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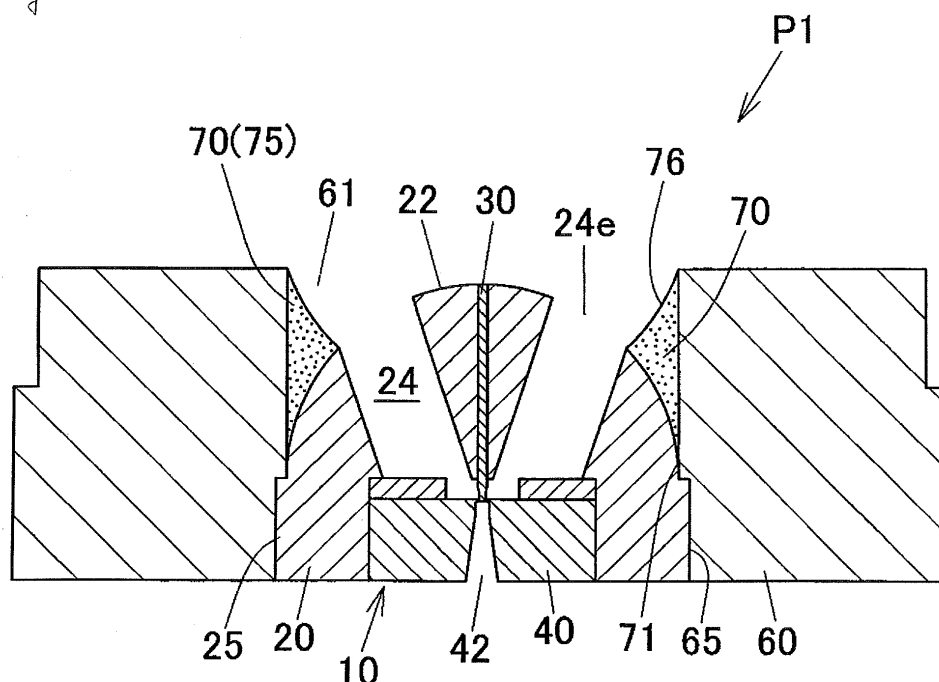
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(54) **DIE ASSEMBLY TOOL FOR EXTRUSION MOLDING**

(57) A die assembly P1 is configured such that an extrusion die 10 is mounted in a die mounting hole 61 formed in a die mounting plate 60 and a metallic material introduced in the die mounting hole 61 is introduced in the extrusion die 10 via a porthole 24 formed in a metallic material pressure receiving surface 22 of the die 10. A

material accumulating portion 70 extending to a point on a more extrusion directional downstream side than an inlet position of the porthole 24 is provided outside the porthole 24 in the die mounting hole 61 to accumulate a part 75 of the metallic material introduced into the die mounting hole 61.

Fig. 2



Description**TECHNICAL FIELD**

[0001] The present invention relates to an extrusion die assembly used for extruding a metal material, and its related art.

BACKGROUND ART

[0002] As an extrusion die (die set) used for manufacturing a metallic hollow extruded product, such as, e.g., an aluminum heat exchanging tube for use in car air-conditioning heat exchangers, there are a die called a porthole die as shown in Fig. 19A, a die called a spider die as shown in Fig. 19B, or a die called a bridge die as shown in Fig. 19C.

[0003] These extrusion dies are constructed such that a male die 1 and a female die 2 are combined with the mandrel 1a of the male die 1 disposed in the corresponding die hole 2a of the female die 2 to define a circular extrusion hole by and between the mandrel 1a and the die hole 2a. In the die, it is configured such that a metal billet (metallic material) pressed against the billet pressure receiving surface (metallic material pressure receiving surface 1b) of the male die 1 is introduced in both the dies 1 and 2 via material introduction holes 1c and then passed through the extrusion hole while being plastically deformed, so that an extruded article having a cross-section corresponding to the cross-sectional configuration of the extrusion hole is formed.

[0004] In such extrusion dies, large stress due to pressing of the metal billet is applied to the billet pressure receiving surface 1b of the male die 1, causing generation of cracks in the periphery of the pressure receiving portion of the die by the stress, which may sometimes make it difficult to attain sufficiently long die life.

[0005] Conventionally, an extrusion die for a metallic material as disclosed by the below-listed Patent Documents 1 and 2 has been conventionally proposed. In the die, it is configured such that the billet pressure receiving surface of the male die is formed into a convex configuration protruded in a direction opposite to the billet extruding direction (i.e., protruded rearward) so that the pressing force of the metal billet to be applied to the billet pressure receiving surface can be received by a bridge portion of the male die.

Patent Document 1: Japanese Unexamined Laid-open Utility Model Publication No. S53-102938 (see claims, drawings)

Patent Document 2: Japanese Examined Laid-open Patent Publication No. H06-81644 (see claims, drawings)

DISCLOSURE OF THE INVENTION**PROBLEMS TO BE SOLVED BY THE INVENTION**

[0006] In the conventional extrusion dies disclosed in the aforementioned Patent Documents 1 and 2, since the billet pressure receiving surface is formed into a convex configuration, the pressure resistance against a metal billet can be improved and therefore the durability can be enhanced. In the technical field of the billet extrusion, however, it is now strongly required to further enhance the durability and attain the cost reduction, etc., by extending the die life.

[0007] 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.

The present invention was made to solve the aforementioned problems, and aims to provide an extrusion die assembly capable of enhancing the durability.

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

MEANS FOR SOLVING THE PROBLEMS

[0008] The present invention provides the following means to attain the aforementioned objects.

[0009] [1] An extrusion die assembly in which an extrusion die is mounted in a die mounting hole of a die mounting plate, so that a metallic material to be introduced into the die mounting hole is introduced in the die via a porthole formed in a metallic material pressure receiving surface of the die, characterized in that a material accumulating portion extending to a point on a more extrusion directional downstream side than an inlet position of the porthole is provided outside the porthole in the die mounting hole so as to accumulate a part of the metallic material introduced into the die mounting hole in the material accumulating portion.

[0010] [2] The extrusion die assembly as recited in the aforementioned Item 1, wherein the extrusion die comprises

a die case having a pressure receiving portion with an external surface constituting the metallic material pressure

receiving surface,

a male die mounted in the die case, and

a female die mounted in the die case so as to form an extrusion hole by and between the male die and the female die, wherein the pressure receiving surface is formed into a convex configuration protruded toward an upstream side of an extrusion direction, and the porthole is formed in an external periphery of the pressure receiving portion, and

wherein the material accumulating portion is provided at an external peripheral portion of the pressure receiving portion. **[0011]** [3] The extrusion die assembly as recited in the aforementioned Item 1 or 2, wherein an inlet side peripheral edge portion of the die mounting hole of the die mounting plate is removed to thereby form a removed portion at an upstream side external periphery of the material accumulating portion.

[0012] [4] The extrusion die assembly as recited in the aforementioned Item 3, wherein an inner peripheral wall surface of the removed portion is formed into a tapered surface which gradually reduces in diameter toward a downstream side.

[0013] [5] The extrusion die assembly as recited in the aforementioned Item 3, wherein an inner peripheral wall surface of the removed portion is arranged in parallel with a central axis of the die.

[0014] [6] The extrusion die assembly as recited in the aforementioned Item 3, wherein an inner peripheral wall surface of the removed portion is formed into a tapered surface which gradually increases in diameter toward a downstream side.

[0015] [7] The extrusion die assembly as recited in any one of the aforementioned Items 1 to 6, wherein the die mounting plate is provided with a plurality of die mounting holes, and the extrusion dies are mounted in each die mounting hole.

[0016] [8] The extrusion die assembly as recited in any one of the aforementioned Items 1 to 6, wherein a plurality of extrusion dies are disposed in a single die mounting hole.

[0017] [9] The extrusion die assembly as recited in the aforementioned Item 2, wherein the pressure receiving surface of the die is formed into a convex spherical surface forming a part of a spherical surface.

[0018] [10] The extrusion die assembly as recited in the aforementioned Item 2 or 9, wherein the pressure receiving surface of the die is constituted by a 1/6 to 4/6 convex spherical surface.

[0019] [11] The extrusion die assembly as recited in the aforementioned Item 2, 9 or 10, wherein a plurality of portholes are formed at equal intervals around a central axis of the die.

[0020] [12] The extrusion die assembly as recited in the aforementioned Item 2, 9, 10 or 11, wherein the male die and the female die form a flat circular extrusion hole having a height (thickness) smaller than a width,

wherein a portion of the male die corresponding to the extrusion hole is formed into a comb-like configuration having a plurality of passage forming protrusions arranged in a lateral direction, and

wherein a multi-passage hollow member having a plurality of passages arranged in a lateral direction is formed when a metallic material passes through the extrusion hole.

[0021] [13] The extrusion die assembly as recited in the aforementioned Item 2, 9, 10 or 11, wherein the male die and the female die form a circular extrusion hole, and wherein a tubular member circular in cross-section is formed when a metallic material passes through the extrusion hole.

[0022] [14] The extrusion die assembly as recited in any one of the aforementioned Items 1 to 13, wherein the metallic material is aluminum or its alloy.

[0023] [15] A production method of an extruded article, wherein the extruded article is formed using the extrusion die assembly as recited in any one of the aforementioned Items 1 to 14.

[0024] [16] A production method of a multi-passage hollow member, wherein the multi-passage hollow member is formed using the extrusion die assembly as recited in the aforementioned Item 12.

[0025] [17] A production method of a tubular member, wherein the tubular member is formed using the extrusion die assembly as recited in the aforementioned Item 13.

[0026] [18] A metallic material extrusion method in which an extrusion die is mounted in a die mounting hole of a die mounting plate so that a metallic material introduced in the die mounting hole is introduced in the die via a porthole formed in a metallic material pressure receiving surface of the extrusion die,

wherein a material accumulating portion extending to a point on a more extrusion directional downstream side than an inlet position of the porthole is formed outside the porthole in the die mounting hole so that a part of the metallic material is accumulated in the material accumulating portion when the metallic material is introduced in the die mounting hole.

[0027] [19] A metallic material extruder, comprising:

a container;

a die mounting plate attached to the container; and

an extrusion die mounted in a die mounting hole of the die mounting plate,

wherein it is constructed such that a metallic material introduced in the container is introduced in the die mounting hole and the metallic material introduced in the die mounting hole is introduced in the extrusion die via a porthole formed in a metallic material pressure receiving surface of the extrusion die, and

wherein a material accumulating portion extending to a point on a more extrusion directional downstream side than

an inlet position of the porthole is formed outside the porthole in the die mounting hole so that a part of the metallic material introduced in the die mounting hole is accumulated in the metallic accumulating portion.

EFFECTS OF THE INVENTION

[0028] According to the extrusion die assembly of the aforementioned invention [1], since a metallic material is accumulated in the material accumulating portion provided outside the porthole, flowing metallic material will be guided by the same accumulated material, resulting in smooth introduction of the metallic material in the porthole. Thus, the pressing resistance of the metallic material can be reduced, which in turn can improve the pressure resistance of the die.

[0029] According to the extrusion die assembly of the aforementioned invention [2], since the pressure receiving surface of the extrusion die is formed into a convex configuration, the pressing force of the metallic material can be received by the pressure receiving surface in a dispersed manner when the metallic material is pressed against the pressure receiving surface, which in turn can reduce the pressing force in the normal direction at each portion of the pressure receiving surface. As a result, the strength against the pressing force of the metallic material can be improved, resulting in further improved durability. In other words, in cases where the metallic material is pressed against the pressure receiving surface of a convex configuration, since a compressing force toward the central axis is applied to each portion of the pressure receiving surface, the shearing force to be generated in the die case at the time of extrusion will be reduced. As a result, the shearing forces generated at the positions of the die case exposed to the hollow portion of the die case, which are portions where the largest shearing force will be generated, can be reduced, which in turn can improve the strength of the extrusion die against the pressing force of the metallic material.

[0030] According to the extrusion die assembly of the aforementioned inventions [3] to [6], it becomes possible to accumulate the metallic material in the material accumulating portion in a desired manner. Thus, the aforementioned effects can be secured assuredly.

[0031] According to the extrusion die assembly of the aforementioned inventions [7] and [8], since a plurality of dies are arranged, the pressing force of the metallic material can be dispersed in each die, resulting in further improved pressure resistance.

[0032] According to the extrusion die assembly of the aforementioned invention [9], the pressing force of the metallic material can be received more assuredly by the pressure receiving surface in a dispersed manner. Thus, the durability can be improved assuredly.

[0033] According to the extrusion die assembly of the aforementioned invention [10], the pressing force of the metallic material against the pressure receiving surface can be dispersed in a balanced manner more assuredly, which can improve the strength against the pressure force of the metallic material more assuredly. In other words, in cases where the metallic material is pressed against the pressure receiving surface of a convex configuration, since a compressing force toward the central axis is applied to each portion of the pressure receiving surface more assuredly, the shearing force to be generated in the die case at the time of extrusion will be reduced more assuredly. As a result, the shearing forces generated at the positions of the die case exposed to the hollow portion of the die case, which are portions where the largest shearing force will be generated, can be reduced, which in turn can more assuredly improve the strength of the extrusion die against the pressing force of the metallic material.

[0034] According to the extrusion die assembly of the aforementioned invention [11], since the metallic material can be introduced into the extrusion die evenly from its periphery, resulting in stable extrusion.

[0035] According to the extrusion die assembly of the aforementioned invention [12], a multi-passage hollow member with a plurality of passages arranged in the lateral direction can be formed assuredly.

[0036] According to the extrusion die assembly of the aforementioned invention [13], a tubular member circular in cross-section can be formed assuredly.

[0037] According to the extrusion die assembly of the aforementioned invention [14], an aluminum or aluminum alloy extruded article can be produced.

[0038] According to the aforementioned invention [15], in the same manner as mentioned above, an extruded article production method having the same effects as mentioned above can be provided.

[0039] According to the aforementioned invention [16], in the same manner as mentioned above, a multi-passage hollow member production method having the same effects as mentioned above can be provided.

[0040] According to the aforementioned invention [17], in the same manner as mentioned above, a tubular member production method having the same effects as mentioned above can be provided.

[0041] According to the metallic material extrusion method the aforementioned invention [18], in the same manner as mentioned above, the durability of the extrusion die can be improved.

[0042] According to the metallic material extruder of the aforementioned invention [19], in the same manner as mentioned above, the durability of the extrusion die can be improved.

BRIEF DESCRIPTION OF DRAWINGS

[0043]

- 5 [FIG. 1] Fig. 1 is a perspective view of an extrusion die assembly according to a first embodiment of the present invention.
 [FIG. 2] Fig. 2 is a front cross-sectional view of the extrusion die assembly.
 [FIG. 3] Fig. 3 is a side cross-sectional view of the extrusion die assembly.
 10 [FIG. 4] Fig. 4 is an enlarged front cross-sectional view showing the vicinity of the aluminum accumulating portion of the extrusion die assembly.
 [FIG. 5] Fig. 5 is a perspective view of an extrusion die applied to the die assembly.
 [FIG. 6] Fig. 6 is an exploded perspective view of the extrusion die.
 [FIG. 7] Fig. 7 is a cut-out perspective view of the extrusion die.
 [FIG. 8] Fig. 8 is a front cross-sectional view of the extrusion die.
 15 [FIG. 9] Fig. 9 is a side cross-sectional view of the extrusion die.
 [FIG. 10] Fig. 10 is an enlarged perspective view showing the inside of the extrusion die.
 [FIG. 11] Fig. 11 is a cut-out perspective view showing the principle portion of the extruder to which the die assembly is applied.
 [FIG. 12] Fig. 12 is a perspective view showing a multi-passage hollow member extruded by the extruder.
 20 [FIG. 13] Fig. 13 is a front cross-sectional view showing the multi-passage hollow member extruded by the extruder.
 [FIG. 14] Fig. 14 is a cross-sectional view showing the extrusion die assembly according to a first modified embodiment of the present invention.
 [FIG. 15] Fig. 15 is a cross-sectional view showing an extrusion die assembly according to a second modified embodiment of the present invention.
 25 [FIG. 16] Fig. 16 is a cross-sectional view showing an extrusion die assembly according to a third modified embodiment of the present invention.
 [FIG. 17] Fig. 17 is a cross-sectional view showing an extrusion die assembly according to a fourth modified embodiment of the present invention.
 [FIG. 18] Fig. 18 is a cross-sectional view showing an extrusion die assembly according to a fifth modified embodiment
 30 of the present invention.
 [FIG. 19A] Fig. 19A is an exploded perspective view showing a porthole die as a conventional extrusion die.
 [FIG. 19B] Fig. 19B is an exploded perspective view showing a spider die as a conventional extrusion die.
 [FIG. 19C] Fig. 19C is an exploded perspective view showing a bridge die as a conventional extrusion die.

35 BRIEF DESCRIPTION OF THE REFERENCE NUMERALS

[0044]

- 40 6 Container
 10 extrusion die
 11 extrusion hole
 20 die case
 21 pressure receiving portion
 22 billet pressure receiving surface (metallic material pressure receiving surface)
 45 24 porthole
 24e port inlet
 30 male die
 33 passage forming protruded portion
 40 female die
 50 60 die mounting plate
 61 die mounting hole
 70 aluminum accumulating portion (material accumulating portion)
 72 removed portion
 73 upstream side peripheral surface
 55 75 accumulated material (part of the metallic material)
 90 hollow member
 93 passage
 A1 central axis of the die (die case)

P1 to P6 die assembly
 θ inclination angle

BEST MODE FOR CARRYING OUT THE INVENTION

[0045] The extrusion die assembly P1 for a metallic material according to a first embodiment of this invention is used to extrude a multi-passage hollow member (flat multi-passage tube) 90 shown in Figs. 12 and 13.

[0046] The hollow member 90 is a metal member. In this embodiment, concretely, the hollow member constitutes a heat exchanging tube made of aluminum (including aluminum alloy; hereinafter referred to as "aluminum").

[0047] This hollow member 90 is a member for use in a heat exchanger, such as, e.g., a condenser for car air-conditioners, and has a flattened configuration having a width larger than a thickness. The hollow portion 91 of this hollow member 90 is divided into a plurality of heat exchanging passages 93 by a plurality of partitioning walls 92 extended in the tube length direction and arranged in parallel with each other. Thus, these passages 93 are extended in the tube length direction and arranged in parallel with each other.

[0048] In this embodiment, a direction with which the tube length direction perpendicularly intersects and along which the passages 93 are arranged will be referred to as a "width direction" or a "lateral direction," and a direction with which the tube length direction perpendicularly intersects and with which the width direction perpendicularly intersects will be referred to as a "height direction (thickness direction)" or a "vertical direction."

[0049] Figs. 1 to 4 show an extrusion die assembly P1 as one example of an embodiment of the present invention. As shown in these figures, the extrusion die assembly P1 of this embodiment is used in manufacturing the aforementioned hollow member 90, and equipped with, as fundamental structural elements, an extrusion die 10 constituting a die set, and a die mounting plate (die holder) 60 for mounting the extrusion die 10.

[0050] As shown in Figs. 1 to 9, the extrusion die 10 is equipped with a die case 20, a male die 30, a female die 40, and a flow control plate 50.

[0051] The die case 20 has a hollow structure, and is comprised of a dome-shaped pressure receiving portion 21 to be arranged at the upstream side (rear side) with respect to the extrusion direction of a metal billet as an aluminum material and a base portion 25 to be arranged at the downstream side (front side).

[0052] In the pressure receiving portion 21, the surface thereof (rear surface) facing to a direction opposite to the extrusion direction of the metal billet constitutes a billet pressure receiving surface 22 as a metallic material pressure receiving surface. This billet pressure receiving surface 22 is formed into a convex configuration protruded in a direction (i.e., in a rear direction) opposite to the extrusion direction, more specifically, a convex hemispherical surface configuration.

[0053] In the peripheral wall center of the pressure receiving portion 21, a male die holding slit 23 communicated with the internal hollow portion (i.e., welding chamber 12) is formed along the central axis A1. This male die holding slit 23 is formed into a flat rectangular cross-sectional configuration corresponding to the cross-sectional configuration of the male die 30. Furthermore, as shown in Fig. 9, at both side portions of the rear end side of the male die holding slit 23, engaging stepped portions 23a and 23a as engaging means for engaging the male die 30, which will be mentioned later, are formed.

[0054] At both sides of the peripheral wall of the pressure receiving portion 21 across the central axis A1, a pair of portholes 24 and 24 are formed. The inlet 24e of each porthole 24 is formed into a generally trapezoidal shape as seen from the upstream side of the axial direction.

[0055] The pair of portholes 24 and 24 are arranged such that the outlet portions (i.e., front end portions) face an extrusion hole 11 which will be mentioned later.

[0056] Each porthole 24 is arranged such that the central axis A2 of the porthole 24 approaches the central axis A1 of the pressure receiving portion 21 as it advances toward the downstream side and intersects with the central axis A1 of the pressure receiving portion 21 in an inclined state. The detail structure, such as, e.g., the inclination angle θ of the central axis A2 of this porthole 24, will be detailed later.

[0057] In this embodiment, it is constituted such that the central axis of the die case 20 coincides with the central axis of the pressure receiving portion 21.

[0058] The base portion 25 is integrally formed with the pressure receiving portion 21 and formed into a circular configuration centering on the axial center A1. The base portion 25 has a diameter larger than that of the pressure receiving portion 21.

[0059] In the present invention, the base portion 25 and the pressure receiving portion 21 are not always required to be formed integrally, and can be formed separately. Whether both the portions 21 and 25 are to be formed integrally or separately can be arbitrarily decided in consideration of various factors, such as, e.g., maintenance efficiency.

[0060] At the inner side of the base portion 25, a female die holding hole 26 having a cross-sectional shape (circular cross-sectional shape) corresponding to the cross-sectional shape of the female die 40 and communicated with the inner welding chamber 12 is formed. The central axis of this female die holding hole 26 is configured so as to coincide with the central axis A1 of the die case 20.

[0061] At the rear end side in the inner periphery of the female die holding hole 26, as shown in Figs. 7 and 8, an engaging stepped portion 26a for engaging the female die 40, which will be explained later, via a flow control plate 50 is formed.

[0062] In the male die 30, the front half principal portion constitutes a mandrel 31. As shown in Figs. 9 and 10, the front end portion of the mandrel 31 is configured to form a hollow portion 91 of a hollow member 90 and has a plurality of passage forming protruded portions 33 each corresponding to each passage 93 of the hollow member 90. These plural passage forming protruded portions 33 are arranged along the widthwise direction of the mandrel 31 at predetermined intervals. Each gap formed between adjacent passage forming protruded portions 33 constitutes a partition forming groove 32 for forming a partition 92 of a hollow member 90.

[0063] As shown in Figs. 6 and 9, at both the widthwise side edges of the rear end portion of the male die 30, engaging protrusions 33a and 33a corresponding to the aforementioned engaging stepped portions 23a and 23a of the male die holding slit 23 formed in the die case 20 are integrally provided in a laterally protruded manner.

[0064] This male die 30 is inserted into the male die holding slit 23 of the aforementioned die case 20 from the side of the billet pressure receiving surface 22 and fixed therein. At this time, the engaging protrusions 33a and 33a of the male die 30 are engaged with the engaging stepped portions 23a and 23a formed in the male die holding slit 23 to be positioned. Thus, the mandrel 31 of the male die 30 is held in a state in which the mandrel 31 of the male die 30 forwardly protrudes from the male die holding slit 23 by a predetermined amount.

[0065] The basal end face (i.e., rear end face) of the male die 30 is formed so as to constitute a part of the spherical surface forming the billet pressure receiving surface 22 of the die case 20, so that the basal end face (i.e., rear end face) of the male die 30 and the billet pressure receiving surface 22 form a prescribed smooth convex hemispherical surface.

[0066] As shown in Fig. 6, the female die 40 is cylindrical, and has, at its both sides of the peripheral surface, key protrusions 47 and 47 extended in parallel with the central axis.

[0067] The female die 40 is provided with a die hole (bearing hole 41) opened to the rear end face side thereof and formed corresponding to the mandrel 31 of the male die 30, and a relief hole 42 communicated with the die hole 41 and opened to the front end face side thereof.

[0068] The die hole 41 is provided with an inwardly protruded portion along the inner peripheral edge portion so that an outer peripheral portion of the hollow member 90 can be defined. The relief hole 42 is formed into a tapered shape which gradually increases in thickness (height) toward the front end side (downstream side) and opened at the downstream side.

[0069] The flow control plate 50 is formed into a round shape corresponding to the cross-sectional shape of the female die holding hole 26 of the die case 20. Corresponding to the mandrel 31 of the male die 30 and the die hole 41 of the female die 40, a central through-hole 51 is formed at the center of the flow control plate 50.

[0070] The flow control plate 50 has, at its both sides of the external peripheral edge portion, key protrusions 57 and 57 corresponding to the key protrusions 47 and 47 of the female die 40 are formed.

[0071] As shown in Figs. 6 to 9, the female die 40 is mounted and secured in the female die holding hole 26 of the die case 20 via the flow control plate 50. In this mounted state, the external periphery of one end face (rear end face) of the female die 40 is engaged with the engaging stepped portion 26a of the female die holding hole 26 via the external peripheral edge portion of the flow control plate 50, so that the female die 40 and the flow control plate 50 are positioned in the axial direction. At the same time, the key protrusions 47 and 47 of the female die 40 and the key protrusions 57 and 57 of the flow control plate 50 are engaged with the keyways (not illustrated) formed in the inner peripheral surface of the female die holding hole 26 to be positioned in the circumference direction about the central axis.

[0072] Thus, the mandrel 31 of the male die 30 and the die hole 41 of the female die 40 are positioned in the central through-hole 51 of the flow control plate 50. At this time, the mandrel 31 of the male die 30 is positioned within the die hole 41 of the female die 40, which forms a flat circular extrusion hole 11 by and between the mandrel 31 and the die hole 41. This extrusion hole 11 is formed to have a cross-sectional configuration corresponding to a cross-sectional configuration of the hollow member 90 to be formed in which a plurality of partition forming grooves 32 of the mandrel 31 are arranged in parallel in the widthwise direction.

[0073] In this embodiment, as shown in Fig. 8, the central axes A2 of the portholes 24 are set to be inclined with respect to the central axis A1 of the die case 20. In this embodiment, it is preferable that the inclination angle θ of the central axis A2 of the porthole 24 with respect to the central axis A1 of the die case 20 is set to 3 to 45°, more preferably 10 to 35°, still more preferably 15 to 30°. When the inclination angle θ is set so as to fall within the above specified ranges, the metallic material flows through the portholes 24 and 24 and the welding chamber 12 in a stable manner, and then smoothly passes through around the entire periphery of the extrusion hole 11 in a balanced manner. As a result, a high quality extrusion molded article (extruded article) excellent in dimensional accuracy can be formed. In other words, if the inclination angle θ is too small, the metallic material passed through the portholes 24 and 24 and the welding chamber 12 cannot be smoothly introduced into the extrusion hole 11, which may sometimes make it difficult to stably obtain a high quality extrusion molded article. To the contrary, if the inclination angle θ is too large, the material flowing direction of the porthole 24 with respect to the material extrusion direction inclines largely, which increases the extrusion

resistance of the metallic material, and therefore it is not preferable.

[0074] In this embodiment, it is preferably constructed such that the billet pressure receiving surface 22 of the die case 20 has a convex spherical surface of a $1/6$ sphere to a $4/6$ sphere. When the billet pressure receiving surface 22 is formed into the aforementioned specific convex spherical configuration, the pressing force of a metal billet can be assuredly received by the billet pressure receiving surface 22 in a well-balanced dispersed manner, resulting in sufficient strength, which in turn can extend the die life more assuredly. That is, when a billet is pressed against the pressure receiving surface 22 constituted by a specific convex spherical configuration, compressing forces toward the center of the pressure receiving portion 21 are more assuredly applied to each portion of the pressure receiving surface 22, and therefore the shearing force to be generated in the die case 20 at the time of the extrusion forming is reduced more assuredly. As a result, the shearing forces generated at the positions of the die case 20 exposed to the hollow portion of the die case 20, which are portions where the largest shearing force will be generated in the die case 20, can be reduced assuredly. Thus, the strength of the die 10 against the pressing force of the billet can be improved more assuredly. In addition to the above, it also makes it possible to simplify the die configuration, reduce the size and weight, and also attain the cost reduction. In other words, if the billet pressure receiving surface 22 is formed by a configuration constituted by a convex spherical surface of a sphere smaller than a $1/6$ sphere, such as, e.g., a convex spherical surface constituted by a $1/8$ sphere, sufficient strength against a billet pressing force cannot be obtained, which may cause deteriorated die life due to generation of cracks. To the contrary, if the billet pressure receiving surface 22 is formed into a configuration constituted by a convex spherical surface of a sphere exceeding a $4/6$ sphere, such as, e.g., a convex spherical surface configuration of a $5/6$ sphere, the cost may be increased due to the complicated configuration.

[0075] In this embodiment, the sphere with a ratio, such as, e.g., a $1/8$ sphere, a $1/6$ sphere, or a $4/6$ sphere, is defined by a partial sphere obtained by cutting a perfect sphere with a plane perpendicular to the central axis of the perfect sphere. That is, in this embodiment, an " n/m sphere (" m " and " n " are natural numbers, and $n < m$)" is defined by a partial sphere obtained by cutting a perfect sphere with a plane perpendicular to the central axis of the perfect sphere at a position where a distance from a surface of the perfect sphere to an inner position of the perfect sphere on the central axis (diameter) is n/m where the length of the central axis (diameter) of the perfect sphere is "1."

[0076] As shown in Fig. 8, in this embodiment, the inner side surface 24a and the outer side surface 24b among the inner periphery of the porthole 24 are arranged generally in parallel with each other and also generally in parallel to the central axis A2 of the porthole 24. Furthermore, the inner side surface 24a and the outer side surface 24b of the porthole inner periphery are each constituted as an inclined surface (tapered surface) inclined to the central axis A1 of the die case 20.

[0077] On the other hand, as shown in Figs. 1 to 4, the die mounting plate 60 for mounting the aforementioned extrusion die 10 has a die mounting hole 61 at its central portion. This die mounting hole 61 has, at its downstream side peripheral wall, a circumferentially continuing dented stepped portion 65 corresponding to the base portion 25 of the extrusion die 10. In this die mounting plate 60, the portion where the dented stepped portion 65 of the die mounting hole 61 functions as a "die holding hole" for inserting and holding the extrusion die 10.

[0078] In this die mounting hole 61 of the die mounting plate 60, the extrusion die 10 is mounted with the pressure receiving portion 21 facing toward the upstream side (inlet side). In this mounted state, the base portion 25 of the extrusion die 10 is fitted in the dented stepped portion 65 of the die mounting hole 61 (die holding hole). Thus, the die assembly P1 is assembled.

[0079] In this die assembly P1, outside the portholes 24, an aluminum accumulating portion 70 functioning as a material accumulating portion is formed by and between the pressure receiving surface 22 of the extrusion die 10 and the inner peripheral surface of the die mounting hole 61 of the die mounting plate 60. This aluminum accumulating portion 70 is formed in a range from the vicinity of the inlet of the die mounting hole 61 to the downstream side of the inlet position of the porthole 24. In other words, the downstream side edge 71 of the aluminum accumulating portion 70 is located at a point on a more downstream side than the inlet position of the porthole 24.

[0080] This downstream side edge 71 of this aluminum accumulating portion 70 is set to the contact position where the pressure receiving surface 22 and the inner peripheral surface of the die mounting hole 61 are in contact with each other, and is closed. Thus, aluminum material as extrusion material cannot pass through the downstream side edge 71. Therefore, as will be explained later, it is constituted such that a part 75 of the aluminum material will be retained in the aluminum accumulating portion 70 during the extrusion process.

[0081] In this embodiment, as shown in Fig. 11, the aforementioned die assembly P1 is set to an extruder. That is, the die mounting plate 60 mounting the die assembly P1 of this embodiment is set so as to be disposed in front of the container 6 with the die mounting plate 60 fixed by a backer (not illustrated).

[0082] An aluminum billet as an aluminum material inserted in the container 6 is pressed with a stem (not illustrated) in the right direction in Fig. 11 (i.e., in the extrusion direction) via a dummy block 7. Thereby, the aluminum billet is introduced into the die mounting hole 61 of the die mounting plate 60 and then pressed against the billet pressure receiving surface 22 of the die case 20 to be plastically deformed. As a result, the aluminum material passes through the pair of portholes 24 and 24 while being plastically deformed and then reaches the welding chamber 12 of the die case

20. Then, the aluminum material is forwardly extruded through the extrusion hole 11 into a cross-sectional configuration corresponding to the opening configuration of the extrusion hole 11. Thus, an aluminum extruded article (hollow member 90) is manufactured.

[0083] In this extrusion, because of the existence of the aluminum accumulating portion 70 formed by and between the billet pressure receiving surface 22 and the inner peripheral surface of the die mounting hole 61, the aluminum material will be retained in this aluminum accumulating portion 70 (see Figs. 2 and 4). The aluminum material will flow on the surface (inner peripheral surface 76) of this accumulated material 75 to be introduced in the portholes 24.

[0084] Since the accumulated material 75 is the same material as the flowing aluminum material, the skid resistance between both the materials becomes small, enabling the aluminum material to be smoothly flowed on the surface 76 of the accumulated material 75 to be smoothly introduced into the portholes 24. Thus, the pressing resistance can be reduced, enabling reduction of the load to the extrusion die 10 due to the pressing force of the aluminum material, which in turn can improve the resistance to pressure. Especially in the case of aluminum material, since it also functions as lubricant, the aluminum material will flow more smoothly, which can further reduce the pressing resistance. As a result, the load to the extrusion die 10 can be further reduced, which assuredly can improve the durability of the extrusion die 10. This improved durability of the extrusion die 10 extends the die life, resulting in extended exchange cycle thereof, which in turn can reduce the cost.

[0085] Furthermore, the accumulated material 75 filled in the aluminum accumulating portion 70 causes an inwardly pressing force from the external periphery of the extrusion die 10 when the accumulated material 75 received a load of the aluminum material in the extrusion direction. That is, a binding force tightening the extrusion die 10 from the external periphery thereof will be applied to the extrusion die 10, further improving the strength of the extrusion die 10, which in turn can further improve the durability.

[0086] Furthermore, in this embodiment, since the billet pressure receiving surface 22 of the die 10 is formed into a convex spherical configuration, when the aluminum billet is pressed against the billet pressure receiving surface 22, the pressing force can be received by the convex pressure receiving surface 22 in a dispersed manner. Therefore, the pressing force to be applied to each portion of the billet pressure receiving surface 22 in the direction of a normal line can be reduced, thereby increasing the strength against the pressing force of the aluminum material, which can further improve the durability.

[0087] In this embodiment, the portholes 24 for introducing materials are formed in the pressure receiving portion 21 of the die case 20 covering the male die 30 and the female die 40. In other words, the front end wall portion of the pressure receiving portion 21 and the wall portion of the base portion 25 are formed integrally and continuously in the peripheral direction. Therefore, the existence of this continued peripheral wall portion can further increase the strength of the die case 20, which in turn can further increase the strength of the entire extrusion die. Accordingly, there exists no portion weak in strength, such as a conventional bridge portion, and it is not required to increase the size, such as, e.g., the thickness, beyond the necessity for the purpose of increasing the strength, which makes it possible to attain the size and weight reduction as well as the cost reduction.

[0088] Furthermore, in this embodiment, the portholes 24 and 24 are formed at positions away from the central axis A1 of the pressure receiving portion 21, i.e., at the periphery of the pressure receiving portion 21, and the central axis A2 of each porthole 24 is inclined with respect to the central axis A1 of the die case 20 so as to gradually approach the central axis A1 of the die case 20 toward the downstream side. Therefore, the aluminum material passing through the portholes 24 and 24 can be stably extruded while being smoothly introduced toward the central axis A1, i.e., the extrusion hole 11. Furthermore, in this embodiment, since the downstream side end portions (outlets) of the portholes 24 and 24 are arranged so as to face to the extrusion hole 11, the aluminum material can be more smoothly introduced into the extrusion hole 11.

[0089] Furthermore, in this embodiment, since the portholes 24 and 24 are arranged at both sides of the height direction (thickness direction) of the flat extrusion hole 11, the aluminum material can be more smoothly introduced into the extrusion hole 11 in a stable manner from both the thickness sides. Accordingly, the aluminum material will be extruded while evenly passing through the entire area of the extrusion hole 11 in a well-balanced manner, to thereby obtain a high quality extruded hollow member 90.

[0090] Especially like in this embodiment, even in the case of extruding a hollow member 90 having a complicated configuration, such as, e.g., a flat harmonica tube configuration, aluminum material can be introduced into the entire region of the extrusion hole 11 in a well-balanced manner, which can assuredly maintain the quality.

[0091] For reference, in cases where an aluminum heat exchanging tube (hollow member) provided with a plurality of passages 93 each rectangular in cross-section having a height of 0.5 mm and a width of 0.5 mm and arranged in parallel, in a conventional extrusion die, since the strength was not sufficient, cracks generated in the male die caused a shortened die life. On the other hand, in the extrusion die 10 according to the present invention, since the strength is sufficient, no crack will be generated in the male die 30. Therefore, the wear of the male die 30 becomes a factor of the die life, which can remarkably improve the die life.

[0092] For example, according to the results of experiments relevant to a die life performed by the present inventors,

in the extrusion die according to the present invention, the length of die life could be extended about three times as compared with a conventional one.

[0093] Moreover, in the present invention, since it has sufficient pressure resistance (strength), the extrusion limit speed can be raised considerably. For example, in a conventional extrusion die, the upper limit of the extrusion speed was 60 m/min. On the other hand, in the extrusion die according to the present invention, the upper limit of the extrusion speed can be raised up to 150 m/min, i.e., the extrusion limit speed can be raised about 2.5 times, and therefore the further improved productive efficiency can be expected.

[0094] In the aforementioned embodiments, the pressure receiving surface 22 of the extrusion die 10 is formed to have a hemispherical convex surface. In the present invention, however, the configuration of the pressure receiving surface is not limited to it.

[0095] For example, the pressure receiving surface can be formed into a polyhedral configuration constituted by a number of sides. In other words, it can be formed into a polyhedral configuration such as a multi-sided pyramid in which a plurality of sides are arranged in the peripheral direction or a polyhedral configuration in which a plurality of sides are arranged in the radial direction. In the above cases, each side constituting the pressure receiving surface can be flat or curved.

[0096] Furthermore, the pressure receiving portion can be formed into a laterally extended configuration in which the lateral directional length is longer than the lengthwise directional length, the lateral direction and the vertical direction being perpendicular to the axial direction, such as, e.g., a laterally elongated elliptical configuration as seen from the upstream side of the axial direction or a laterally elongated oval configuration as seen from the upstream side of the axial direction.

[0097] The pressure receiving portion can be formed into a configuration having a protrusion size along the axial direction longer than the size of the radial direction perpendicular to the axial direction, e.g., a semi-elliptical configuration obtained by dividing an elliptical configuration in the major axis direction.

[0098] Furthermore, in the aforementioned embodiment, the die case 20 is integrally formed. In the present invention, however, it is not limited to it and can be constituted such that the die case can be divided into two members. For example, it can be constituted such that the die case consists of two members, i.e., a male die case for holding a male die and a female die case for holding a female die.

[0099] Furthermore, in the aforementioned embodiment, the male die 30, the female die 40 and the flow control plate 50 are formed separately from the die case 20. The present invention, however, is not limited to the above, and can be constituted such that at least one of the male die 30, the female die 40 and the flow control plate 50 is formed integrally with the die case 20. Furthermore, in the present invention, the flow control plate 50 can be omitted as needed.

[0100] Furthermore, in the aforementioned embodiment, the explanation is directed to a die for extruding a flat multi-passage tubular member. In the present invention, however, the configuration of the extruded article (configuration of the extrusion hole) is not specifically limited. For example, in the present invention, it can be constituted such that a male die is provided with a round mandrel and a female die is provided with a round die hole to form a circular extrusion hole so that a circular tubular member is extruded.

[0101] Furthermore, in the aforementioned embodiment, the explanation is directed to the case in which two portholes are formed at both sides of the central axis. However, the present invention is not limited to the above. In the present invention, it can be constituted that one porthole is formed or three or more portholes are formed.

[0102] Especially in the case of extruding a tubular member round in cross-section, it is preferable that three or more portholes are formed at equal intervals in the peripheral direction.

[0103] Furthermore, in the present invention, the configuration of the porthole inlet is not specifically limited. In the case of forming a plurality of portholes, portholes can be formed such that inlet configurations thereof differ with each other.

[0104] Furthermore, in the present invention, it can be formed such that the opening area of the porthole inlet is larger than the passage cross-sectional area of the inside portion the porthole.

[0105] Furthermore, in the aforementioned embodiment, the base portion is formed at the front end portion of the die case. In the present invention, however, it is not necessarily required to provide such a base portion.

[0106] Furthermore, in the aforementioned embodiment, the configuration of the aluminum accumulating portion 70 functioning as a material accumulating portion is not specifically limited. For example, as shown in Figs. 14 to 16, the inlet side peripheral edge portion of the die mounting hole 61 of the die mounting plate 60 can be removed to form a removed portion 72 at the upstream side external periphery of the aluminum accumulating portion 70.

[0107] In this case, in the die assembly P2 shown in Fig. 14, the inlet side peripheral portion of the die mounting hole 61 of the die mounting plate 60, i.e., the peripheral edge portion of the die mounting hole 61 at the pressure receiving surface side of the die mounting plate 60, is removed in a chamfered manner. Thus, the inner peripheral wall surface 73 of this removed portion 72 is formed into a tapered surface which gradually decreases in diameter toward the downstream side.

[0108] In the die assembly P3 shown in Fig. 15, the inlet side peripheral edge portion of the die mounting hole 61 of the die mounting plate 60 is removed stepwise (L-shaped cross-section), whereby a stepped removed portion 72 is

formed at the upstream side external periphery of the aluminum accumulating portion 70. Accordingly, the inner peripheral wall surface 73 of this removed portion 72 extends in parallel with the axis of the die 10.

[0109] In the die assembly P4 shown in Fig. 16, the inlet side peripheral edge portion of the die mounting hole 61 of the die mounting plate 60 is removed in a reverse-chamfered manner, so that a removed portion 72 is formed at the upstream side external periphery of the aluminum accumulating portion 70. Accordingly, the inner peripheral wall surface 73 of this removed portion 72 is formed into a divergent tapered surface (reverse-tapered surface) which gradually increases in diameter toward the downstream side.

[0110] In the case of forming a removed portion 72 at the upstream side external periphery of the aluminum accumulating portion 70 as mentioned above, aluminum material is accumulated also in the removed portion, and therefore sufficient amount of the aluminum material can be accumulated, resulting in an accumulated material 75 having a desired configuration, which in turn can guide the aluminum material more smoothly.

[0111] In the aforementioned embodiment, although the explanation is directed to the case in which a single die 10 is set in the die mounting plate 60, the present invention is not limited to the above. In the present invention, two or more dies 10 can be set in the die mounting plate 60.

[0112] For example, as shown in the die assembly P5 shown in Fig. 17, it can be constituted such that two die mounting holes 61 and 61 are formed in the die mounting plate 60 and dies 10 and 10 are mounted in the die mounting holes 61 respectively.

[0113] Alternatively, as shown in the die assembly P6 shown in Fig. 18, it can be constituted such that a laterally elongated large die mounting hole 61 capable of mounting two dies 10 and 10 is formed in a die mounting plate 60 and two dies 10 and 10 are mounted in the die mounting hole 61 side by side. In this die assembly P6, an additional aluminum accumulating portion 70 is formed between the adjacent dies 10 and 10.

[0114] In the case of mounting a plurality of dies 10 in a die mounting plate 60, pressing force of metallic material can be dispersed by each die 10, resulting in a further reduced burden of each die 10 against the pressing force, which in turn can further improve the durability of the die 10.

[0115] Furthermore, in the present invention, like the aforementioned embodiments, it is preferable that the rear end surface (basal end surface) of the male die 30 is formed as a part of the convex surface (spherical surface) constituting the billet pressure receiving surface 22 of the pressure receiving portion 21 and that the rear end surface of the male die 30 and the billet pressure receiving surface 22 collectively form a desired smooth convex surface (spherical surface). In the present invention, however, the configuration of the rear end surface (basal end surface) of the male die 30 is not limited to the above, and can be configured as follows. That is, in the present invention, in cases where the surface area of the rear end face of the male die 30 is, for example, 1/3 or less of the surface area of the billet pressure receiving surface 22 of the die 10, the rear end face of the male die 30 can be constituted by a part of a columnar external peripheral surface in which the rear end face is circular corresponding to the billet pressure receiving surface 22 in the width direction (longitudinal direction) and straight in the thickness direction (direction perpendicular to the longitudinal direction) because of the following reasons. That is, in cases where the surface area of the rear end face of the male die 30 is small as mentioned above, influences on die life and extrusion load due to the fact that the rear end face of the male die 30 is formed not into a part of a convex surface (spherical surface) but into a part of an external periphery of a circular column is small and the processing cost of the rear end face of the male die 30 can be reduced.

EXAMPLES

<EXAMPLE 1>

[0116] A die assembly P1 corresponding to the aforementioned embodiment (see Figs. 1 to 4) was prepared. In the die 10 of this die assembly P1, two portholes 24 were formed in the pressure receiving portion 21 at both sides of the thickness direction of the extrusion hole 11. The inclination angle θ of this porthole 24 was set to 20° . The billet pressure receiving surface 22 was formed into a 1/2 spherical configuration having a radius of 30 mm.

[0117] In this die mounting plate 60, no cut-out processing was performed at the inlet side periphery of the die mounting hole 61. Therefore, the inner periphery of the die mounting hole 61 constituted a peripheral wall surface of the aluminum accumulating portion 70. The peripheral wall surface of the aluminum accumulating portion 70 extended in parallel with the central axis A1 of the die 10.

[0118] The male die 30 was adjusted to 2.0 mm in height (thickness) of the mandrel 31, 19.2 mm in width of the mandrel 31, 1.2 mm in height of the passage forming protruded portion 33, 0.6 mm in width of the passage forming protruded portion 33, and 0.2 mm in width of the partition forming groove 32.

[0119] The female die 40 was adjusted to 1.7 mm in height of the die hole 41 and 20.0 mm in width of the die hole 41.

[0120] As shown in Fig. 11, the extrusion die 10 was set to an extruder similar to the extruder shown in the embodiment and extrusion was performed to produce a flat multi-passagage tubular member (heat exchanging tubular member) as shown in Figs. 12 and 13.

[0121] The die life (the amount (tons) of introduced material until cracks or wear occurred in the die) and the extrusion load were measured. Furthermore, the die life limiting factors were investigated. The results are shown in Table 1.

[0122]

[Table 1]

	Die life (ton/die)	Die life limiting factor	Extrusion load (x 10 ⁴ N)
Example 1	3.0	Wear of male die	1,480
Example 2	3.0	Wear of male die	1,480
Example 3	2.6	Veneration of cracks in male	1,350
Example 4	3.0	Wear of male die	1,400
Example 5	3.2	Wear of male die	1,400
Example 6	3.2	Wear of male die	1,400
Comparative Example	0.7	Generation of cracks in male die	1,500

<EXAMPLE 2>

[0123] A die assembly P2 corresponding to the first modified embodiment (see Fig. 14) was prepared. In this die assembly P2, the inlet side peripheral portion of the die mounting hole 61 of the die mounting plate 60 was removed in a chamfered manner to thereby form a removed portion 72 at the upstream side external periphery of the aluminum accumulating portion 70. The inner peripheral wall surface 73 of this removed portion 72 was formed into a tapered surface which gradually decreased in diameter toward the downstream side.

[0124] Other than the above, the same evaluations as mentioned above were performed by executing extrusion in the same manner as mentioned above. The results are shown in Table 1.

<EXAMPLE 3>

[0125] A die assembly P3 corresponding to the second modified embodiment (see Fig. 15) was prepared. In this die assembly P3, the inlet side peripheral portion of the die mounting hole 61 of the die mounting plate 60 was removed in a stepped manner (an L-shaped manner) to thereby form a removed portion 72 at the upstream side external periphery of the aluminum accumulating portion 70. The inner peripheral wall surface 73 of this removed portion 72 extended in parallel with the central axis A1 of the die 10.

[0126] Other than the above, the same evaluations as mentioned above were performed by executing extrusion in the same manner as mentioned above. The results are shown in Table 1.

<EXAMPLE 4>

[0127] A die assembly P4 corresponding to the third modified embodiment (see Fig. 16) was prepared. In this die assembly P4, the inlet side peripheral portion of the die mounting hole 61 of the die mounting plate 60 was removed in a reversed-chamfered manner to thereby form a removed portion 72 at the upstream side external periphery of the aluminum accumulating portion 70. The inner peripheral wall surface 73 of this removed portion 72 was formed into a reversed-tapered surface which gradually increased in diameter toward the downstream side.

[0128] Other than the above, the same evaluations as mentioned above were performed by executing extrusion in the same manner as mentioned above. The results are shown in Table 1.

<EXAMPLE 5>

[0129] A die assembly P5 corresponding to the fourth modified embodiment (see Fig. 17) was prepared. In this die assembly P5, two die mounting holes 61 and 61 were formed in the die mounting plate 60. Dies 10 and 10 were mounted in the corresponding die mounting holes 61 and 61. At the inner peripheral surface of each die mounting hole 61, no special processing such as peripheral edge portion removing processing was performed, so that the peripheral wall surface of the aluminum accumulating portion 70 was formed by the inner peripheral surface of each die mounting hole 61. Needless to say, this peripheral wall surface extended in parallel with the central axis A1.

[0130] Other than the above, the same evaluations as mentioned above were performed by executing extrusion in the same manner as mentioned above. The results are shown in Table 1.

<EXAMPLE 6>

[0131] A die assembly P6 corresponding to the fifth modified embodiment (see Fig. 18) was prepared. In this die assembly P6, a single laterally elongated die mounting hole 61 capable of mounting two dies 10 and 10 side by side was formed in the die mounting plate 60. In this die mounting hole 61, dies 10 and 10 were arranged side by side. In this die assembly P6, the adjacent dies 10 and 10 were communicated with each other in the die mounting hole 61, so that an aluminum accumulating portion 70 was also formed between both the dies 10 and 10.

[0132] At the inner peripheral surface of the die mounting hole 61, no special processing such as peripheral edge portion removing processing was performed, so that the peripheral wall surface of the aluminum accumulating portion 70 was formed by the inner peripheral surface of the die mounting hole 61. Needless to say, this peripheral wall surface extended in parallel with the central axis A1.

[0133] Other than the above, the same evaluations as mentioned above were performed by executing extrusion in the same manner as mentioned above. The results are shown in Table 1.

<COMPARATIVE EXAMPLE>

[0134] A die assembly in which a bridge type extrusion die was mounted in a die mounting hole formed in a die mounting plate was prepared. In this die, the diameter was 30 mm, the height (length along the extrusion direction) was 50 mm, and the billet pressure receiving surface was formed into a flat surface perpendicular to the extrusion direction. In this die assembly, portholes were formed in a flat pressure receiving surface perpendicular to the extrusion direction. No aluminum accumulating portion reaching to a point on a more downstream side than the inlet position of the porthole was formed around the porthole.

[0135] Other than the above, the same evaluations as mentioned above were performed by executing extrusion in the same manner as mentioned above. The results are shown in Table 1.

<EVALUATIONS>

[0136] As shown in Table 1, in Comparative Example, cracks of the male die became die life limiting factors and the die life was short.

[0137] On the other hand, in each Example, a longer die life could be secured as compared with Comparative Example.

[0138] Among other things, in the die assemblies of Examples 1, 2, 4, 5 and 6 except for Example 3, wear of the male die was one of die life limiting factors and they had sufficiently long die life. Especially, in the die assemblies of Examples 5 and 6 in which a plurality of dies 10 were arranged, a longer die life could be secured.

[0139] In the die assembly of Example 3, although cracks of the male die were one of die life limiting factors, a certain die life could be secured and the die life was at least longer than that of Comparative Example.

[0140]

[Table 2]

	Spherical size of billet pressure receiving surface	Die life (ton/die)
Example 7	1/8	1.2
Example 8	1/6	2.0
Example 9	1/3	2.5
Example 10	1/2	3.0
Example 11	4/6	3.0
Example 12	5/6	3.0

<EXAMPLE 7>

[0141] A die assembly P1 corresponding to the aforementioned embodiment (see Figs. 1 to 4) was prepared. In the die 10 of this die assembly P1, two portholes 24 were formed in the pressure receiving portion 21 at both sides with respect to the thickness direction of the extrusion hole 11. The inclination angle θ of this porthole 24 was set to 25°.

[0142] The billet pressure receiving surface 22 of this die 10 was formed into a 1/8 spherical configuration having a radius of 45.4 mm. The diameter of this pressure receiving portion 21 was adjusted to 60 mm.

[0143] The male die 30 was adjusted to 2.0 mm in height (thickness) of the mandrel 31, 19.2 mm in width of the

mandrel 31, 1.2 mm in height of the passage forming protruded portion 33, 0.6 mm in width of the passage forming protruded portion 33, and 0.2 mm in width of the partition forming groove 32.

[0144] The female die 40 adjusted to 1.7 mm in height of the die hole 41 and 20.0 mm in width of the die hole 41 was used.

[0145] As shown in Fig. 11, the extrusion die 10 was set to an extruder similar to the extruder shown in the embodiment and extrusion was performed to produce a flat multi-passage tubular member (heat exchanging tubular member) as shown in Figs. 12 and 13.

[0146] Die life (ton/die) was measured. The results are shown in Table 2.

<EXAMPLE 8>

[0147] As shown in Table 2, an extrusion die 10 which was the same as the extrusion die of Example 7 except that the billet pressure receiving surface 22 was constituted by a 1/6 spherical surface and the radius was set to 40.3 mm was prepared. The extrusion die 10 was set to the same extruder as mentioned above and extrusion was performed to produce a flat multi-passage tubular member.

<EXAMPLE 9>

[0148] As shown in Table 2, an extrusion die 10 which was the same as the extrusion die of Example 7 except that the billet pressure receiving surface 22 was constituted by a 1/3 spherical surface and the radius was set to 32.0 mm was prepared. The extrusion die 10 was set to the same extruder as mentioned above and extrusion was performed to produce a flat multi-passage tubular member.

<EXAMPLE 10>

[0149] As shown in Table 2, an extrusion die 10 which was the same as the extrusion die of Example 7 except that the billet pressure receiving surface 22 was constituted by a 1/2 spherical surface and the radius was set to 30.0 mm was prepared. The extrusion die 10 was set to the same extruder as mentioned above and extrusion was performed to produce a flat multi-passage tubular member.

<EXAMPLE 11>

[0150] As shown in Table 2, an extrusion die 10 which was the same as the extrusion die of Example 7 except that the billet pressure receiving surface 22 was constituted by a 4/6 spherical surface and the radius was set to 32.0 mm was prepared. The extrusion die 10 was set to the same extruder as mentioned above and extrusion was performed to produce a flat multi-passage tubular member.

<EXAMPLE 12>

[0151] As shown in Table 2, an extrusion die 10 which was the same as the extrusion die of Example 7 except that the billet pressure receiving surface 22 was constituted by a 5/6 spherical surface and the radius was set to 40.3 mm was prepared. The extrusion die 10 was set to the same extruder as mentioned above and extrusion was performed to produce a flat multi-passage tubular member.

<EVALUATIONS>

[0152] As shown in Table 2, in the die (Example 7) in which the spherical radius of the billet pressure receiving surface 22 was large and the protruded amount thereof was relatively small, the die life was slightly short.

[0153] Furthermore, in the die (Example 12) in which the spherical radius of the billet pressure receiving surface 22 was small and the protruded amount thereof was relatively large, it is considered that although a long die life can be secured, it may be slightly difficult to process the billet pressure receiving surface 22.

[0154] To the contrary, in the die (Examples 8 to 11) in which the pressure receiving surface 22 was formed into an appropriate convex configuration, i. e. , a 1/6 to 4/6 spherical configuration, the die life could be extended and the die production cost could be reduced. Among other things, in the die (Example 10) in which the billet pressure receiving surface 22 was formed into a 1/2 spherical configuration, the die production cost could be reduced while keeping sufficient long die life, which was excellent in result.

[0155] Comparing with the die of Example 10, in the die (Example 11) in which the billet pressure receiving surface 22 was formed into a 4/6 spherical configuration, the die production cost slightly increased and the results were slightly not good among the dies of Examples 8 to 11.

[0156] This application claims priority to Japanese Patent Application No. 2007-4282 filed on January 12, 2007, and Japanese Patent Application No. 2007-57263 filed on March 7, 2007, and the entire disclosures of which are incorporated herein by reference in their entirety.

[0157] 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.

[0158] 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.

[0159] 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. For example, in the present disclosure, the term "preferably" is non-exclusive and means "preferably, but not limited to." In this disclosure and during the prosecution of this application, means-plus-function or step-plus-function limitations will only be employed where for a specific claim limitation all of the following conditions are present in that limitation: a) "means for" or "step for" is expressly recited; b) a corresponding function is expressly recited; and c) structure, material or acts that support that structure are not recited. In this disclosure and during the prosecution of this application, the terminology "present invention" or "invention" may be used as a reference to one or more aspect within the present disclosure. The language present invention or invention should not be improperly interpreted as an identification of criticality, should not be improperly interpreted as applying across all aspects or embodiments (i.e., it should be understood that the present invention has a number of aspects and embodiments), and should not be improperly interpreted as limiting the scope of the application or claims. In this disclosure and during the prosecution of this application, the terminology "embodiment" can be used to describe any aspect, feature, process or step, any combination thereof, and/or any portion thereof, etc. In some examples, various embodiments may include overlapping features. In this disclosure and during the prosecution of this case, the following abbreviated terminology may be employed: "e.g." which means "for example;" and "NB" which means "note well."

INDUSTRIAL APPLICABILITY

[0160] The extrusion die assembly according to the present invention can be preferably used in manufacturing an extruded product, such as, e.g., a hollow tube, more specifically, a heat exchanging tube for use in, e.g., automobile air-conditioning gas coolers, evaporators, household hot-water supplying apparatuses.

Claims

1. An extrusion die assembly in which an extrusion die is mounted in a die mounting hole of a die mounting plate, so that a metallic material to be introduced into the die mounting hole is introduced in the die via a porthole formed in a metallic material pressure receiving surface of the die, **characterized in that** a material accumulating portion extending to a point on a more extrusion directional downstream side than an inlet position of the porthole is provided outside the porthole in the die mounting hole so as to accumulate a part of the metallic material introduced into the die mounting hole in the material accumulating portion.
2. The extrusion die assembly as recited in claim 1, wherein the extrusion die comprises
 - a die case having a pressure receiving portion with an external surface constituting the metallic material pressure receiving surface,
 - a male die mounted in the die case, and
 - a female die mounted in the die case so as to form an extrusion hole by and between the male die and the female die, wherein the pressure receiving surface is formed into a convex configuration protruded toward an upstream side of an extrusion direction, and the porthole is formed in an external periphery of the pressure receiving portion, and wherein the material accumulating portion is provided at an external peripheral portion of the pressure receiving portion.

3. The extrusion die assembly as recited in claim 1 or 2, wherein an inlet side peripheral edge portion of the die mounting hole of the die mounting plate is removed to thereby form a removed portion at an upstream side external periphery of the material accumulating portion.
- 5 4. The extrusion die assembly as recited in claim 3, wherein an inner peripheral wall surface of the removed portion is formed into a tapered surface which gradually reduces in diameter toward a downstream side.
5. The extrusion die assembly as recited in claim 3, wherein an inner peripheral wall surface of the removed portion is arranged in parallel with a central axis of the die.
- 10 6. The extrusion die assembly as recited in claim 3, wherein an inner peripheral wall surface of the removed portion is formed into a tapered surface which gradually increases in diameter toward a downstream side.
- 15 7. The extrusion die assembly as recited in claim 1 or 2, wherein the die mounting plate is provided with a plurality of die mounting holes, and the extrusion dies are mounted in each die mounting hole.
8. The extrusion die assembly as recited in claim 1 or 2, wherein a plurality of extrusion dies are disposed in a single die mounting hole.
- 20 9. The extrusion die assembly as recited in claim 2, wherein the pressure receiving surface of the die is formed into a convex spherical surface forming a part of a spherical surface.
10. The extrusion die assembly as recited in claim 2 or 9, wherein the pressure receiving surface of the die is constituted by a 1/6 to 4/6 convex spherical surface.
- 25 11. The extrusion die assembly as recited in claim 2 or 9, wherein a plurality of portholes are formed at equal intervals around a central axis of the die.
- 30 12. The extrusion die assembly as recited in claim 2 or 9,
wherein the male die and the female die form a flat circular extrusion hole having a height (thickness) smaller than a width,
wherein a portion of the male die corresponding to the extrusion hole is formed into a comb-like configuration having a plurality of passage forming protrusions arranged in a lateral direction, and
wherein a multi-passage hollow member having a plurality of passages arranged in a lateral direction is formed
35 when a metallic material passes through the extrusion hole.
13. The extrusion die assembly as recited in claim 2 or 9,
wherein the male die and the female die form a circular extrusion hole, and
wherein a tubular member circular in cross-section is formed when a metallic material passes through the extrusion
40 hole.
14. The extrusion die assembly as recited in claim 1 or 2, wherein the metallic material is aluminum or its alloy.
- 45 15. A production method of an extruded article, wherein the extruded article is formed using the extrusion die assembly as recited in claim 1 or 2.
16. A production method of a multi-passage hollow member, wherein the multi-passage hollow member is formed using the extrusion die assembly as recited in claim 12.
- 50 17. A production method of a tubular member, wherein the tubular member is formed using the extrusion die assembly as recited in claim 13.
- 55 18. A metallic material extrusion method in which an extrusion die is mounted in a die mounting hole of a die mounting plate so that a metallic material introduced in the die mounting hole is introduced in the die via a porthole formed in a metallic material pressure receiving surface of the extrusion die,
wherein a material accumulating portion extending to a point on a more extrusion directional downstream side than an inlet position of the porthole is formed outside the porthole in the die mounting hole so that a part of the metallic material is accumulated in the material accumulating portion when the metallic material is introduced in the die

mounting hole.

19. A metallic material extruder, comprising:

5 a container;
 a die mounting plate attached to the container; and
 an extrusion die mounted in a die mounting hole of the die mounting plate,
 wherein it is constructed such that a metallic material introduced in the container is introduced in the die mounting
10 hole and the metallic material introduced in the die mounting hole is introduced in the extrusion die via a porthole
 formed in a metallic material pressure receiving surface of the extrusion die, and
 wherein a material accumulating portion extending to a point on a more extrusion directional downstream side
 than an inlet position of the porthole is formed outside the porthole in the die mounting hole so that a part of the
 metallic material introduced in the die mounting hole is accumulated in the metallic accumulating portion.

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Fig. 1

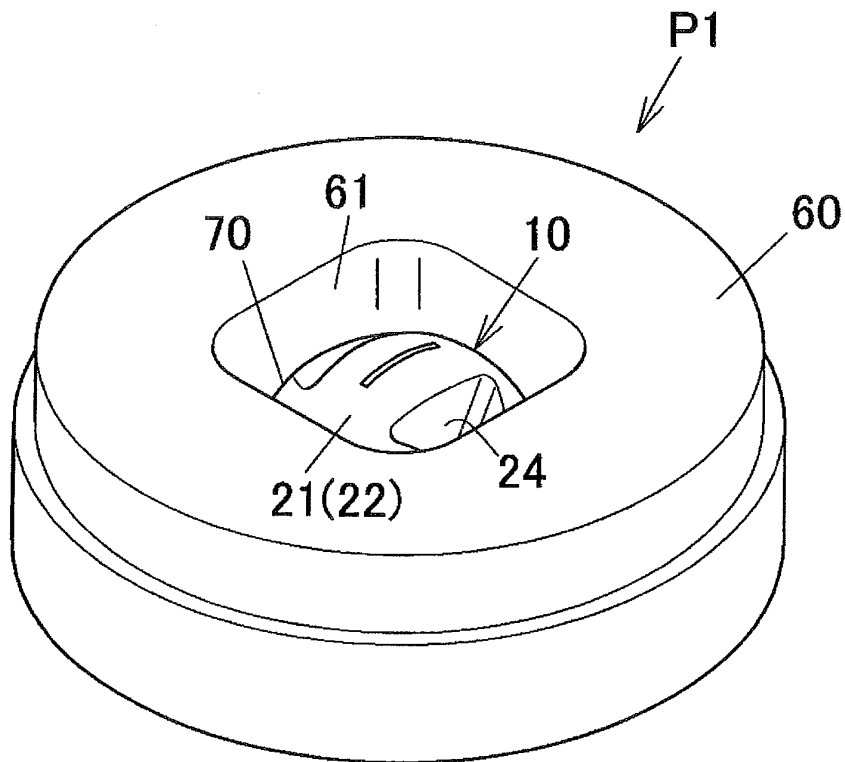


Fig. 2

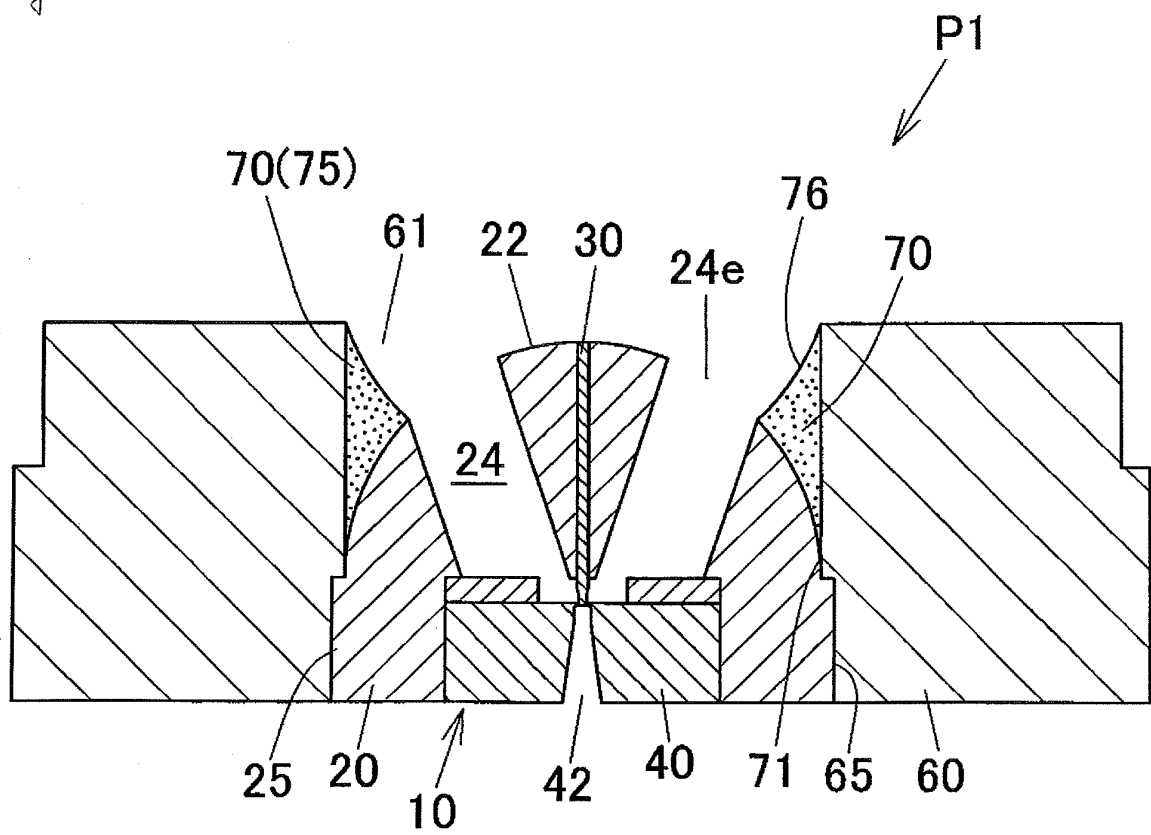


Fig. 3

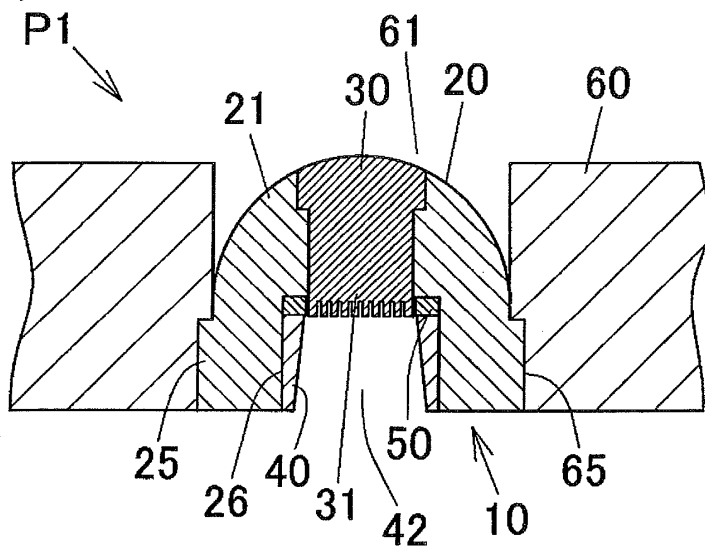


Fig. 4

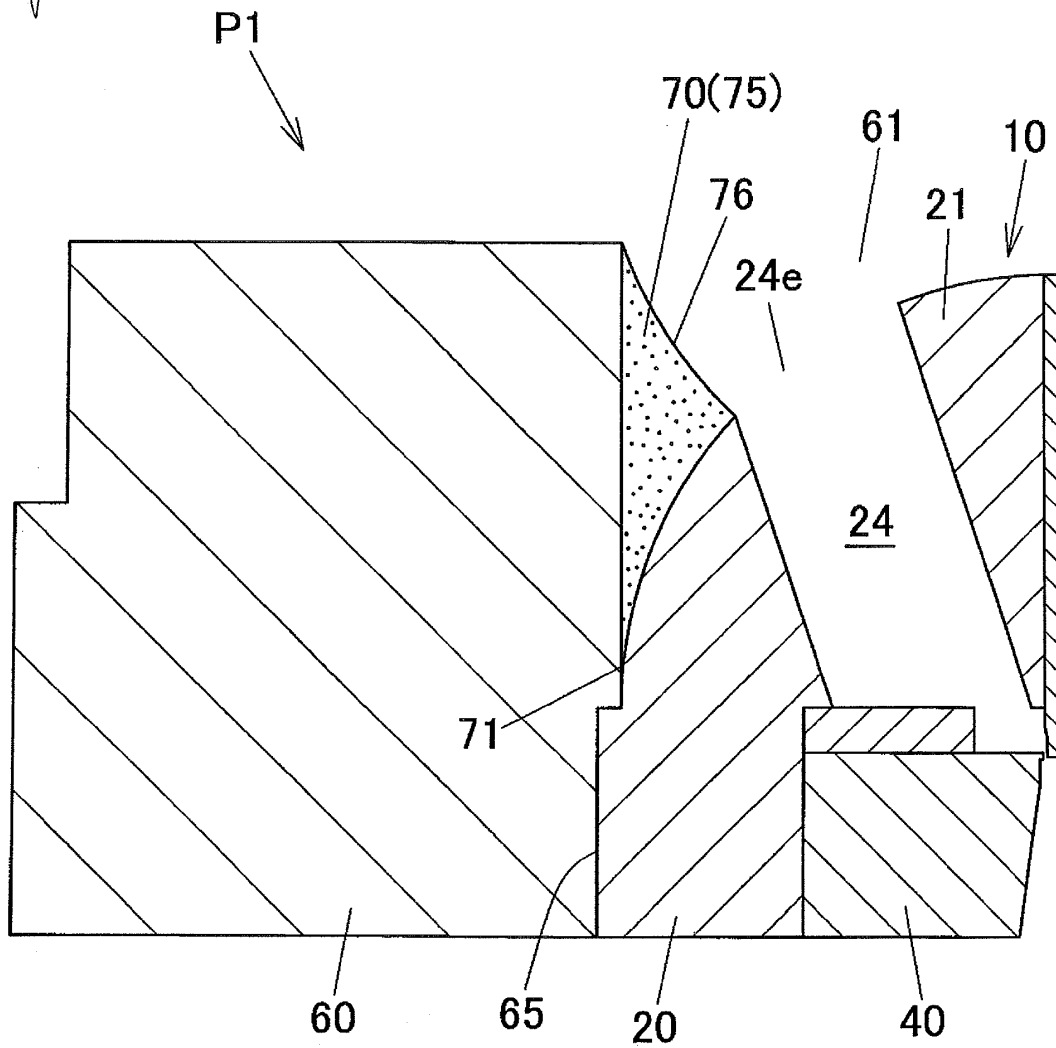


Fig. 5

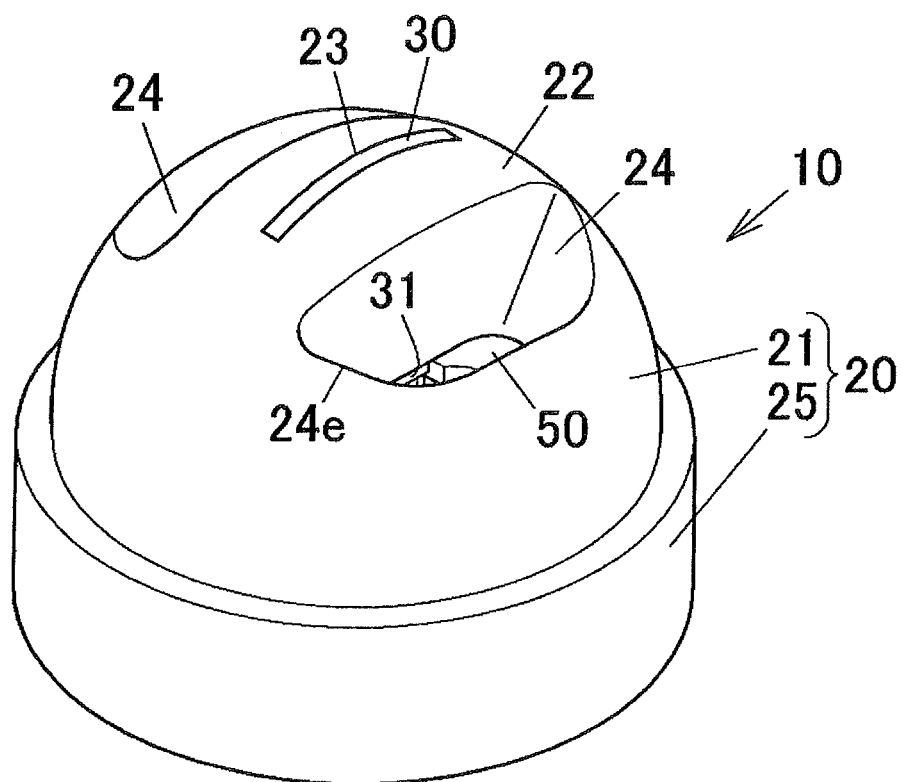


Fig. 6

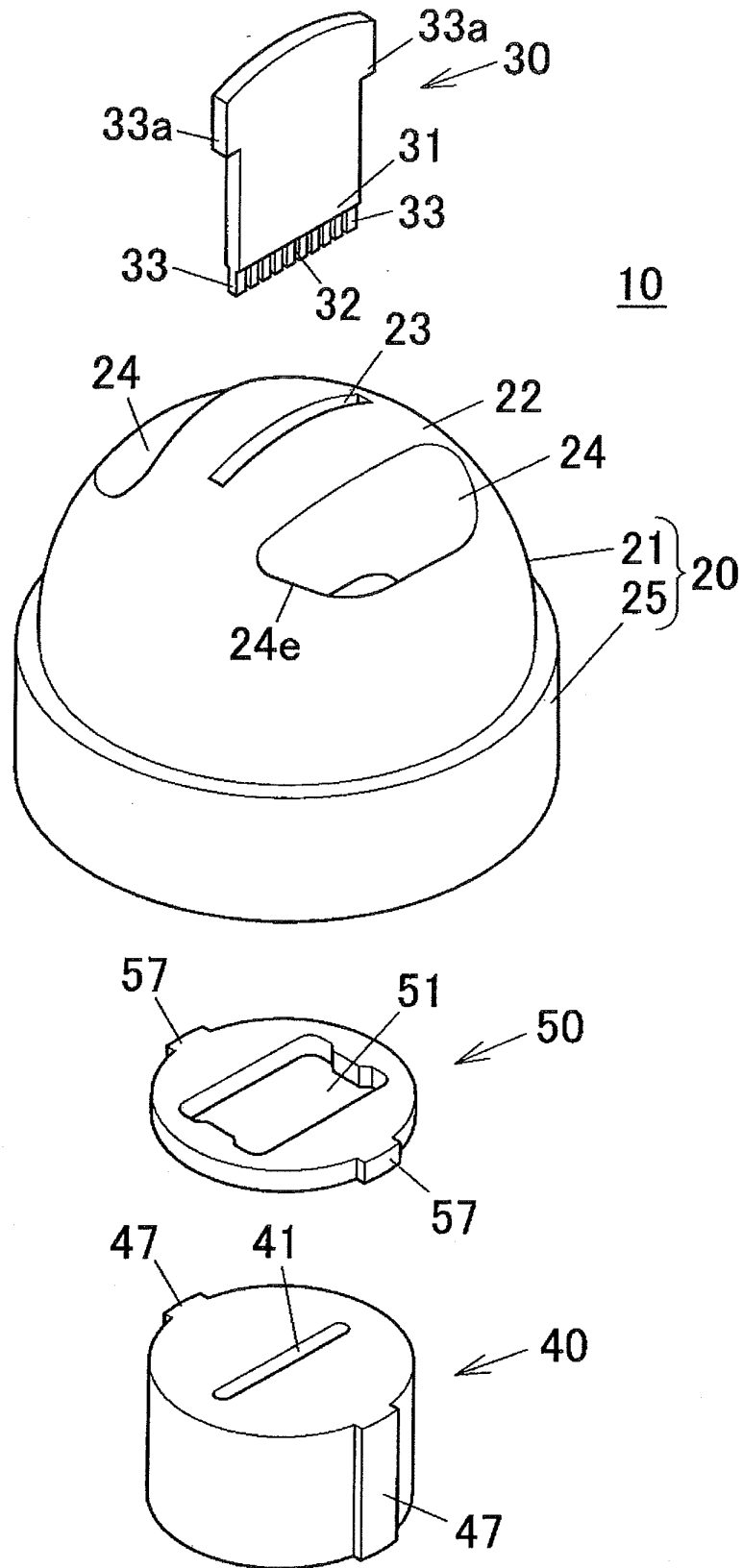


Fig. 7

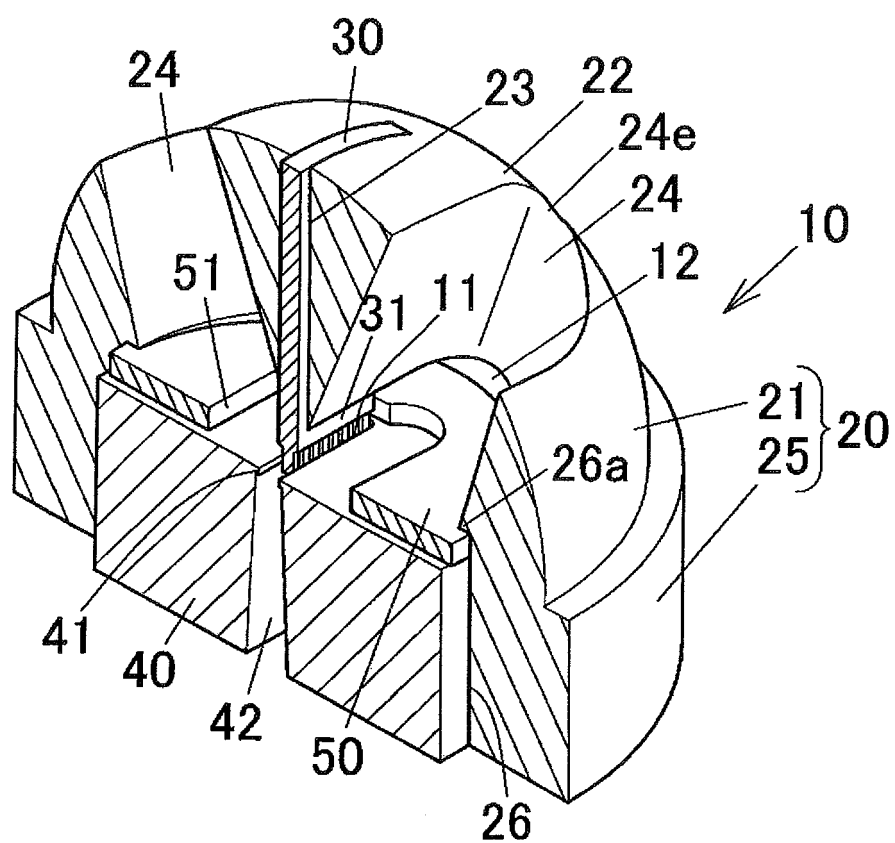


Fig. 8

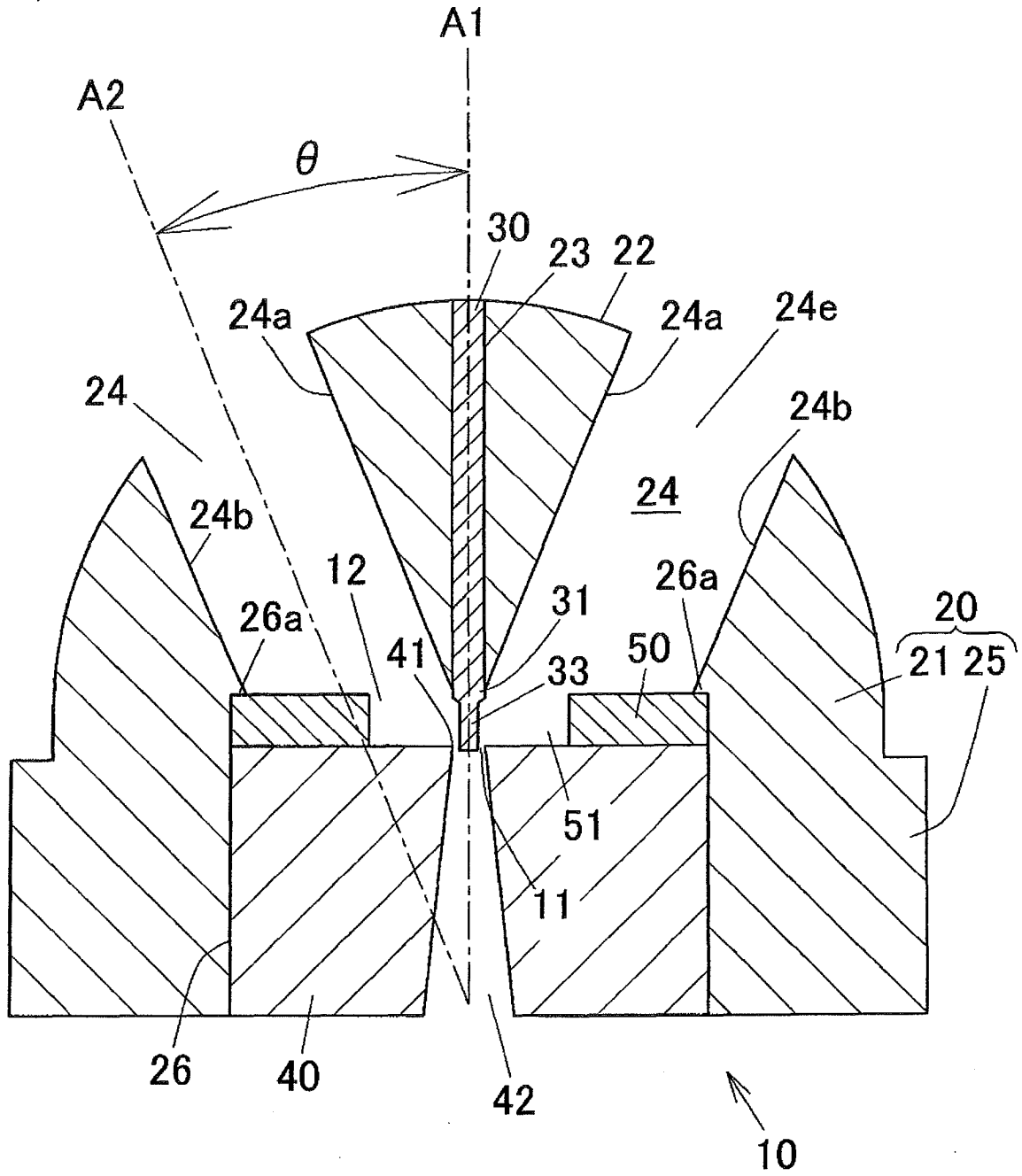


Fig. 9

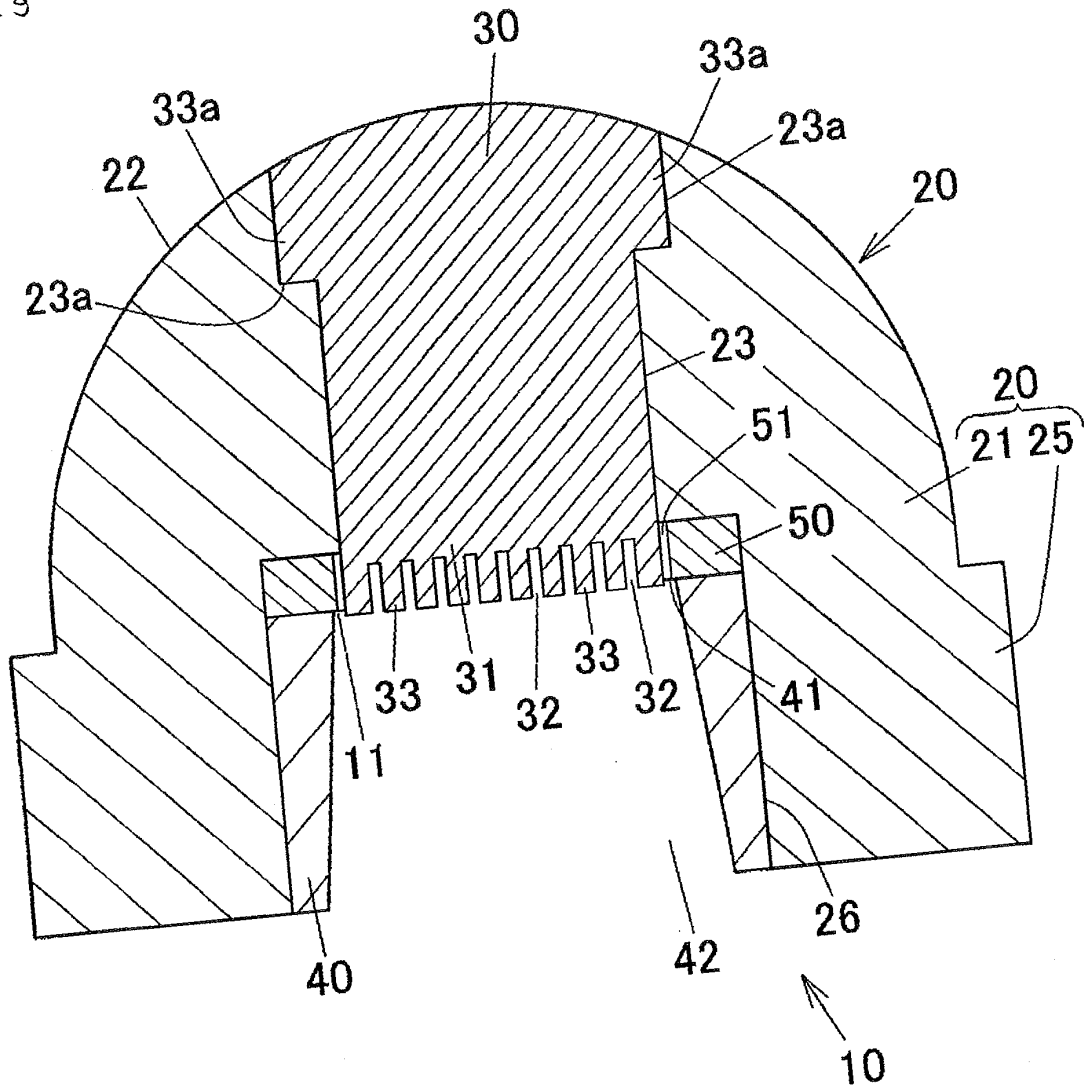


Fig. 10

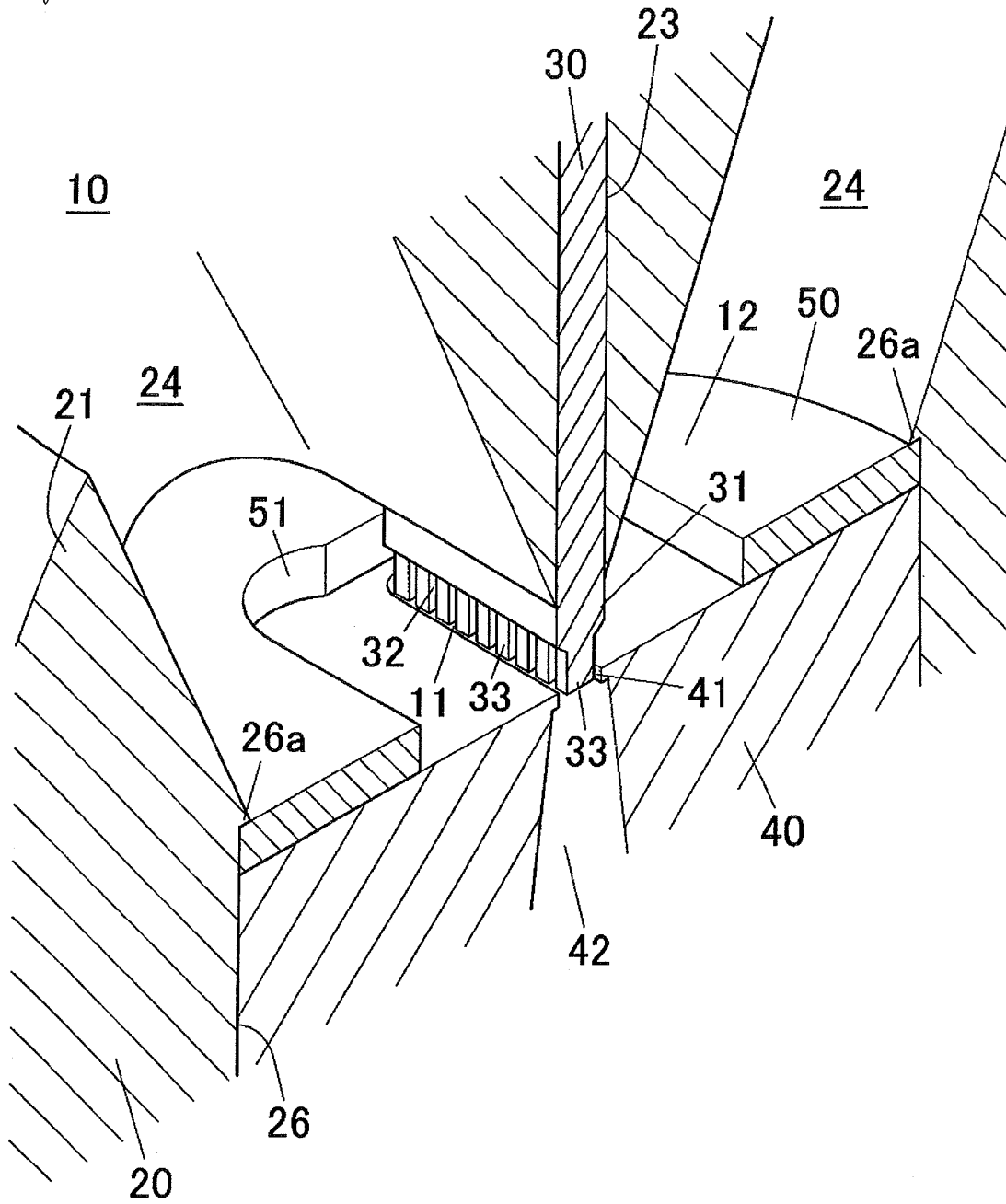


Fig. 11

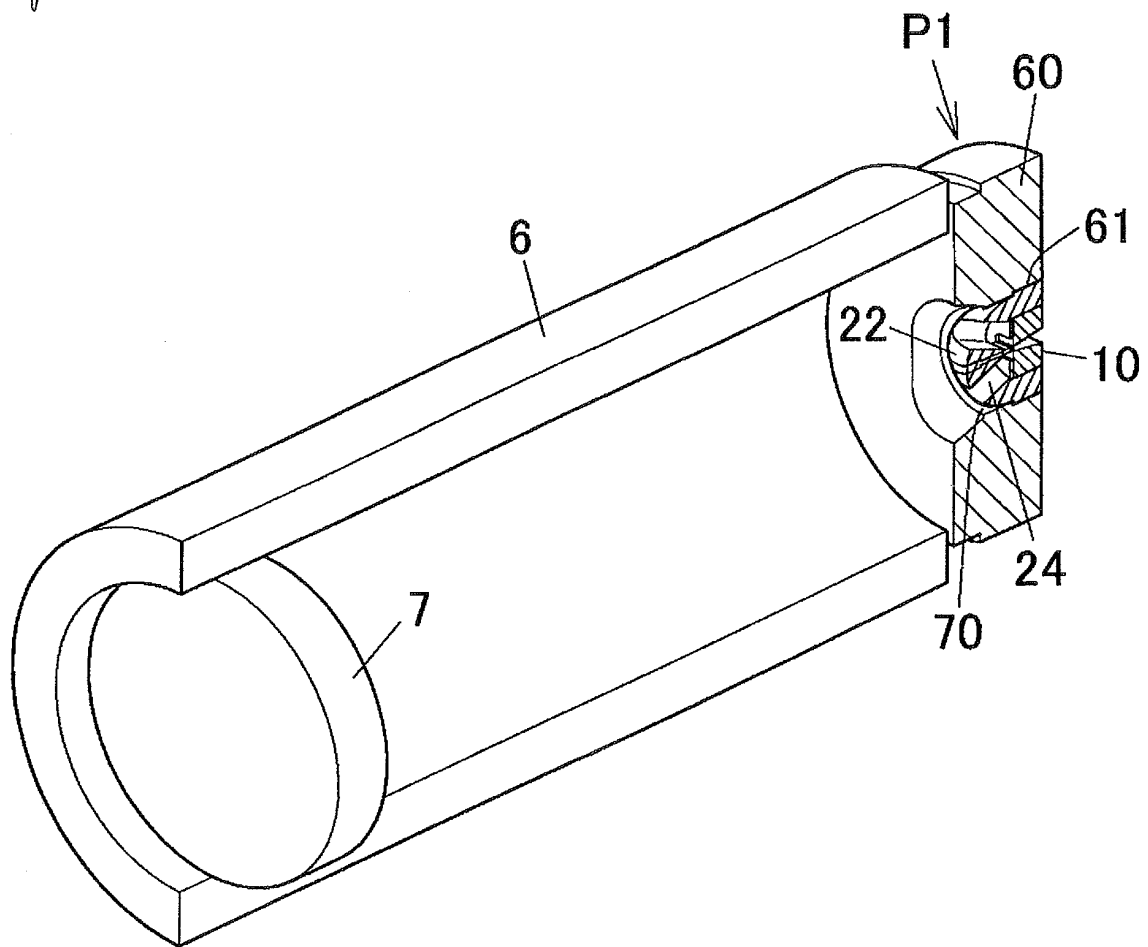


Fig. 12

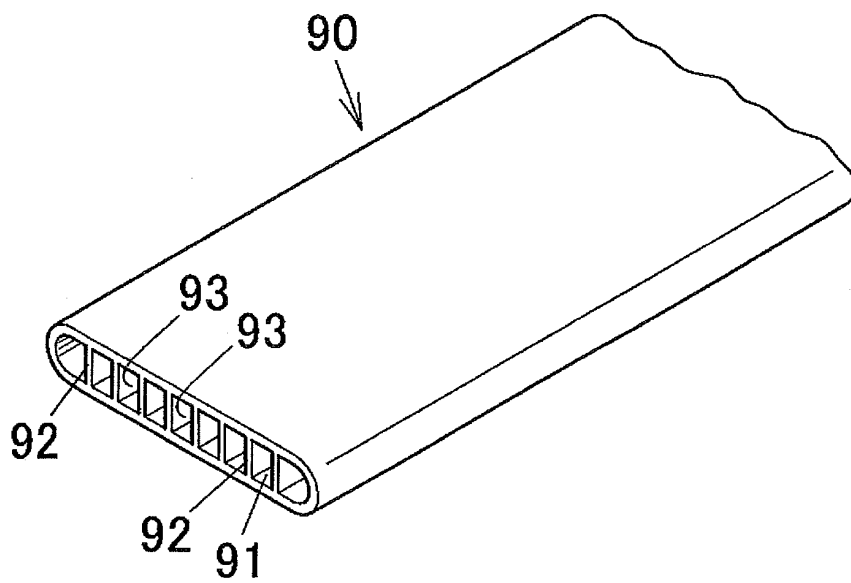


Fig. 13

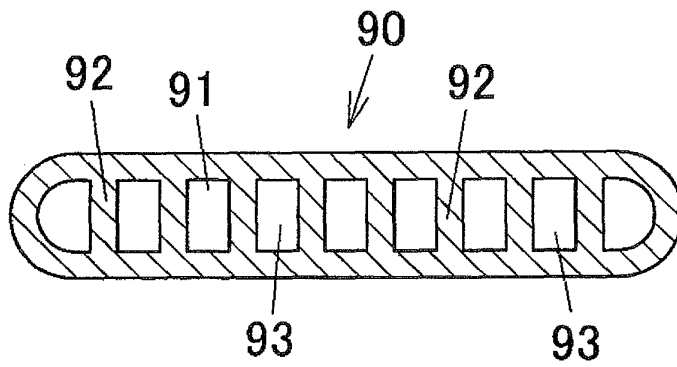


Fig. 14

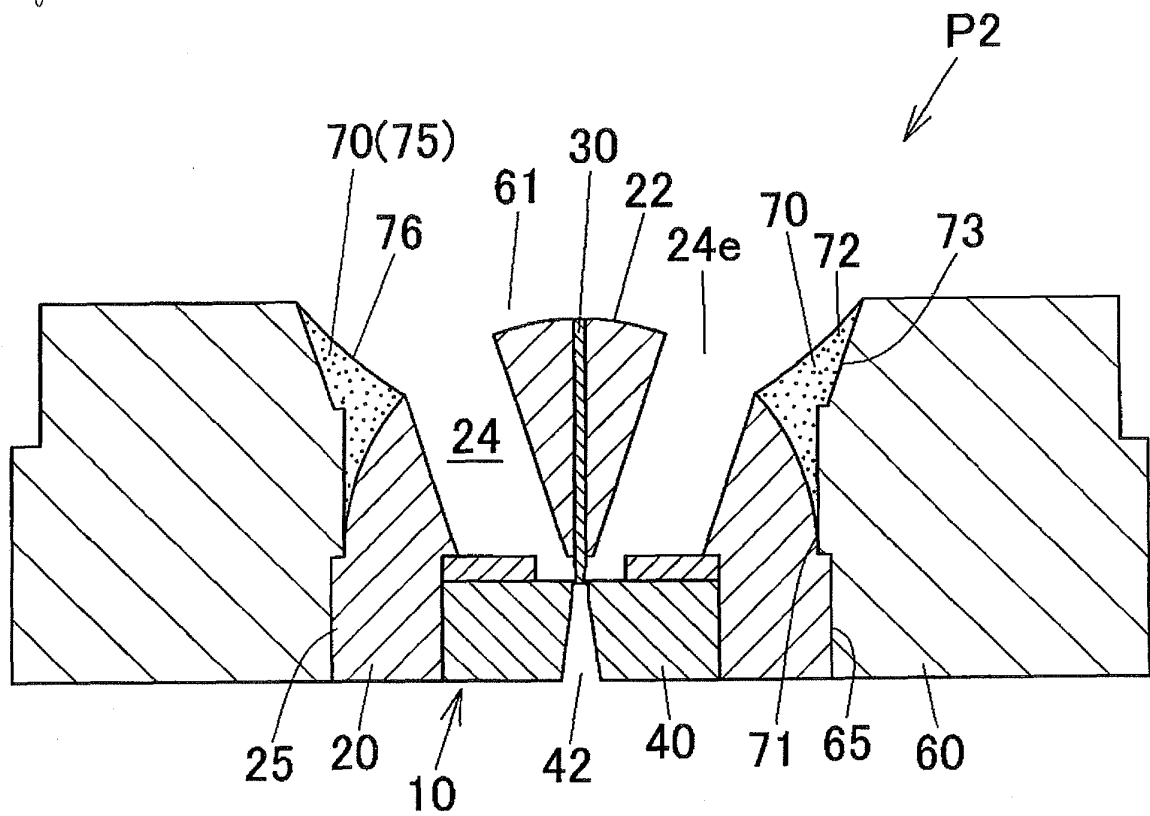


Fig. 15

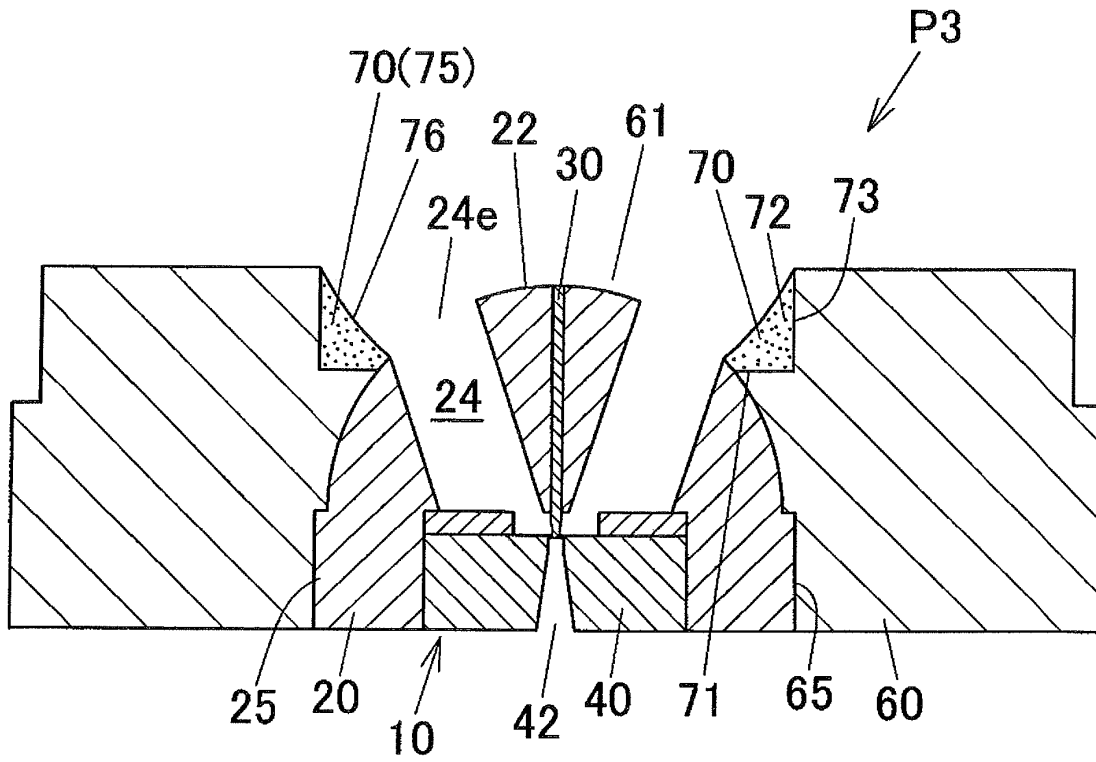


Fig. 16

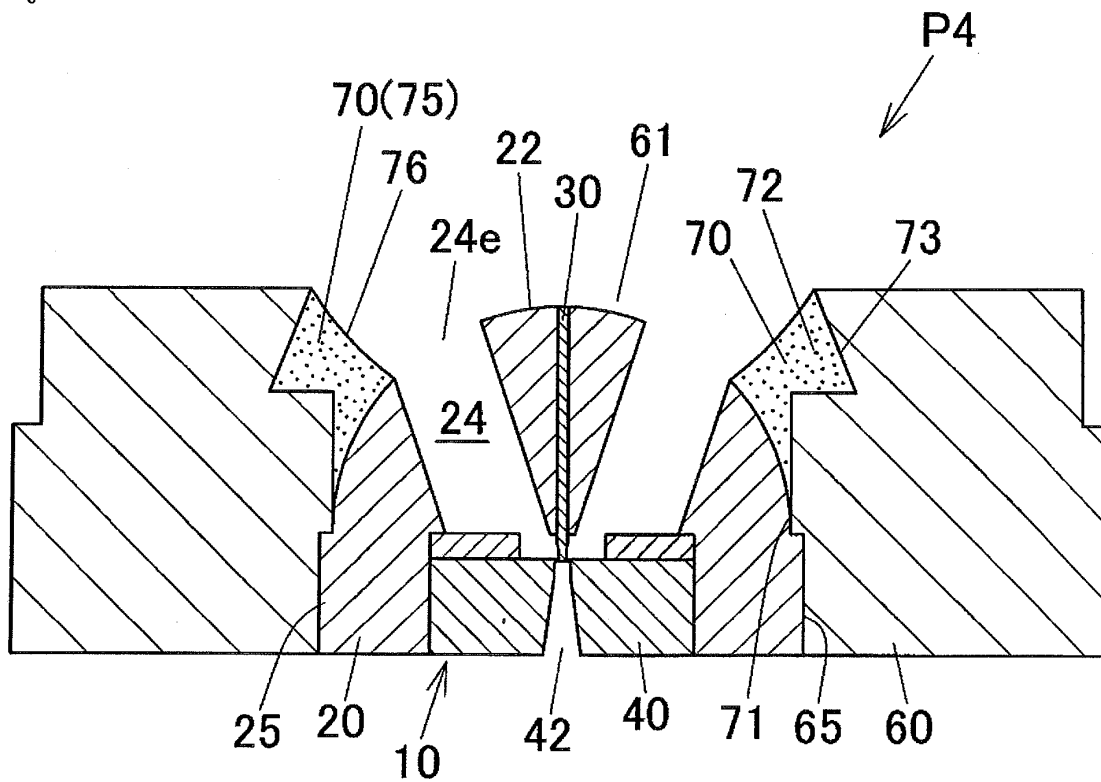


Fig. 17

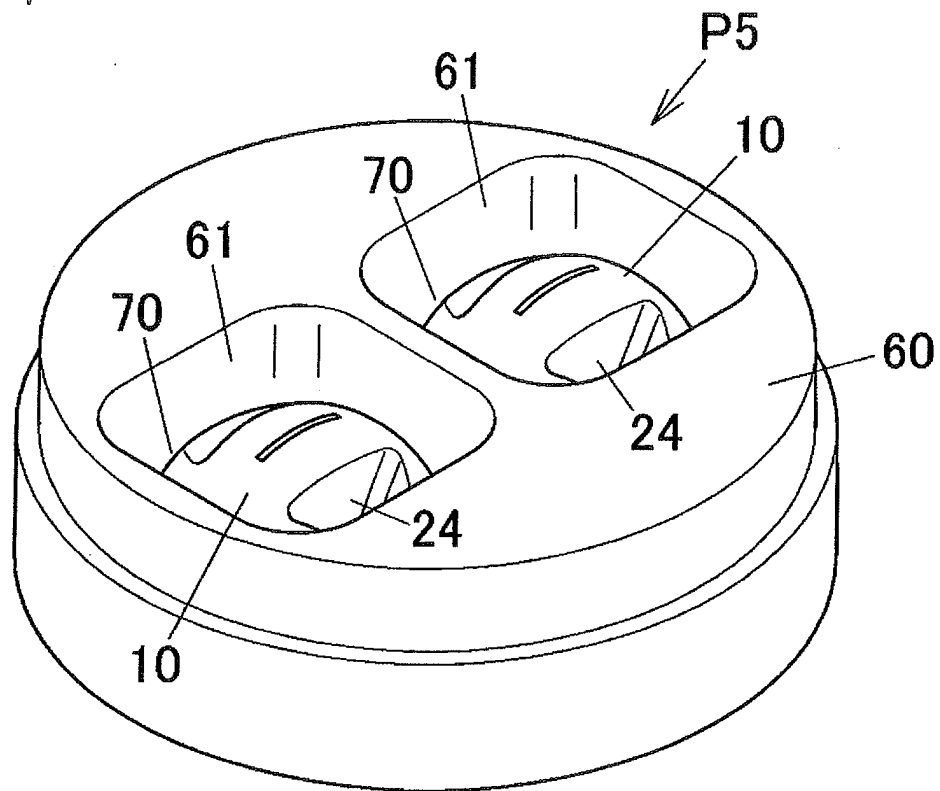


Fig. 18

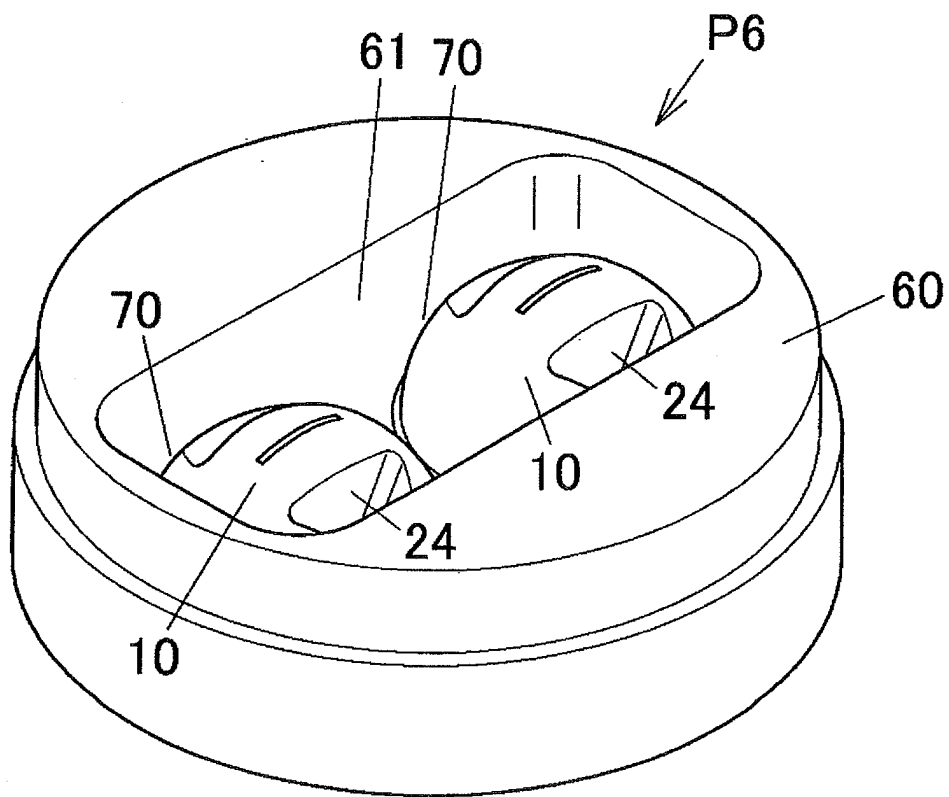


Fig. 13A

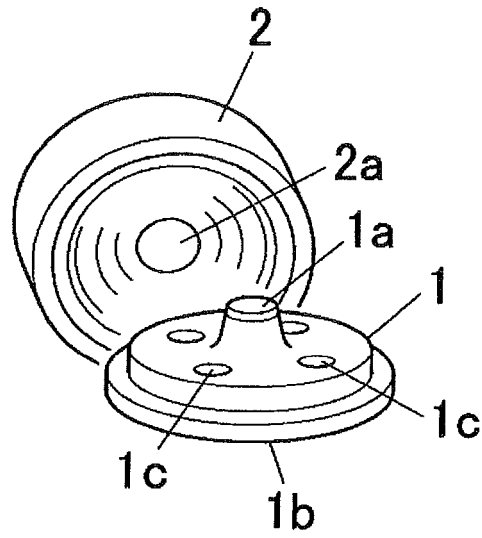


Fig. 13B

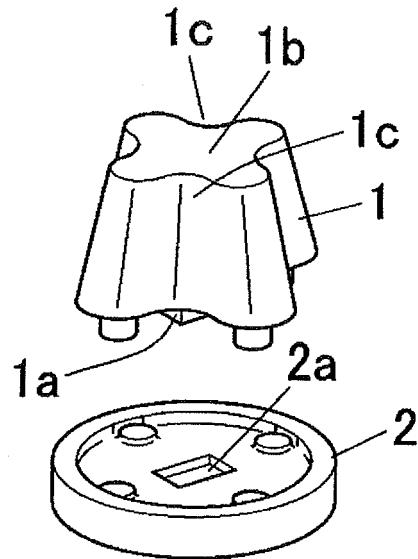
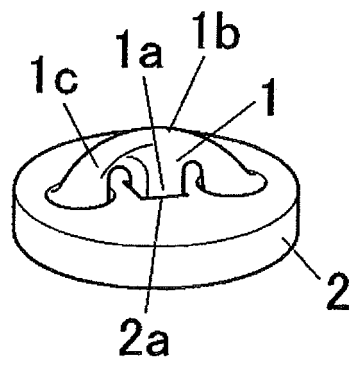


Fig. 13C



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2008/050203

A. CLASSIFICATION OF SUBJECT MATTER B21C25/02 (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) B21C23/00-35/06		
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 1996-2008 Kokai Jitsuyo Shinan Koho 1971-2008 Toroku Jitsuyo Shinan Koho 1994-2008		
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.
P, X	JP 2007-98473 A (Showa Denko Kabushiki Kaisha), 19 April, 2007 (19.04.07), Claims; Par. Nos. [0002], [0075], [0090]; Figs. 7 to 9 & WO 2007/029888 A1	1, 2, 7-12, 14-16, 18, 19
<u>X</u>	JP 49-46707 B1 (ROBERT ARMAND CREUZET), 11 December, 1974 (11.12.74), Column 2, line 29 to column 4, line 12; drawings & FR 2082001 A1 & GB 1339732 A & US 3748885 A	<u>1, 2, 11,</u> <u>13-15, 17-19</u> <u>7, 8, 12, 16</u> <u>3-6, 9, 10</u>
Y		
<u>A</u>		
☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 12 March, 2008 (12.03.08)		Date of mailing of the international search report 25 March, 2008 (25.03.08)
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer
Facsimile No.		Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2008/050203

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
<u>X</u>	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 85772/1976 (Laid-open No. 102938/1978)	<u>1, 2, 11,</u> <u>13-15, 17-19</u>
<u>Y</u>	(Nippon Keikinzoku Sogo Kenkyusho), 19 August, 1978 (19.08.78), Claims; page 4, line 18 to page 5, line 2; Fig. 4 (Family: none)	<u>7, 8, 12, 16</u> <u>3-6, 9, 10</u>
<u>A</u>		
<u>Y</u>	JP 2004-306124 A (Yugen Kaisha Yano Engineering), 04 November, 2004 (04.11.04), Par. No. [0001]; Figs. 1, 11, 16 (Family: none)	<u>7, 8, 12, 16</u> <u>1-6, 9-11,</u> <u>13-15, 17-19</u>
<u>A</u>		

Form PCT/ISA/210 (continuation of second sheet) (April 2007)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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- JP H0681644 B [0005]
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- JP 2007057263 A [0156]