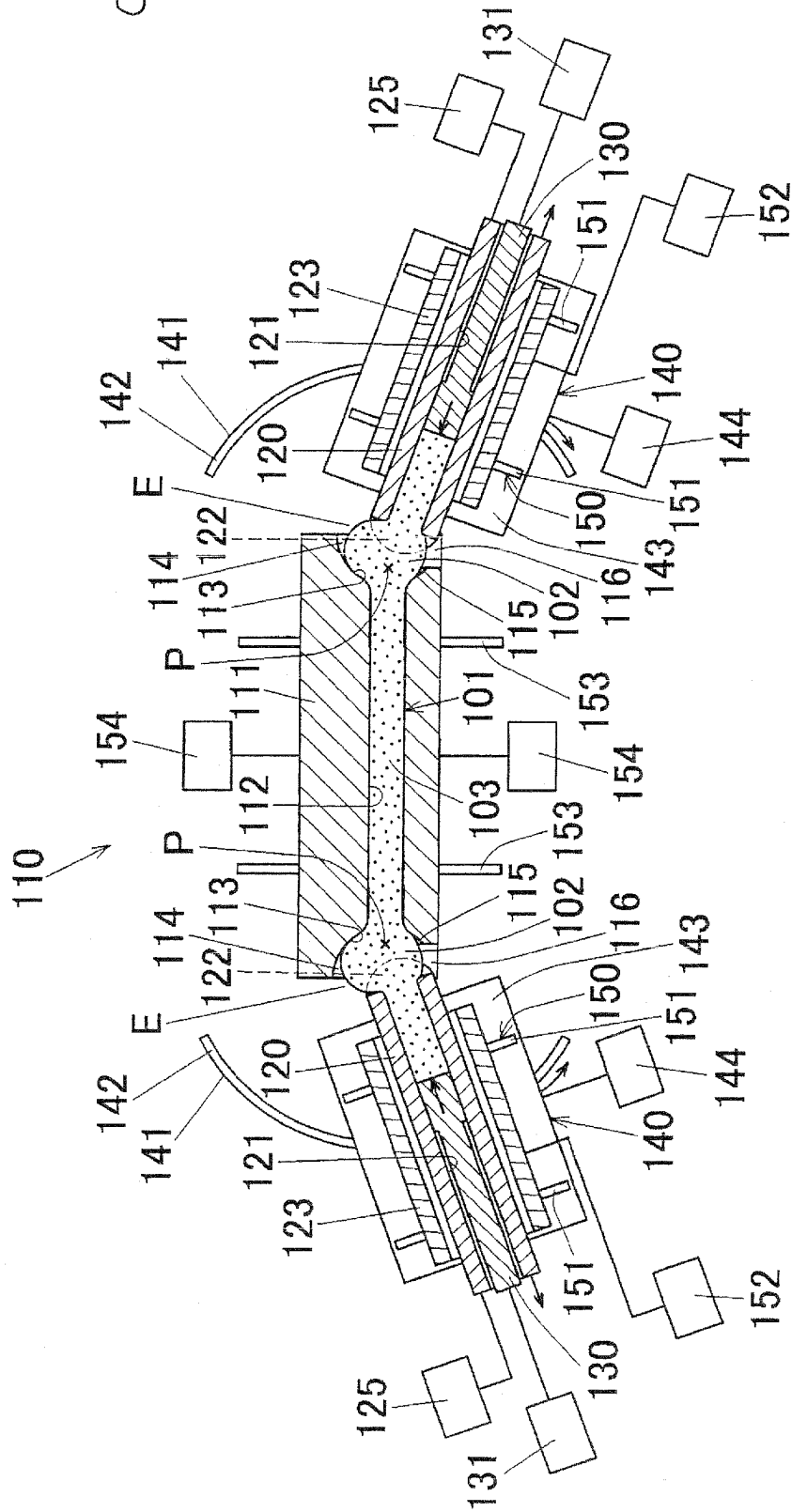


Fig. 12

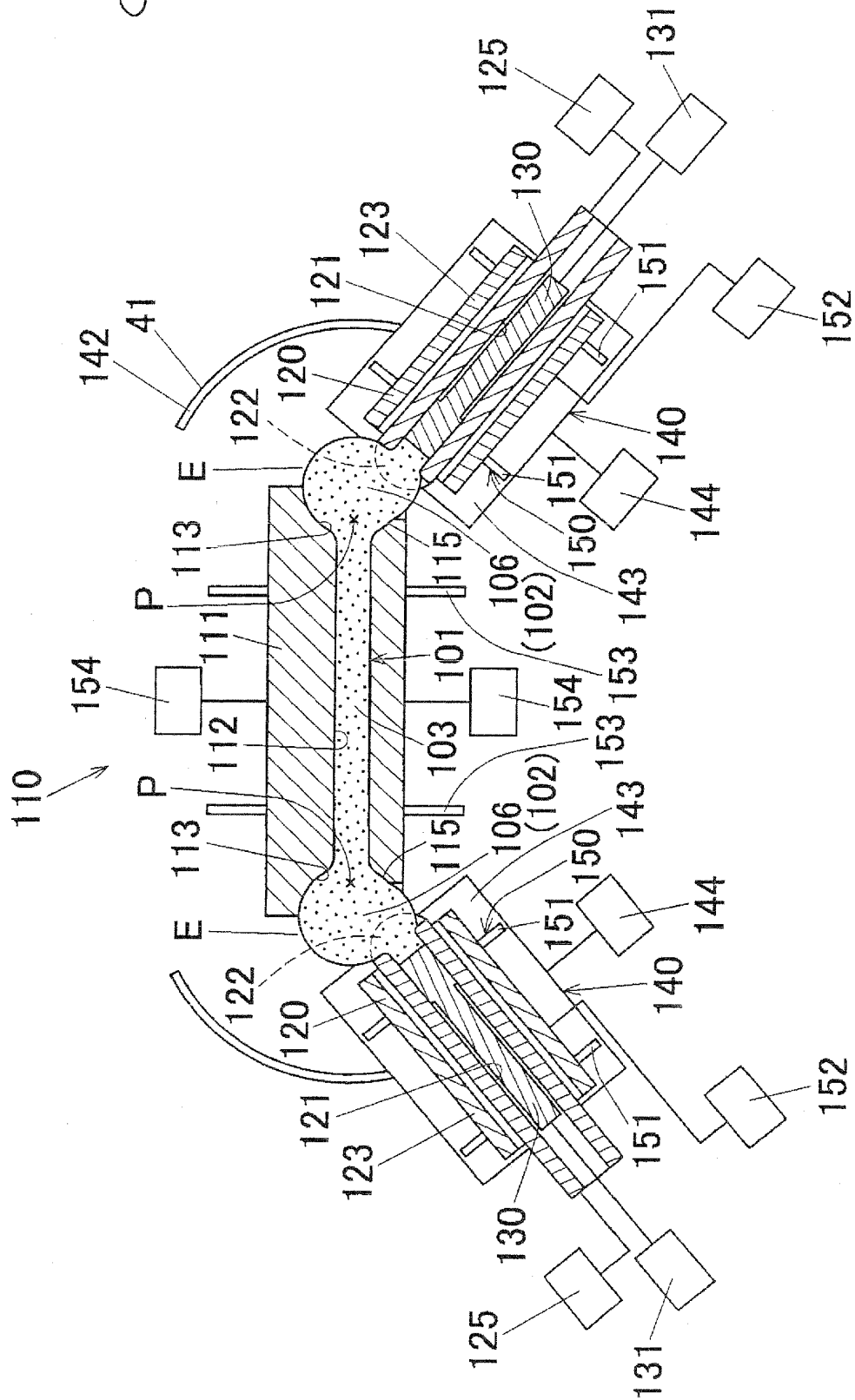


Fig.13

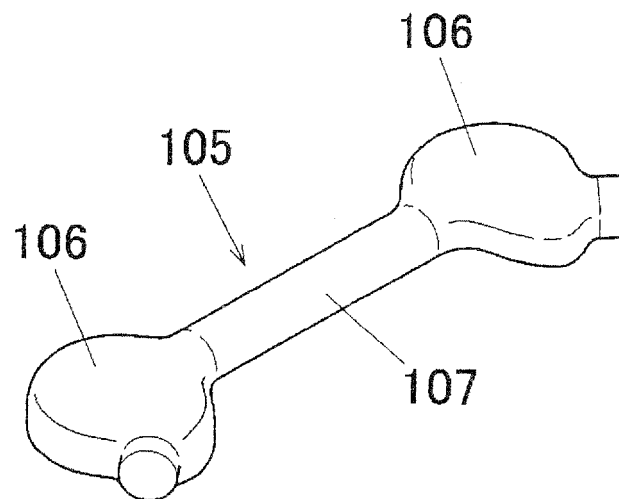
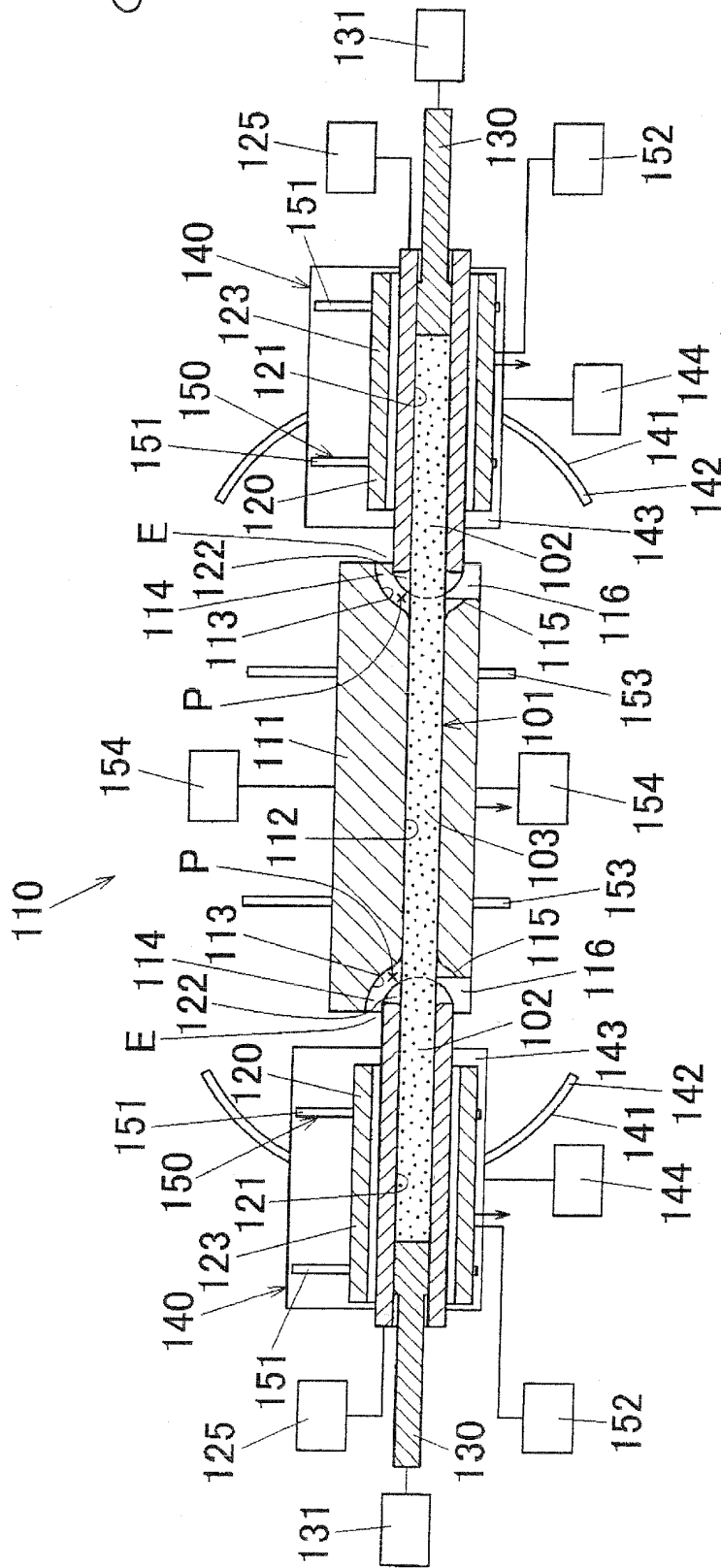


Fig. 14



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2006/317840

A. CLASSIFICATION OF SUBJECT MATTER

B21J5/08(2006.01) i, B21K1/12(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)

B21J1/00-13/14, B21J17/00-19/04, B21K1/00-31/00

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	1996-2006
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Kokai Jitsuyo Shinan Koho	1971-2006	Toroku Jitsuyo Shinan Koho	1994-2006
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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.
X Y A	JP 2005-144554 A (Showa Denko Kabushiki Kaisha), 09 June, 2005 (09.06.05), Par. Nos. [0067] to [0105]; all drawings & WO 2005/037456 A1	4, 8, 27, 36 1, 5, 9, 11, 14, 16, 19-23, 28-32, 37, 39-42, 47, 49-52 2, 3, 6, 7, 10, 12, 13, 15, 17, 18, 24-26, 33-35, 38, 43-46, 48, 53-56

☒ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

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“O” document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search
05 December, 2006 (05.12.06)

Date of mailing of the international search report	12 December, 2006 (12.12.06)
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Name and mailing address of the ISA/
Japanese Patent Office

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2006/317840

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	JP 51-035653 A (Kobe Steel, Ltd.), 26 March, 1976 (26.03.76), Page 3, upper left column, line 7 to upper right column, line 12; Fig. 4 (Family: none)	4, 8, 27, 36 1, 5, 9, 11, 14, 16, 19-23, 28-32, 37, 39-42, 47, 49-52 2, 3, 6, 7, 10, 12, 13, 15, 17, 18, 24-26, 33-35, 38, 43-46, 48, 53-56
X Y A	JP 49-106949 A (Sumio SATO), 11 October, 1974 (11.10.74), Full text; Fig. 3 (Family: none)	4, 8, 27, 36 1, 5, 9, 11, 14, 16, 19-23, 28-32, 37, 39-42, 47, 49-52 2, 3, 6, 7, 10, 12, 13, 15, 17, 18, 24-26, 33-35, 38, 43-46, 48, 53-56
A	JP 62-45442 A (Tadashi IURA), 27 February, 1987 (27.02.87), Full text; all drawings (Family: none)	1-56

Form PCT/ISA/210 (continuation of second sheet) (April 2005)

REFERENCES CITED IN THE DESCRIPTION

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- JP H07506768 W [0005]
- JP 2005059097 A [0005]
- JP 2005144554 A [0005]
- JP 2005262192 A [0234]
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- JP 2005307849 A [0234]
- US 73036605 P [0234]