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(54) **PAPER-MAKING MOLD, AND PAPER MOLDING**

(57) A papermaking mold 10 includes a mold main body 10A having a wire part and a wire 108 disposed on the wire part. The wire part has a base surface 102, a columnar projection 106 lying sideways on the base surface 102, and at least two plate-like projections 105 at

predetermined positions at a predetermined spacing in the longitudinal direction of the columnar projection 106. The facing inner sides 105A of every adjacent two of the plate-like projections 105 are each formed of a part of a circular conical surface or a part of a hyperboloid.

Fig. 1(a)

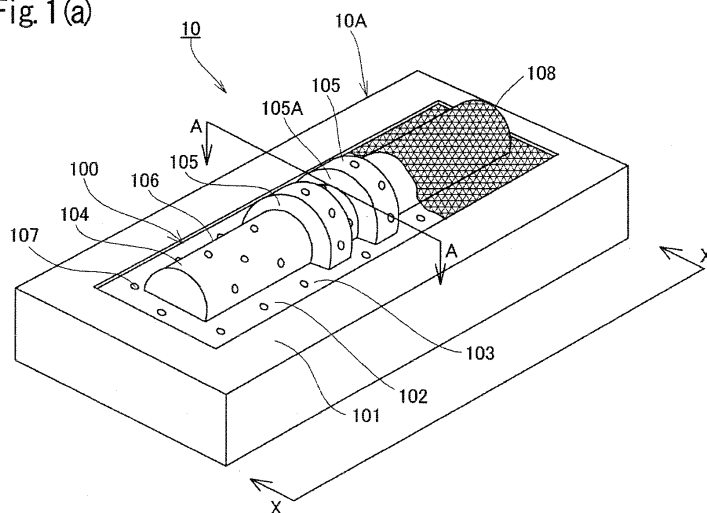
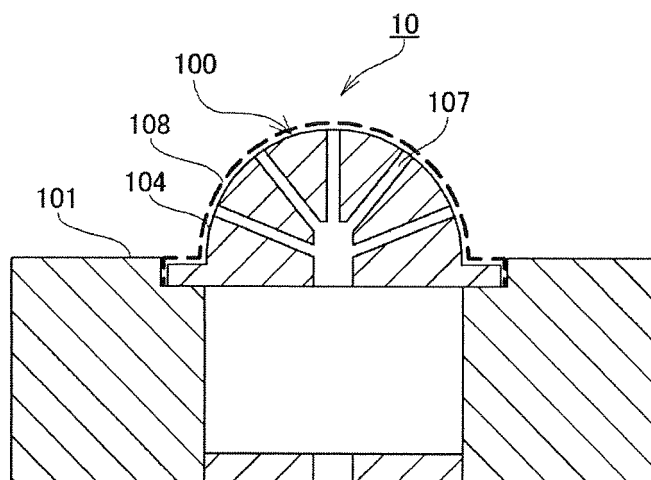


Fig. 1(b)



Description

Technical Field

[0001] The present invention relates to a papermaking mold and a fiber molded article.

Background Art

[0002] The common assignee of the present invention has proposed a technique of producing a fiber molded article in JP 2005-290600A. The technique is pertinent to a method in which a wet mat of fibers is prepared by papermaking processing using a raw material slurry containing a fibrous material such as inorganic fiber and organic fiber, dewatering the wet fiber mat, followed by drying and pressing to make a fiber molded article with a desired contour.

[0003] JP 2005-290600A diagrammatically shows in its Fig. 1, etc. a papermaking mold having a wire part, the wire part comprising a base surface, a semicylindrical columnar projection lying sideways on the base surface, and two semicylindrical plate-like projections arranged at a predetermined position at a predetermined spacing in the longitudinal direction of the columnar projection. In making a fiber molded article as shown in Fig. 8 of JP 2005-290600A by use of such a papermaking mold, the plate-like projection projecting from the base surface of the wire part is usually provided with a planar (two-dimensional) draft relative to the base surface (see Fig. 14, in which the draft is exaggerated).

[0004] When a molded article to be produced is designed to have plate-like projections closely spaced, the papermaking mold to be used should have similarly closely spaced plate-like projections. However, it becomes more difficult to sufficiently supply the raw material slurry to a closer space between the plate-like projections in the formation of a wet fiber mat, i.e., a fiber molded article precursor. As a result, that part of the resulting fiber mat may be thinner than designed, or a fiber mat may not be formed in that part. Therefore, it has been difficult to produce a fiber molded article having closely spaced plate-like projections.

Disclosure of the Invention

[0005] In the light of the above problem, the present invention is contemplated to provide a papermaking mold suitable to produce a fiber molded article having closely spaced plate-like projections and a fiber molded article produced by using the mold.

[0006] The present invention provides a papermaking mold including a mold main body having a wire part and a wire disposed on the wire part. The wire part has a base surface, a columnar projection lying sideways on the base surface, and at least two plate-like projections arranged at predetermined positions at a predetermined spacing in the longitudinal direction of the columnar pro-

jection. The facing inner sides of every adjacent two of the plate-like projections are each formed of a part of a circular conical surface or a part of a hyperboloid.

[0007] The present invention also provides a fiber molded article having a flange. The fiber molded article has a base plate inclusive of the flange, a columnar projection, and at least two plate-like projections arranged at predetermined positions at a predetermined spacing in the longitudinal direction of the columnar projection. The facing inner sides of every adjacent two of the plate-like projections are each formed of a part of a circular conical surface or a part of a hyperboloid.

[0008] The present invention also provides a casting mold part having a base surface and a cavity that is concave relative to the base surface and forms a molding surface to produce a casting having a plurality of plate-like parts at a predetermined spacing. The cavity has a plurality of depressions for forming plate-like projections that are spaced face-to-face in a prescribed direction. The adjacent inner sides of every adjacent two of the depressions for forming plate-like projections are each formed of a part of a circular conical surface or a part of a hyperboloid.

[0009] The present invention also provides a drying and pressing mold composed of male and female members which is used to produce the fiber molded article. The male and female members are configured to be butted together to form a clearance therebetween defining the outer contour of the fiber molded article to be produced.

[0010] The present invention also provides a male member that constitutes the drying and pressing mold used to produce the fiber molded article. The male member has a forming part. The forming part has a base surface, a columnar projection lying sideways on the base surface, and at least two plate-like projections arranged at predetermined positions at a predetermined spacing in the longitudinal direction of the columnar projection. The facing inner sides of every adjacent two of the plate-like projections are each formed of a part of a circular conical surface or a part of a hyperboloid.

[0011] The present invention also provides a female member that constitutes the drying and pressing mold used to produce the fiber molded article. The female member has a concave forming part defining the contour of the fiber molded article to be produced. The concave molding part has at least two depressions corresponding to the plate-like projections of the fiber molded article at predetermined positions at a predetermined spacing. The adjacent inner sides of every adjacent two of the depressions are each formed of a part of a circular conical surface or a part of a hyperboloid.

[0012] The present invention also provides a drying and pressing mold composed of male and female members which is used to produce the casting mold part. The male and female members are configured to be butted together to form a clearance therebetween defining the outer contour of the casting mold part to be produced.

[0013] The present invention also provides a male member that constitutes the drying and pressing mold used to produce the casting mold part. The male member has a forming part including a base surface, a columnar projection lying sideways on the base surface, and at least two plate-like projections arranged at predetermined positions at a predetermined spacing in the longitudinal direction of the columnar projection. The facing inner sides of every adjacent two of the plate-like projections are each formed of a part of a circular conical surface or a part of a hyperboloid.

[0014] The present invention also provides a female member that constitutes the drying and pressing mold used to produce the casting mold part. The female member has a concave forming part defining the contour of the casting mold part to be produced. The concave molding part has at least two depressions corresponding to the plate-like projections of the casting mold part at predetermined positions at a predetermined spacing. The adjacent inner sides of every adjacent two of the depressions are each formed of a part of a circular conical surface or a part of a hyperboloid.

[0015] The present invention also provides a method of producing a fiber molded article. The method includes the steps of forming a wet fiber mat from a raw material slurry using the papermaking mold of the invention, transferring the wet fiber mat to the female member of the drying and pressing mold used to produce the fiber molded article according to the invention, and press-forming the fiber mat between the female member and the male member of the drying and pressing mold.

[0016] The present invention also provides a method of producing a casting mold part. The method includes the steps of forming a wet fiber mat from a raw material slurry using the papermaking mold of the invention, transferring the wet fiber mat to the female member of the drying and pressing mold used to produce the casting mold part according to the invention, and press-forming the fiber mat between the female member and the male member of the drying and pressing mold.

Brief Description of Drawings

[0017]

Fig. 1 illustrates an embodiment of the papermaking mold according to the present invention, in which Fig. 1(a) is a perspective view, and Fig. 1(b) is a cross-sectional view on arrow A-A.

Fig. 2 illustrates the contour of the mold main body in the embodiment of the papermaking mold according to the present invention, in which Fig. 2(a) is a view on arrow X-X in Fig. 1, and Fig. 2(b) is a plan view of Fig. 2(a).

Fig. 3 illustrates an embodiment of the drying/pressing mold used in the production of the fiber molded article according to the present invention.

Fig. 4 illustrates an embodiment of the female mem-

ber of the drying/pressing mold used in the production of the fiber molded article according to the present invention, in which Fig. 4(a) is a side view, and Fig. 4(b) is a bottom view.

Fig. 5 illustrates an embodiment of the male member of the drying/pressing mold used in the production of the fiber molded article according to the present invention, in which Fig. 5(a) is a side view, and Fig. 4(b) is a plan view.

Fig. 6 is a perspective of an embodiment of the fiber molded articles according to the invention.

Fig. 7 illustrates the embodiment of the fiber molded article according to the invention, in which Fig. 7(a) is a cross-sectional view, and Fig. 7(b) is a bottom view.

Fig. 8 schematically illustrates an embodiment of an apparatus for producing the fiber molded article according to the invention.

Fig. 9 schematically illustrates the step of papermaking in an embodiment of the method of producing the fiber molded article using the apparatus of Fig. 8. Fig. 10 schematically illustrates the step of transferring a fiber mat after the step of papermaking in the embodiment of the method of producing the fiber molded article using the apparatus of Fig. 8.

Fig. 11 schematically illustrates the step of drying/pressing in the embodiment of the method of producing the fiber molded article using the apparatus of Fig. 8.

Fig. 12 schematically illustrates release from the mold after completion of the step of drying/pressing in the embodiment of the method of producing the fiber molded article using the apparatus of Fig. 8.

Fig. 13 is a perspective of casting mold parts according to an embodiment of the present invention before being combined into a casting mold assembly.

Fig. 14 illustrates an embodiment of the casting mold part of the invention, in which Fig. 14(a) is a cross-sectional view, and Fig. 14(b) is a bottom view.

Fig. 15 illustrates an embodiment of a papermaking mold used in the production of the casting mold part according to the invention, in which Fig. 15(a) is a perspective view, and Fig. 15(b) is a cross-sectional view on arrow A-A.

Fig. 16 illustrates the contour of a mold main body of the papermaking mold of Fig. 15, in which Fig. 16(a) is a view on arrow X-X in Fig. 15, and Fig. 2(b) is a plan view of Fig. 16(a).

Fig. 17 is a perspective view of an embodiment of a drying/pressing mold used in the production of the casting mold part of the invention.

Fig. 18 illustrates an embodiment of a female member of a drying/pressing mold used in the production of the casting mold part of the invention, in which Fig. 18(a) is a side view, and Fig. 18(b) is a bottom view.

Fig. 19 illustrates an embodiment of a male member of a drying/pressing mold used in the production of

the casting mold part of the invention, in which Fig. 19(a) is a side view, and Fig. 19(b) is a plan view. Fig. 20 schematically illustrates an embodiment of an apparatus for producing the casting mold part according to the invention.

Fig. 21 schematically illustrates the step of papermaking in an embodiment of the method of producing a casting mold part using the apparatus of Fig. 20. Fig. 22 schematically illustrates the step of transferring a fiber mat after the step of papermaking in the embodiment of the method of producing a casting mold part using the apparatus of Fig. 20.

Fig. 23 schematically illustrates the step of drying/pressing in the embodiment of the method of producing a casting mold part using the apparatus of Fig. 20.

Fig. 24 schematically illustrates release from the mold after completion of the step of drying/pressing in the embodiment of the method of producing a casting mold part using the apparatus of Fig. 20.

Fig. 25 is a cross-sectional view schematically illustrating the step of forming a thick-walled part using the apparatus of Fig. 20.

Fig. 26 is a cross-sectional view schematically illustrating the step of releasing a casting mold part using the apparatus of Fig. 20.

Fig. 27 is a schematic perspective view of a fiber mat used in the production of an embodiment of the casting mold according to the invention.

Fig. 28 is an enlarged fragmentary cross-section of the fiber mat used in the production of the embodiment of the casting mold according to the invention.

Fig. 29 is an enlarged fragmentary cross-section of the casting mold parts according to the invention, butted together into a casting mold assembly.

Fig. 30 illustrates the contour of a mold main body of the papermaking mold used in Example of the invention, in which Fig. 30(a) is a side view, and Fig. 30(b) is a plan view of Fig. 30(a).

Fig. 31 illustrates the contour of a mold main body of the papermaking mold used in Comparative Example of the invention, in which Fig. 31(a) is a side view, and Fig. 31(b) is a plan view of Fig. 31(a).

Fig. 32 illustrates the P part of the contour of the mold main body used in the Comparative Example, in which Fig. 32(a) is a side view, and Fig. 32(b) is a plan view of Fig. 32(a).

Detailed Description of the Invention

[0018] The present invention will be described based on its preferred embodiments with reference to the accompanying drawing.

Firstly, a preferred embodiment of the papermaking mold according to the invention is described.

As used herein, the term "fiber molded article" denotes an article obtained by depositing a papermaking material including fibers on a papermaking mold to form a wet

fiber mat and dewatering and drying the fiber mat.

[0019] One embodiment of the papermaking mold of the invention is shown in Figs. 1 and 2.

The papermaking mold 10 includes a mold main body 10A having, on its upper side, a wire part 100 and a butting face 101. The wire part 100 has a recess 103 providing a base surface 102 at a position lower than the butting face 101.

[0020] The wire part 100 has a projection 104 including plate-like projections 105 and a columnar projection 106. In the particular embodiment shown in Fig. 1, all the plate-like projections 105 and the columnar projection 106 are depicted as having a semicircular cross-section perpendicular to the longitudinal direction of the projection 104. The following description will be based chiefly on the shape of the projections the crosswise section of which is semicircular.

The wire part 100 has the columnar projection 106 having a semicircular cross-section and lying sideways on the base surface 102 and two plate-like projections 105 each having a semicircular cross-section arranged at predetermined positions at a predetermined spacing in the longitudinal direction of the columnar projection 106. The plate-like projections 105 each have a larger diameter than that of the columnar projection 106. All the semicircular cross-sections of the plate-like projections 105 and the columnar projection 106 are coaxial, having their centers on the same axis (designated axis C in Fig. 2(b)). Both ends of the columnar projection 106 stick longitudinally outward from the outer sides 105B of the plate-like projections 105. The papermaking mold 10 has formed inside thereof gas/liquid passageways 107 open on the base surface 102 and the outer surface of the projection 104 of the wire part 100. A papermaking wire 108 is fitted on the surface of the wire part 100. The wire 108 may be any of those conventionally employed for the production of this type of fiber molded articles.

[0021] The facing sides (inner sides) 105A of the two plate-like projections 105 are each formed of a part of a circular conical surface the cone point of which, designated point S, is on the base surface 102 and on axis C (the axis on which the center of the circular cross-section of the columnar projection 106 is positioned). The term "circular conical surface" as used herein refers to a surface formed by revolution of a straight line (in the case of Fig. 2, a straight line connecting points R and S; point R is an arbitrary point on the outer periphery 105C hereinafter described) intersecting another straight line (axis C in the case of Fig. 2) around the another straight line.

The phrase "a part of a circular conical surface" as used herein means the part of the above-defined circular conical surface other than the part hidden by the columnar projection (the hidden part is indicated by the dotted line segment of the straight line connecting points R and S in Fig. 2). For example, that part of a circular conical surface is the portion surrounded by points R-R1-R2-R3 in Figs. 2(a) or the portion surrounded by points R-R3-R3-R in Fig. 2(b). The angle formed by the two intersect-

ing straight lines, one of which revolves about the other, hereinafter also called "slope α ", may be inconstant or varied while a straight line revolves 360 degrees about an intersecting straight line as long as the effects of the invention are not impaired. When the slope α is varied, the cross-section of the plate-like projection is not semicircular. While the conical surface as the inner side 105A preferably has its point S positioned on the axis C of the circular cross-sections of the plate-like projections 105 and the columnar projection 106, the point S may be deviated from the axis C or the base surface 102 unless the effects of the present invention are affected. The slope α of the conical surface as the inner side 105A is decided by the difference between the radius of the outer periphery 105C and that of the inner periphery 105D of the inner side 105A of the plate-like projection 105 (equal to the difference between the radius of the semicircular cross-section of the plate-like projection and that of the columnar projection) and the distance d (see Fig. 2(b)) between the outer and the inner peripheries. The slope α is preferably 0.1° to 10° , more preferably 0.5° to 5° , even more preferably 1° to 3° . When the slope α of the conical surface is in the recited range, a fiber mat can easily be removed from the papermaking mold without being damaged, and the spacing between the adjacent plate-like projections can be made small. The distance D between the facing inner sides 105A is preferably 1 to 50 mm, taking into consideration ease of papermaking and no need for extra raw material for papermaking.

[0022] Since the papermaking mold 10 having the plate-like projections 105 has a circular conical surface to form the facing inner sides 105A of the projections 105, the papermaking material is allowed to be duly deposited on the wire 108 between the plate-like projections 105. Accordingly, a crack-free fiber molded article can be produced even if the plate-like projections are closely spaced.

[0023] An embodiment of the drying/pressing mold that can be used in combination with the papermaking mold 10 in the production of a fiber molded article will then be described.

As shown in Fig. 3, the drying/pressing mold of the present embodiment has a female member 20 and a male member 30 for drying and pressing. The female member 20 and the male member 30 are configured to be butted together to form a clearance therebetween defining the outer contour of a fiber molded article 40A to be produced.

[0024] As shown in Figs. 3 and 4, the female member 20 has a concave forming part 200 and a butting face 201. The concavity of the concave forming part 200 is an inversion of the outer contour (convexity) of the fiber molded article 40A to be produced. The forming part 200 has its surface coated with a fluororesin. The forming part 200 has a recess 202 from the butting face 201, the recess 202 being shaped to accommodate the flange 42 of the fiber molded article 40A. The forming part 200 has a concavity relative to the base surface (bottom) 203 of

the recess 202. The concavity is composed of depressions 204 and a depression 205 corresponding to the plate-like projections and the columnar projection, respectively, of the fiber molded article 40A. The depressions 204 corresponding to the plate-like projections and the depression 205 corresponding to the columnar projection are configured to have their semicircular cross-sections aligned on the same axis C (see Fig. 4(b)). The recess 202, the depressions 204 corresponding to the plate-like projections and the depression 205 corresponding to the columnar projection define a space-forming wall (described later). The female member 20 has, in the inside thereof, gas/liquid passageways 206 open on the surface of the forming part 200.

[0025] The adjacent sides (inner sides) 204A of the adjacent depressions 204 corresponding to the plate-like projections are each formed of a part of a circular conical surface. While the conical surface as the inner side 204A preferably has its point S positioned on the axis C (the axis on which the center of the outer periphery 204C and the center of the inner periphery 204D of the depression 204 for forming the plate-like projection is positioned), the point S may be deviated from the axis C or the base surface 203 unless the effects of the present invention are affected.

[0026] The male member 30 is configured so that a wet fiber mat formed on the papermaking mold 10 is put thereon and dried. Accordingly, the male member 30 has a forming part 300 the contour of which is equal to that of the wire part 100 (exclusive of the wire) of the papermaking mold 10 as shown in Figs. 3 and 5. The forming part 300 has its surface coated with a fluororesin. The forming part 300 has a base surface 301 and a convexity 302 projecting from the base surface 301. The convexity 302 includes a columnar projection 304 having a semicircular cross-section and lying sideways on the base surface 301 and two plate-like projections 303 each having a semicircular cross-section arranged at predetermined positions at a predetermined spacing in the longitudinal direction of the columnar projection. The plate-like projections 303 each have a larger diameter than that of the columnar projection 304. The semicircular cross-section of each of the plate-like projections 303 and that of the columnar projection 304 have their center on the same axis. Both ends of the columnar projection 304 stick longitudinally outward from the outer sides 303B of the plate-like projections 303. The male member 30 has, in the inside thereof, gas/liquid passageways 305 open on the base surface 301 and the outer surface of the convexity 302 of the forming part 300.

[0027] The facing sides (inner sides) 303A of the adjacent plate-like projections 303 are each formed of a part of a circular conical surface the cone point of which, designated point S, is on the base surface 301 and on axis C on which the center of the circular cross-section of the columnar projection 303 is positioned. While the conical surface as the plate-like projection 303 preferably has its point S positioned on the axis of the circular cross-

sections of the plate-like projections 303 and the columnar projection 304, the point S may be deviated from the axis C or the base surface 301 unless the effects of the present invention are affected. The slope α of the conical surface as the inner side 303A is decided by the difference between the radius of the outer periphery 303C and that of the inner periphery 303D of the inner side 303A of the plate-like projection 303 (equal to the difference between the radius of the semicircular cross-section of the plate-like projection and that of the columnar projection) and the distance d (see Fig. 5(b)) between the outer and the inner peripheries. The slope α is preferably 0.1° to 10° , more preferably 0.5° to 5° , even more preferably 1° to 3° . When the slope α of the conical surface is in the recited range, a fiber mat can easily be removed from the mold without being damaged, and the spacing between the adjacent plate-like projections is allowed to be made small. The distance D between the facing inner sides 303A is preferably 1 to 50 mm in terms of compactness of the fiber molded article.

[0028] Since the male member of the drying/pressing mold has a part of a circular conical surface to form the facing inner sides 303A of the plate-like projections 303, the fiber molded article obtained after the drying/pressing operation can easily be removed from the drying/shaping mold. Furthermore, using the drying/pressing mold allows for producing thin and crack-free fiber molded articles that are assembled into a casting mold suitable to produce a casting having closely spaced plate-like parts as hereinafter described.

[0029] A preferred embodiment of the fiber molded article according to the present invention will be described with reference to a fiber molded article produced by using the papermaking mold and the drying/pressing mold of the aforementioned embodiments. Figs. 6 and 7 will be referred to.

[0030] Fig. 6 shows an appearance of a fiber molded article 40, in which 40A is an outer appearance with the convexity up, and 40B is an outer appearance of the reverse side of 40A. The fiber molded article 40 will be described with reference to the fiber molded article 40A only.

Having been shaped by the above described drying/pressing mold between the female member 20 and the male member 30, the fiber molded article 40A has the same contour as defined by the forming part of the drying/pressing mold. The fiber molded article 40A has a convexity 41 including plate-like projections 411 and a columnar projection 412. In the embodiment shown in Fig. 6, the columnar projection 412 and the plate-like projections 411 are depicted as half-circular columns, i.e., the cross-sections of the columnar projection 412 and the plate-like projections 411 perpendicular to the longitudinal direction of the plate-like projection 411 are semicircular. In what follows, every projection will be described assuming that the outer contour has the shape of a half-circular column.

The fiber molded article 40 has a base plate 420 including

a flange 42, the columnar projection 412 lying sideways on the base surface 420, and two plate-like projections 411 arranged at predetermined positions at a predetermined spacing in the longitudinal direction of the columnar projection 412. The plate-like projections 411 each have a larger diameter than that of the columnar projection 412. The semicircular cross-section of each of the plate-like projections 411 and that of the columnar projection 412 have their center on the same axis (designated axis C' in Fig. 7(b)). Both ends of the columnar projection 412 stick longitudinally outward from the outer sides 411B of the plate-like projections 411.

[0031] The facing sides (inner sides) 411A of the adjacent plate-like projections 411 are each formed of a part of a circular conical surface the cone point of which, designated point S', is on the base surface 421 and on axis C' (the axis on which the center of the circular cross-section of the columnar projection 412 is positioned). While the conical surface as the inner side 411A preferably has its point S' positioned on the axis of the circular cross-sections of the plate-like projections 411 and the columnar projection 412, the cone point may be deviated from the axis C' or the base surface 421 unless the effects of the present invention are affected. The slope β of the conical surface as the inner side 411A is decided by the difference between the radius of the outer periphery 411C' and that of the inner periphery 411D' of the reverse side of the inner side 411A of the plate-like projection 411 (equal to the difference between the radius of the semicircular cross-section of the plate-like projection and that of the columnar projection both measured on the reverse side of the respective projections) and the distance d' (see Fig. 7(b)) between the outer and the inner peripheries on the reverse side. The slope β is preferably 0.1° to 10° , more preferably 0.5° to 5° , even more preferably 1° to 3° . When the slope β of the conical surface is in the recited range, a fiber mat can easily be removed from the mold without being damaged, and the spacing between the adjacent plate-like projections is allowed to be made small. The distance D' between the facing inner sides 411A measured on the reverse side is preferably 1 to 50 mm in terms of ease of papermaking and no need for extra raw material for papermaking. The term "reverse side" as used herein means the side I (see Fig. 7(b)) of the fiber molded article 40A that has been brought into contact with the mold main body 10A of the papermaking mold 10.

[0032] The thickness of the fiber molded article 40A can be selected appropriately. To secure the strength and air permeability of the fiber molded article and to minimize the production cost and so on, the thickness is preferably 0.5 to 5 mm, more preferably 1 to 2 mm.

[0033] Any raw materials generally used in papermaking techniques can be used to make the fiber molded article with no particular restriction. For example, the organic fiber, inorganic fiber, and the like disclosed in JP 2005-290600A can be used as raw materials.

[0034] In the case of producing heat-resistant fiber

molded articles that can be used as parts for the production of castings, inorganic powders, thermosetting resins, and the like can be used as raw materials as well as organic and inorganic fibers, as mentioned in JP 2005-290600A. Use of fiber molded articles as parts for producing castings is disclosed, e.g., in JP 2004-195547A commonly assigned to the assignee of the present invention.

[0035] An apparatus for producing the fiber molded article 40A is now described. As shown in Fig. 8, the apparatus 1 for producing the fiber molded article 40A has slurry feed means 2, papermaking means 3, and drying/pressing means 5.

[0036] The slurry feed means 2 has a pouring frame 210, a vertically moving mechanism 21 for vertically moving the pouring frame 210, and a slurry feed pipe 22 for feeding the raw material slurry into the pouring frame 210. The slurry feed pipe 22 has a valve 23.

[0037] The papermaking means 3 has the papermaking mold 10. The wire part 100 of the papermaking mold 10 has the gas/liquid passageways 107 connected to a drainage pipe 11 leading to a suction pump 12. The drainage pipe 11 has a valve 13.

[0038] The drying/pressing means 5 has the female member 20 for drying and pressing, a vertically moving mechanism 51 for vertically moving the female member 20, and the male member 30 for drying and pressing. On being butted together, the female member 20 and the male member 30 form a clearance therebetween defining the outer contour of the fiber molded article 40A to be produced.

[0039] The female member 20 is vertically movable by the vertical moving means 51. The gas/liquid passageways 206 (see Fig. 3) open on the surface of the forming part of the female member 20 connect to a flow pipe 52 leading to a suction pump and a compressor (both not shown). The flow pipe 52 has a valve 53. The female member 20 has a heater 54 as heating means for heating the forming part 200.

[0040] The gas/liquid passageways 305 (see Fig. 3) open on the surface of the forming part 300 of the male member 30 connect to a drainage pipe 31 leading to a suction pump 32. The drainage pipe 31 has a valve 33. Cases are sometimes met with in which the openings of the gas/liquid passageways 305 leave depressions on the surface of the resulting fiber molded article 40A, which may be problematical in terms of appearance. In such cases, the gas/liquid passageways 305 may be dispensed with. While not shown in the drawing, a heater, etc. as heating means for heating the forming part 300 is provided inside the forming part 300.

[0041] The apparatus 1 has transfer means (not shown) that moves the papermaking mold 10 and the male member 30 along a guide 60 to the respective predetermined positions. The apparatus 1 also has control means (not shown) having a sequencer connected to each of the above-mentioned means whereby to operate the means in accordance with the sequence described

hereunder.

[0042] The method of producing the fiber molded article 40A using the apparatus 1 will then be described by way of the drawing.

5 In the method of producing a fiber molded article according to the present embodiment, a wet fiber mat is formed from a raw material slurry containing the above described components, transferred from the papermaking mold 10 to the female member 20, and pressed between the female member 20 and the male member 30 to make the fiber molded article 40A.

[0043] In the present embodiment, the method starts with preparation of a raw material slurry by dispersing raw materials necessary for papermaking such as organic fiber in a dispersion medium. The slurry should be prepared as appropriate for a molded article to be produced. Examples of the dispersion medium include water, white water, a solvent such as ethanol or methanol, and mixtures thereof. Water is preferred in view of stability in fiber mat deposition, dewatering and shaping, stability of the molded article quality, cost, ease of handling, and the like.

[0044] The slurry can contain other components in appropriate ratios. The other components include strengthening agents, such as polyvinyl alcohol, carboxymethyl cellulose (CMC), and polyamideamine-epichlorohydrin resin, flocculants, and colorants.

[0045] In the step of papermaking to form the fiber mat 14A, the vertically moving mechanism 21 operates to lower the pouring frame 210, and the valve 23 opens to supply the slurry through the slurry feed pipe 22 into the pouring frame 210 as shown in Fig. 9. When the slurry in the pouring frame 210 reaches a prescribed amount, the valve 23 closes to stop the slurry feed. Then the valve 13 opens, and the liquid matter of the slurry is sucked by the suction pump 12 through the gas/liquid passageways 107 and the drainage pipe 11. Meanwhile the solid matter of the slurry is deposited on the surface of the wire 108 to build up a wet fiber mat 14A. The liquid content of the fiber mat 14A is preferably 50 to 200 parts by mass, more preferably 70 to 100 parts by mass, per 100 parts by mass of the solids content of fiber mat 14A, taking into consideration ease of handling the fiber mat 14A and deformability of the fiber mat 14A due to flow of the fibers while being pressed between the female member 20 and the male member 30. The liquid content of the fiber mat 14A can be adjusted by the suction of the liquid matter with the suction pump 12. When the liquid content decreases to a predetermined level, the suction is stopped.

[0046] After completion of the formation of the fiber mat 14A, the vertically moving mechanism 21 lifts the pouring frame 210, and the transfer means operates to transfer the papermaking mold 10 under the female member 20 along the guide 60 as shown in Fig. 10.

[0047] The female member 20 is lowered and joined with the papermaking mold 10 by the vertically moving mechanism 51.

[0048] The fiber mat 14A is sucked to the forming part 200 of the female member 20 through the flow pipe 52

and separated from the papermaking mold 10.

[0049] As shown in Fig. 11, the male member 30 is returned under the female member 20 by the transfer means along the guide 60, and the vertically moving mechanism 51 then operates to lower the female member 20 and to butt the female member 20 to the male member 30 heated to a prescribed temperature. The fiber mat 14A is pressed between the male and female members to give the dry fiber molded article 40A.

[0050] The mold temperature of the female member 20 and the male member 30 is decided as appropriate to the fiber molded article 40A to be produced. To avoid scorching of the fiber mat 14A, the mold temperature is preferably 100°C to 250°C, more preferably 120°C to 200°C. The pressing pressure is decided as appropriate to the material making the fiber molded article 40A, the strength, and the like.

[0051] During the drying and pressing, the valve 33 is open, and the water content of the fiber mat 14A is sucked by the suction pump 32 through the gas/liquid passages 305 (see Fig. 3) and the drainage pipe 31 and discharged outside. At the same time, the vertically moving mechanism 21 operates to lower the pouring frame 210 to have the wire part 100 of the papermaking mold 10 enclosed in the pouring frame 210, and another fiber mat is formed in the same manner as in the above-described papermaking step.

[0052] On completion of the drying/pressing step, the suction through the flow pipe 52 is switched to blowing air from the compressor, and the vertically moving mechanism 51 lifts the female member 20 as shown in Fig. 12. The suction by the suction pump 32 is stopped, and the fiber molded article 40A left on the male member 30 is removed from the male member 30. Production of the fiber molded article 40A thus completes. Meanwhile the pouring frame 210 is moved up by the vertically moving mechanism 21, and the next fiber mat 14A is then transferred to the heating step. In the method of the present embodiment, the above-described steps of papermaking and drying/pressing are repeatedly carried out.

[0053] As stated earlier, a heat resistant fiber molded article that can be used as a part for the production of a casting can be produced by using an inorganic powder, a thermosetting resin, etc. as a raw material in addition to the organic fiber and the inorganic fiber.

[0054] Use of the fiber molded article as a casting mold part as an example of a part for producing a casting will be described based on its preferred embodiment with reference to the drawing.

A casting mold assembly according to the present invention will be described first based on its preferred embodiment.

The casting mold assembly of the present embodiment is used to produce a casting having a solid cylindrical portion and a plurality of disk-shaped plate-like portions integral with the cylindrical portion that are arranged at a prescribed spacing in the axial direction of the cylindrical portion. The side of the plate-like portions of the cast-

ing is formed of a part of a circular conical surface.

[0055] As shown in Fig. 13, the casting mold assembly 130 of the present embodiment is composed of a complementary pair of casting mold parts 130A and 130B. Each casting mold part is a heat-resistant fiber molded article. The casting mold parts 130A and 130B are equal halves so that the following description refers to only the mold part 130A.

[0056] As shown in Fig. 14, the casting mold part 130A has a base surface 1321, which is a surface of a flange 132A, and a cavity 131A defining the molding surface to make the casting. The cavity 131A is concave relative to the base surface 1321. The cavity 131A has depressions 1311 for forming plate-like projections that are arranged face-to-face at a prescribed spacing in a certain direction. The cavity 131A also has a depression 1312 for forming a columnar projection as if to link the depressions 1311 for forming plate-like projections. The depression 1312 is shallower than the depressions 1311 for forming plate-like projections. All the depressions 1311 for forming plate-like projections and the depression 1312 for forming a columnar projection are configured such that the inner side outlines of their vertical cross-sections are coaxial semicircles having axis C' (see Fig. 14(b)). Both ends of the depression 1312 are positioned longitudinally outward from the depressions 1311 for forming plate-like projections. The base surface 1321 provides a butting face when assembled with the complementary casting mold part 130B.

[0057] The adjacent sides (inner sides) 1311A of the adjacent depressions 1311 for forming plate-like projections are each formed of a part of a circular conical surface. The term "circular conical surface" as used herein refers to a surface formed by revolution of a straight line intersecting another straight line around the another straight line. The angle formed by the two intersecting straight lines, one of which revolves about the other, hereinafter also called "slope β ", may be inconstant or varied while a straight line revolves 360 degrees about an intersecting straight line as long as the effects of the invention are not impaired. When the slope β is varied, the inner outline of a vertical cross-section of the depression 1311 for forming plate-like projection is not semicircular. While the conical surface as the inner side 1311A preferably has its cone point S' positioned on the common axis C' of the outer periphery 1311C and the inner periphery 1311D of the depression 1311 forming plate-like projection, the point may be deviated from the axis C' or the base surface 1321 unless the effects of the present invention are affected.

[0058] The slope β of the conical surface as the inner side 1311A is decided by the difference between the radius of the outer periphery 1311C and that of the inner periphery 1311D of the depression 1311 for forming a plate-like projection and the distance d' (see Fig. 14(b)) between the outer and the inner peripheries 1311C and 1311D. The slope β of the conical surface as the inner side 1311A is preferably 0.1° to 10°, more preferably 0.5°

to 5°, even more preferably 1° to 3°. When the slope β of the conical surface is in the recited range, a fiber mat as a precursor of the casting mold part can easily be removed from a papermaking mold (described later) without being damaged even if a casting to be produced has closely spaced plate-like parts.

[0059] The distance D' between the adjacent inner sides 1311A is preferably 1 to 50 mm, taking into consideration ease of making a fiber mat and reduction of the waste of the raw material for papermaking. As used herein, the "distance D' between the adjacent inner sides 1311A" is the length of the part of the depression 1312 for forming a columnar projection which links the adjacent depressions 1311 for forming plate-like projections.

[0060] The casting mold part 130A preferably has a surface roughness Ra of 20 μm or smaller, more preferably 10 μm or smaller. The surface roughness Ra is measured, e.g., with Surtronic 10 from Rank Taylor Hobson.

[0061] The thickness of the casting mold part 130A can be selected appropriately. To secure the strength and air permeability of the casting mold part and to minimize the production cost and so on, the thickness is preferably 0.5 to 5 mm, more preferably 1 to 2 mm.

[0062] The casting mold part 130A preferably has a mass ratio of inorganic powder/inorganic fiber/organic fiber/thermosetting resin (solid basis)/thermoexpanded particles of 70-80%/2-8%/0-10%/8-16%/0.5-10%, more preferably 70-80%/2-6%/0-6%/10-14%/2-8%, based on the total mass (=100% by mass) of organic powder, inorganic fiber, organic fiber, a thermosetting resin, and thermoexpanded particles. With the proportion of the inorganic powder being in the above range, satisfactory shape retention during a pour, surface properties of molded articles (i.e., casting mold parts), and mold release after molding are obtained. With the proportion of the inorganic fiber being in the above range, satisfactory molding properties and shape retention during a pour are secured. With the proportion of the organic fiber being in the above range, satisfactory molding properties are obtained. In order to reduce gas generation and belch of flame from the flow-off due to combustion of organic fiber, the amount of the organic fiber is preferably as small as possible and may be zero as the case may be. With the proportion of the thermosetting resin and the thermoexpanded particles being within the above range, satisfactory molding properties, shape retention during pouring, and surface smoothness are obtained. When the proportion of the thermoexpanded particles is in the recited range, satisfactory molding precision is obtained.

[0063] Examples of the inorganic powder include graphite (flaky, lumpy, etc.), obsidian, and mullite. One or more than one kind of inorganic powder can be selected for use. Graphite, particularly flaky graphite, is preferred in view of molding properties and cost.

[0064] The inorganic fiber serves mainly to constitute the skeleton of the molded article. On pouring molten metal, it does not burn even with the heat of the molten

metal and continues serving to retain the shape of the article.

Examples of the inorganic fiber include artificial mineral fibers, such as carbon fiber and rock wool, ceramic fibers, and natural mineral fibers. They can be used either alone or in combination of two or more thereof. Carbon fiber that maintains high strength even in high temperatures, such as pitch-based carbon fiber or polyacrylonitrile (PAN)-based carbon fiber, is preferred for effectively reducing thermal shrinkage accompanying carbonization of the thermosetting resin. PAN-based carbon fiber is especially preferred.

[0065] The inorganic fiber preferably has an average length of 0.5 to 15 mm, more preferably 3 to 8 mm, in terms of good drainage in papermaking and dewatering efficiency and molding properties and uniformity of the fiber molded article.

[0066] The organic fiber is exemplified by paper fiber (pulp fiber), fibrillated synthetic fibers, and regenerated fibers (e.g., rayon fiber). These fibers are used either individually or as a mixture of two or more thereof. Preferred of them is paper fiber in view of molding properties, strength after drying, and cost.

[0067] Examples of the paper fiber include not only wood pulp but non-wood pulp, such as cotton pulp, linter pulp, bamboo, and straw. These kinds of pulp, whether virgin or recycled, can be used either alone or in combination thereof. From the standpoint of ease and stability of supply, environmental conservation, and reduction of production cost, used paper pulp is preferred.

[0068] It is preferred for the organic fiber to have an average length of 0.8 to 2.0 mm, more preferably 0.9 to 1.8 mm, from the viewpoint of molding properties, surface smoothness, and impact strength of the resulting molded article.

[0069] The thermosetting resin is a component necessary to retain the low- and high-temperature strength of the molded article and to provide molded articles with good surface properties which contribute to improve the surface smoothness of castings. Examples of the thermosetting resin include phenol resins, epoxy resins, and furan resins. Phenol resins are preferred of them in view of reduced generation of combustible gas, resistance to burning, and a high carbon residue content after thermal decomposition (carbonization) as high as 25% or more to form a carbonized film to provide castings with an improved casting surface. Usable phenol resins include novolak phenol resins requiring a curing agent and resol type phenol resins requiring no curing agent. In using a novolak phenol resin, a curing agent is required. Since the curing agent easily dissolves in water, it is preferably applied to the surface of a molded article after dewatering. The curing agent preferably includes hexamethylenetetramine. The thermosetting resins can be used either individually or as a combination of two or more thereof.

[0070] The casting mold part 130A contains thermoexpanded particles (thermoexpandable particles in their ex-

panded state) having an average diameter preferably of from 5 to 80 μm , more preferably of from 25 to 50 μm before thermexpansion. With the particle size of the thermoexpandable particles being confined within the above range, the effects of addition can be produced to the full while minimizing the adverse influences of expansion on molding precision.

[0071] The thermoexpandable particles are exemplified by microcapsules having a blowing agent that vaporizes and expands encapsulated in a thermosetting resin capsule wall. The microcapsules preferably have an average particle size of 5 to 60 μm , more preferably 20 to 50 μm , and, on being heated to 80°C to 200°C, expand to increase preferably to 3 to 5 times in diameter and 50 to 100 times in volume.

[0072] Examples of the thermoplastic resin constituting the capsule wall include polystyrene, polyethylene, polypropylene, polyacrylonitrile, acrylonitrile-vinylidene chloride copolymers, ethylene-vinyl acetate copolymers, and mixtures thereof. The blowing agent to be encapsulated includes low-boiling organic solvents, such as propane, butane, pentane, isobutane, and petroleum ether.

[0073] In addition to the aforementioned components, the casting mold part 130A may contain other components in appropriate ratios. The other components include paper strengthening agents, such as polyvinyl alcohol, carboxymethyl cellulose (CMC), and polyamide-amine-epichlorohydrin resin, flocculants, and colorants.

[0074] It is preferred that the casting mold part 130A generate not more than 250 cc/g, more preferably not more than 200 cc/g, of combustion gas per unit mass. The amount of combustion gas generated is measured using equipment for measuring the amount of generated combustion gas (No. 682 Gas Pressure Tester from Harry W. Dietert Co.). The amount of combustion gas generated is preferably as small as possible. The practically reachable lower limit is about 0.1 to 1 cc/g.

[0075] It is preferred for the casting mold part 130A before use in casting to have a water content of not more than 20% by mass, more preferably 10% by mass or less, to minimize combustion gas generation accompanying thermal decomposition of the thermosetting resin.

[0076] The molds (inclusive of the papermaking mold and the drying/pressing mold) for the production of casting mold parts according to the present invention will then be described with reference to a preferred embodiment in which the casting mold parts according to the above described embodiment are produced. The description will generally be confined to the molds for the production of the casting mold part 130A. The molds for the production of the casting mold part 130B will not be redundantly described.

[0077] The papermaking mold that can be used in the production of the casting mold part 130A has the same configuration as the papermaking mold of the foregoing embodiment (shown in Fig. 1, etc.) and, in addition, has a function to form a sharp edge 133A (see Fig. 13) so that, when the resulting casting mold part 130A is mated

with a complementary casting mold part 130B, a gap may not be formed between the respective mating edges 133 (i.e., 133A and 133B (not shown in Fig. 13)). The papermaking mold having such a function will be described further.

[0078] Figs. 15 and 16 illustrate one embodiment of the papermaking mold used to make the casting mold 130. As shown in Fig. 15(a), the papermaking mold 150 has a wire part 1500 corresponding to the cavity 131A of the casting mold part 130A, which is a casting mold cavity, and a base surface 1321 of the flange 132A (see Fig. 13) that defines the butting face of the papermaking mold.

[0079] The wire part 1500 has a recess 1503 the base surface 1502 (bottom) of which is lower than the butting face 1501 of the papermaking mold 150. The base surface 1502 of the recess 1503 corresponds to the base surface 1321 of the flange 132A of the casting mold part 130A (see Fig. 13).

[0080] The wire part 1500 has a projection 1504 corresponding to the cavity 131 of the casting mold part 130A. The wire part 1500 has plate-like projections 1505 and a columnar projection 1506 each having a semicircular cross-section and projecting above the base surface 1502. The plate-like projections 1505 are arranged face-to-face at a prescribed spacing in a prescribed direction, and the columnar projection 1506 lies as if to link the plate-like projections 1505. The plate-like projections 1505 and the columnar projection 1506 are coaxial, having the center of their semicircular cross-sections on the same axis designated axis C (see Fig. 16(b)). Both ends of the columnar projection 1506 stick longitudinally outward from the outer sides 1505B of the plate-like projections 1505. The papermaking mold 150 has, in the inside thereof, gas/liquid passageways 1507 open on the base surface 1502 and the surface of the projection 1504 of the wire part 1500. A papermaking wire 1508 is fitted on the surface of the wire part 1500. The wire 1508 may be any of those conventionally employed for the production of this type of fiber molded articles.

[0081] The depth of the recess 1503 is designed such that, when the papermaking mold 150 and a female member 170 hereinafter described are butted against each other, and the fiber mat is released from the former, the basal part of the flange of the fiber mat is bent to form a thick-walled part. The depth of the recess 1503 (i.e., the depth from the butting face 1501) is suitably 1 to 20 mm and desirably 3 to 8 mm.

[0082] The facing sides (inner sides) 1505A of the adjacent plate-like projections 1505 are each formed of a part of a circular conical surface the cone point of which, designated point S', is on the base surface 1502 and on axis C (the axis on which the center of the circular cross-section of the columnar projection 1506 is positioned). While the conical surface as the inner side 1505A preferably has its point S' positioned on axis C of the circular cross-sections of the plate-like projections 1505 and the columnar projection 1506, the cone point may be devi-

ated from the axis C or the base surface 1502 unless the effects of the present invention are affected. The slope α of the conical surface as the inner side 1505A is decided by the difference between the radius of the outer periphery 1505C and that of the inner periphery 1505D of the inner side 1505A of the plate-like projection 1505 (equal to the difference between the radius of the semicircular cross-section of the plate-like projection and that of the columnar projection) and the distance d (see Fig. 16(b)) between the outer and the inner peripheries. The slope α is preferably 0.1° to 10° , more preferably 0.5° to 5° , even more preferably 1° to 3° . When the slope α of the conical surface is in the recited range, the fiber mat can easily be released from the mold without being damaged, and the spacing between the adjacent plate-like projections is allowed to be made small. The distance D' between the facing inner sides 1505A is preferably 1 to 50 mm in terms of ease of papermaking and no need for extra raw material for papermaking.

[0083] Since the papermaking mold 150 having the plate-like projections 1505 has a circular conical surface to form the facing inner sides 1505A of the projections 1505, the papermaking material is allowed to be duly deposited on the wire 1508 between the plate-like projections 1505. Accordingly, thin and crack-free fiber molded articles can be produced, which are assembled into a casting mold suitable to produce a casting designed to have a close spacing between the plate-like parts.

[0084] An embodiment of the drying/pressing mold that can be used in combination with the papermaking mold 150 in the production of a fiber molded article will then be described.

[0085] The drying/pressing mold of the present embodiment has the same configuration as the drying/pressing mold of the foregoing embodiment (shown in Fig. 3, etc.) and, in addition, has a function to form a sharp edge 133A so that, when the resulting casting mold part 130A is mated with a complementary casting mold part 130B, a gap may not be formed between the respective mating edges 133A and 133B. The drying/pressing mold having such a function will be described further.

[0086] As shown in Fig. 17, the drying/pressing mold of the present embodiment has a female member 170 and a male member 180 for drying and pressing. The female member 170 and the male member 180 are configured to be butted together to form a clearance therebetween defining the outer contour of a casting mold part 130A to be produced.

[0087] As shown in Figs. 17 and 18, the female member 170 has a concave forming part 1700 and a butting face 1701. The concavity of the forming part 1700 is an inversion of the outer contour (convexity) of the casting mold part 130A to be produced. The forming part 1700 has its surface coated with a fluororesin. The forming part 1700 has a recess 1702 from the butting face 1701, the recess 1702 being shaped to accommodate the flange 132 of the casting mold part 130A. The forming part 1700 has a concavity relative to the base surface

(bottom) 1703 of the recess 1702. The concavity has depressions 1704 for forming plate-like projections having a semicircular cross-section that are arranged face-to-face at a prescribed spacing in a certain direction. The concavity also has a depression 1705 for forming a columnar projection having a semicircular cross-section as if to link the depressions 1704 for forming plate-like projections. The depressions 1704 for forming plate-like projections and the depression 1705 for forming a columnar projection are configured to have their semicircular cross-sections aligned on the same axis C (see Fig. 18(b)). The recess 1702, the depressions 1704 for forming plate-like projections, and the depression 1705 for forming a columnar projection define a space-forming wall (hereinafter described). The female member 170 has, in the inside thereof, gas/liquid passageways 1706 open on the outer surface of the forming part 1700.

[0088] The adjacent sides (inner sides) 1704A of the adjacent depressions 1704 for forming plate-like projections are each formed of a part of a circular conical surface. While the conical surface as the inner side 1704A preferably has its point S positioned on the axis C (the axis on which the center of the outer periphery 1704C and the center of the inner periphery 1704D of the depression 1704 for forming a plate-like projection are positioned), the point may be deviated from the axis C or the base surface 1703 unless the effects of the present invention are affected.

[0089] As shown in Figs. 17 and 19, the male member 180 has a forming part 1800 corresponding to the cavity 131 of the casting mold part 130A to be produced (i.e., the shape of a cast product). The forming part 1800 has its surface coated with a fluororesin. The forming part 1800 has a base surface 1801 and a projection 1802 projecting from the base surface 1801. The projection 1802 has plate-like projections 1803 having a semicircular cross-section and arranged face-to-face at a predetermined spacing in a predetermined direction and a columnar projection 1804 having a semicircular cross-section and lying as if to link the plate-like projections 1803. The semicircular cross-section of each of the plate-like projections 1803 and that of the columnar projection 1804 have their center on the same axis. Both ends of the columnar projection 1804 stick longitudinally outward from the outer sides 1803B of the plate-like projections 1803. The male member 180 has, in the inside thereof, gas/liquid passageways 1805 open on the base surface 1801 and the outer surface of the projection 1802 of the forming part 1800 thereof.

[0090] The facing sides (inner sides) 1803A of the adjacent plate-like projections 1803 are each formed of a part of a circular conical surface the cone point of which, designated point S, is on the base surface 1801 and on axis C on which the center of the circular cross-section of the columnar projection 1803 is positioned. While the conical surface as the inner side 1803A preferably has its point S positioned on axis C of the circular cross-sections of the plate-like projections 1803 and the columnar

projection 1804, the point may be deviated from the axis C or the base surface 1801 unless the effects of the present invention are affected. The slope α of the conical surface as the inner side 1803A is decided by the difference between the radius of the outer periphery 1803C and that of the inner periphery 1803D of the inner side 1803A of the plate-like projection 1803 (equal to the difference between the radius of the semicircular cross-section of the plate-like projection and that of the columnar projection) and the distance d (see Fig. 19(b)) between the outer and the inner peripheries. The slope α is preferably 0.1° to 10° , more preferably 0.5° to 5° , even more preferably 1° to 3° . When the slope α of the conical surface is in the recited range, a fiber mat can easily be removed from the mold without being damaged, and the adjacent plate-like parts are allowed to be closely spaced. The distance D between the facing inner sides 1803A is preferably 1 to 50 mm in terms of compactness of the casting.

[0091] Since the male member of the above described drying/pressing mold has a circular conical surface to form the facing inner sides 1803A of the plate-like projections 1803, the fiber molded article obtained after the drying/pressing operation can easily be released from the mold. Thus, thin and crack-free fiber molded articles can be produced, which are assembled into a casting mold suitable to produce a casting having closely spaced plate-like parts.

[0092] An apparatus for producing the casting mold part 130A is now described.

The casting mold part 130A is produced by use of an apparatus having the same construction as the apparatus previously described (shown in Fig. 11, etc.) and, in addition, having a function to form a sharp edge 133A so that, when the resulting casting mold part 130A is mated with a complementary casting mold part 130B, a gap may not be formed between the respective mating edges 133A and 133B. The apparatus having such a function will be described hereunder.

[0093] As shown in Fig. 20, the apparatus 1' for producing the casting mold part 130A has slurry feed means 2, papermaking means 3, and drying/pressing means 5.

[0094] The slurry feed means 2 has a pouring frame 210, a vertically moving mechanism 21 for vertically moving the pouring frame 210, and a slurry feed pipe 22 for feeding the raw material slurry into the pouring frame 210. The slurry feed pipe 22 has a valve 23.

[0095] The papermaking means 3 has the papermaking mold 150 having the form of the above-described male member. The wire part 1500 of the papermaking mold 150 has the gas/liquid passageways 1507 connected to a drainage pipe 11 leading to a suction pump 12. The drainage pipe 11 has a valve 13.

[0096] The drying/pressing means 5 has the female member 170 for drying and pressing, a vertically moving mechanism 51 for vertically moving the female member 170, and the male member 180 for drying and pressing. On being butted together, the female member 170 and

the male member 180 form a clearance therebetween defining the outer contour of the casting mold part 130A to be produced.

[0097] The female member 170 has the same configuration as the female member 170 shown in Figs. 17 and 18. As shown in Fig. 20, the female member 170 is vertically movable by the vertical moving means 51. The female member 170 has, in the inside thereof, gas/liquid passageways 1706 (see Fig. 17) open on the surface of the forming part 1700 thereof. The gas/liquid passageways 1706 are connected to a flow pipe 52 that leads to a suction pump and a compressor (both not shown). The flow pipe 52 has a valve 53. The female member 170 has a heater 54 as heating means for heating the forming part 1700.

[0098] The male member 180 has the same configuration as the male member 180 shown in Figs. 17 and 19. The gas/liquid passageways 1805 (see Fig. 17) open on the surface of the forming part 1800 of the male member 180 connect to a drainage pipe 31 leading to a suction pump 32 as shown in Fig. 20. The drainage pipe 31 has a valve 33. Cases are sometimes met with in which the openings of the gas/liquid passageways 1805 leave depressions on the surface of the resulting casting mold part 130A, which may cause projections on the surface of a casting. Depending on the field of application of the casting, the casting having such projections requires surface finishing with a working machine. In such cases, the gas/liquid passageways 1805 may be dispensed with. While not shown in the drawing, a heater, etc. as heating means for heating the forming part 1800 is provided inside the forming part 1800.

[0099] As shown in Fig. 25, the apparatus 1' has thick-walled part-forming means 7 constructed by the papermaking mold 150 and the female member 170. The thick-walled part-forming means 7 is designed to bend the basal part of a flange 142A of a fiber mat 14A to make a thick-walled part 144A as described hereunder. The thick-walled part forming means 7 includes (1) separation means 70 for separating the outer peripheral portion of the flange 142A of the fiber mat 14A from the papermaking mold 150 when the papermaking mold 150 and the female member 170 are joined together and (2) a space-forming wall 71 for forming a space between the papermaking mold 150 and the female member 170 in which the basal part is allowed to be bent.

[0100] In this embodiment, the separation means 70 is composed of the gas/liquid passageways 1706 that are open on the bottom of the recess, the flow pipe 52 connecting to the passageways, and the suction pump. The space-forming wall 71 is defined by the recess 1510 of the papermaking mold 150 and the recess 1703 of the male member 170. The gas/liquid passageways 1706, at the recess 1703, may be provided at a higher density than the gas/liquid passageways in the other part so that a suction force may be exerted more strongly to the outer peripheral portion of the flange of the fiber mat 14A.

[0101] The apparatus 1' has transfer means (not

shown) that moves the papermaking mold 150 and the male member 180 along a guide 60 shown in Fig. 20 to the respective predetermined positions. The apparatus 1' also has control means (not shown) having a sequencer connected to each of the above-mentioned means whereby to operate the means in accordance with the sequence described hereunder.

[0102] The method of producing the casting mold 130A using the apparatus 1' will then be described by way of the drawing.

In the method of producing a casting mold 130A according to the embodiment described hereunder, a wet fiber mat 14A is formed on the papermaking mold 150 from a raw material slurry containing the components previously described, transferred from the papermaking mold 150 to the female member 180, and pressed between the female member 180 and the male member 180.

[0103] The method of the present embodiment starts with preparation of a raw material slurry by dispersing the inorganic powder, inorganic fiber, organic fiber, thermosetting resin, and thermoexpandable particles in a dispersion medium. The slurry should be prepared as appropriate for casting mold parts to be produced. Examples of the dispersion medium include water, white water, a solvent such as ethanol or methanol, and mixtures thereof. Water is preferred in view of stability in fiber mat deposition, dewatering and shaping, stability of the molded article quality, cost, ease of handling, and the like.

[0104] The slurry can contain other components in appropriate ratios. The other components include paper strengthening agents, such as polyvinyl alcohol, carboxymethyl cellulose (CMC), and polyamideamine-epichlorohydrin resin, flocculants, and colorants.

[0105] In the step of papermaking to form the casting mold part 130A, the vertically moving mechanism 21 operates to lower the pouring frame 210, and the valve 23 opens to supply the slurry through the slurry feed pipe 22 into the pouring frame 210 as shown in Fig. 21. When the slurry in the pouring frame 210 reaches a prescribed amount, the valve 23 closes to stop the slurry feed. Then the valve 13 opens, and the liquid matter of the slurry is sucked by the suction pump 12 through the gas/liquid passageways 1507 and the drainage pipe 11. Meanwhile the solid matter of the slurry is deposited on the surface of the wire 1508 to build up a wet fiber mat 14A. The liquid content of the fiber mat 14A is preferably 50 to 200 parts by mass, more preferably 70 to 100 parts by mass, per 100 parts by mass of the solids content of fiber mat 14A, taking into consideration ease of handling the fiber mat 14A and deformability of the fiber mat 14A due to flow of the fibers while being pressed between the female member 170 and the male member 180. The liquid content of the fiber mat 14A can be adjusted by the suction of the liquid matter with the suction pump 12. When the liquid content decreases to a predetermined level, the suction is stopped.

[0106] After completion of the formation of the fiber mat 14A, the vertically moving mechanism 21 lifts the

pouring frame 210, and the transfer means operates to transfer the papermaking mold 150 under the female member 170 along the guide 60 as shown in Fig. 22.

[0107] The female member 170 is then lowered and butted against the papermaking mold 150 by the vertically moving mechanism 51, as shown in Fig. 25, whereupon a space for bending the basal part of the flange 142A of the fiber mat 14A is formed by the space-forming wall 71 (the recess 1510 of the papermaking mold 150 and the recess 1703 of the female member 170).

[0108] When the fiber mat 14A is released from the papermaking mold 150, the fiber mat 14A is sucked to the forming part 1700 of the female member 170 through the flow pipe 52. At the same time, the outer peripheral portion of the flange 142A of the fiber mat 14A is sucked through the gas/liquid passageways 1706 open on the bottom of the recess 1703 and separated from the papermaking mold 150, whereby the basal part of the flange 142A is bent to form a thick-walled part 144A as shown in Fig. 26.

[0109] The female mold 170 is moved up by the vertically moving mechanism 51, whereby the fiber mat 14A is transferred from the papermaking mold 150 to the female member 170 as shown in Fig. 26. The male mold 180 is then moved to the position for drying and pressing with the female mold 170 by the transfer means. As shown in Figs. 27 and 28, the thus formed fiber mat 14A has the thick-walled part 144A on the flange 142A along the edge 143A where two faces, the flange 142A and a cavity wall 141A, meet.

[0110] As shown in Fig. 23, the vertically moving mechanism 51 then operates to lower the female member 170 and to join the female member 170 with the male member 180 heated to a prescribed temperature. The fiber mat 14A is pressed between the male and female members to give the dry casting mold part 130A. By this pressing, the edge 133A of the casting mold part 130A where the flange 132A and the inner wall of the cavity 131A meet becomes sharp. The female member 170 and the male member 180 are designed so that there is formed no space accommodating the thick-walled part 144A when butted together. That is, these mold members are designed to form a clearance therebetween corresponding to the contour of a casting mold part as a final product that has no thick-walled part when they are butted together. Being sharp, the edge is liable to be damaged upon contact with other objects. To prevent damage, it is preferred for the edge to have a density of 0.8 g/cm³ or higher.

[0111] The temperature of the female member 170 and the male member 180 is decided as appropriate to the casting mold part 130A to be produced. To avoid scorching of the fiber mat 14A, the mold temperature is preferably 100°C to 250°C, more preferably 120°C to 200°C. The pressing pressure by the female member 170 and the male member 180 is preferably 0.2 to 10 MPa, more preferably 0.5 to 5 MPa, taking it into consideration that the thick-walled part should be flattened out neatly and

so on. Note that the pressing pressure can largely vary depending on the material making the casting mold part 130A, the strength, and the like.

[0112] During the drying and pressing, the valve 33 is open, and the water content of the fiber mat 14A is sucked by the suction pump 32 through the gas/liquid passages 1805 (see Fig. 17) and the drainage pipe 31 and discharged outside. At the same time, the vertically moving mechanism 21 operates to lower the pouring frame 210 to have the wire part 1500 of the papermaking mold 150 enclosed in the pouring frame 210, and another fiber mat is formed in the same manner as in the above-described papermaking step.

[0113] On completion of the drying/pressing step, the suction through the flow pipe 52 is switched to blowing air from the compressor, and the vertically moving mechanism 51 lifts the female member 170 as shown in Fig. 24. The suction by the suction pump 32 is stopped, and the casting mold part 130A left on the male member 180 is removed from the male member 180. Production of the casting mold part 130A thus completes. Meanwhile the pouring frame 210 is moved up by the vertically moving mechanism 21, and the next fiber mat 14A is then transferred to the heating step. In the method of the present embodiment, the above-described steps of papermaking and drying/pressing are repeatedly carried out.

[0114] The thus produced casting mold parts 130A and 130B are mated together on their butting faces to make a casting mold assembly, which is buried in molding sand as a main mold together with a runner, etc. to constitute a casting mold system. A casting is produced by pouring a molten metal into the cavity of the main mold. In this application, when the two casting mold parts are mated with their flanges 132 (132A and 132B) butted together, substantially no gap is formed along the parting line where the edges of the two casting mold parts meet as shown in Fig. 29 because of the sharp-cut edges 133 (133A and 133B). Therefore, a flashless casting can be obtained.

[0115] As described, casting mold parts 130A and 130B can be produced advantageously by using the molds according to the present embodiment including the papermaking mold and the male and female members of the drying/pressing mold. By use of the resulting casting mold parts 130A and 130B, a casting enjoying the effects described can be produced advantageously.

[0116] An embodiment of use of the casting mold made of the above described fiber molded articles as a pattern (usually wooden) that has historically been used to make a sand mold will then be described.

The casting mold part 130A is light-weight and mass-producible using the above described molds. The casting mold part 130A may be configured such that its cavity 131A be similar to the contour of a casting to be produced (such that the cavity 131A corresponds to the contour of the projection 41 in Fig. 6). In this case, the casting mold part 130A can be used as a substitute for a pattern that

has been used to create a sand mold. In the case when the casting mold part 130A is used as a substitute for a pattern, the contour of the reverse side of the depression 1311 for forming plate-like projection of the cavity 131A is the contour of a plate-like part of a casting to be produced (corresponding to the plate-like projection 411 in Fig. 6), and the facing inner sides of the adjacent plate-like projections are formed of a part of a circular conical surface (the inner sides correspond to 411A in Fig. 7). The opposite facing outer sides of each plate-like part (corresponding to 411B in Fig. 7) is also formed of a part of a circular conical surface. Thus, the casting mold part 130A as a substitute for a pattern has both the inner and outer sides of each plate-like projection formed of a conical surface. Accordingly, the plate-like projections each have a draft on both the inner and outer sides thereof so that the pattern can easily be withdrawn from the sand block.

[0117] The present invention is not limited to the foregoing embodiments, and various changes and modifications can be made therein without departing from the spirit and scope thereof.

[0118] For example, while in the foregoing embodiments the adjacent inner sides of adjacent depressions (for forming adjacent plate-like projections) of a casting mold or the facing inner sides of adjacent plate-like projections of a papermaking mold, a drying/pressing mold, and a fiber molded article are formed of a part of a circular conical surface, they may be formed of a part of a hyperboloid. In the case where the casting mold part is used as a substitute for a pattern in sand mold making, the inner and outer sides of the plate-like projections may be formed of a part of a hyperboloid instead of a circular conical surface. The terminology "hyperboloid" as used herein refers to a curved surface formed by revolving a curved line around a straight line intersecting the curved line. The angle formed by the two intersecting lines, the straight line and the curved line, may be inconstant or varied while the curved line revolves 360 degrees about the straight line as long as the effects of the invention are not impaired.

[0119] While the columnar projection and the plate-like projections have been described as a shape having a semicircular cross-section, they may have a shape with a different cross-section such as rectangular or semielliptical.

[0120] While the number of the plate-like projections has been described as two, it may be three or more depending on the intended use of the product.

Examples

[0121] The present invention will now be illustrated in greater detail. Fiber mats as a fiber molded article precursor having the geometry described below were produced in Example 1 and Comparative Example 1, and molding properties and mold releasability of the fiber mats were evaluated as described below.

Example 1

[0122] A fiber mat as a fiber molded article precursor having two plate-like projections the facing inner sides thereof were formed of a part of a circular conical surface was produced using a papermaking mold shown in Fig. 30.

(1) Material

[0123] Organic fiber (recycled newspaper), inorganic fiber (carbon fiber), inorganic powder (graphite powder), thermosetting resin (phenol resin), and thermoexpandable particles were blended at a ratio of 4:4:76:12:4 by mass and dispersed in water to prepare a slurry having a solids content of about 3% by mass.

(2) Papermaking mold

[0124] Material of mold main body: aluminum alloy
Main dimensions of papermaking mold:
L=288.5 mm; W1=13 mm; W2=9 mm; D=3 mm; A1=32.4 mm; A2=32.4 mm; A3=20 mm; d1=0.65 mm; d2=0.65 mm; $\alpha=3^\circ$
Wire: stainless wire; wire diameter=0.19 mm; #40 mesh

(3) Dewatering condition

[0125] Dewatering system: suction by a waterproof vacuum cleaner
Dewatering time: 60 seconds
Water content after dewatering: 30-80%

Comparative Example 1

[0126] A fiber mat as a fiber molded article precursor was prepared using a papermaking mold of Fig. 31 having plate-like projections on the base surface of its wire part. The plate-like projections were provided with a planar (two-dimensional) draft with respect to the base surface.

(1) Material

[0127] Organic fiber (recycled newspaper), inorganic fiber (carbon fiber), inorganic powder (graphite powder), thermosetting resin (phenol resin), and thermoexpandable particles were blended at a ratio of 4:4:76:12:4 by mass and dispersed in water to prepare a slurry having a solids content of about 3% by mass.

(2) Papermaking mold

[0128] Material of mold main body: aluminum alloy
Main dimensions of papermaking mold:
L=288.5 mm; W1=13 mm; W2=9 mm; D=3 mm; B1=32.4 mm; B2=32.4 mm; B3=20 mm; u1=1 mm; u2=1 mm
Wire: stainless wire; wire diameter=0.19 mm; #40 mesh

(3) Dewatering condition

[0129] Dewatering system: suction by a waterproof vacuum cleaner

Dewatering time: 60 seconds

Water content after dewatering: 30-80%

[0130] Each of the fiber mats as formed on the papermaking mold were observed with the naked eye to be inspected for cracks and other defects. Thereafter, the fiber mat was released from the mold by suction using the female member 20 shown in Fig. 8. The fiber mat was again inspected for any damage.

[0131] In Example 1, the fiber mat as deposited on the papermaking mold was confirmed to be free from any defect such as a crack as observed with the naked eye. On operating the female member 20 shown in Fig. 8, the fiber mat was released by suction from the papermaking mold 10 without being damaged.

In Comparative Example 1, in contrast, fiber deposition was insufficient in the parts indicated by "P" in Fig. 32. As a result, the fiber mat formed on the mold suffered from cracking or partial fiber deficiency in the parts P. Therefore, mold release by suction with the female member of Fig. 8 was not carried out.

Industrial Applicability

[0132] The present invention is advantageous in providing a papermaking mold and a drying/pressing mold suited to produce a fiber molded article having closely spaced plate-like projections and in providing such a fiber molded article.

[0133] The present invention is especially suited to produce a casting mold part. The invention is applicable to a casting mold for producing a casting having a shaft and plate-like projections integral with the shaft. For example, the invention is applicable to a wheel shaft with stoppers. The wheel shaft with stoppers is a shaft having the plate-like projections working as a disk stopper for positioning a cast wheel fitted around the shaft. Another example to which the invention is suitably applicable is a shape having a shaft and a plurality of rollers around the shaft like a paper feed roller of a printer. The invention is also suited to the production of cooling fins on the engine case of a motorcycle. In this way the present invention is advantageous in making casting molds of a variety of shapes having a small space.

[0134] The present invention provides a fiber molded article having closely spaced plate-like projections and a papermaking mold suited to produce the fiber molded article.

Claims

1. A papermaking mold comprising a mold main body having a wire part and a wire disposed on the wire part, the wire part having a base surface, a columnar

- projection having a longitudinal direction and lying sideways on the base surface, and at least two plate-like projections at predetermined positions at a predetermined spacing in the longitudinal direction of the columnar projection, the facing inner sides of every adjacent two of the plate-like projections being each formed of a part of a circular conical surface or a part of a hyperboloid.
2. The papermaking mold according to claim 1, wherein the columnar projection has a semicircular cross-section perpendicular to the longitudinal direction thereof.
 3. The papermaking mold according to claim 1 or 2, wherein the circular conical surface or hyperboloid has a slope of 0.1 to 10 degrees.
 4. The papermaking mold according to any one of claims 1 to 3, wherein the spacing between the facing inner sides is 1 to 50 mm.
 5. A fiber molded article having a flange, the fiber molded article comprising a base plate inclusive of the flange, a columnar projection having a longitudinal direction, and at least two plate-like projections at predetermined positions at a predetermined spacing in the longitudinal direction of the columnar projection, the facing inner sides of every adjacent two of the plate-like projections being each formed of a part of a circular conical surface or a part of a hyperboloid.
 6. The fiber molded article according to claim 5, wherein the columnar projection has a semicircular cross-section perpendicular to the longitudinal direction thereof.
 7. The fiber molded article according to claim 5 or 6, wherein the circular conical surface or hyperboloid has a slope of 0.1 to 10 degrees.
 8. The fiber molded article according to any one of claims 5 to 7, wherein the spacing between the facing inner sides is 1 to 50 mm.
 9. A casting mold part having a base surface and a cavity that is concave relative to the base surface and forms a molding surface to produce a casting having a plurality of plate-like parts at a predetermined spacing, wherein the cavity has a plurality of depressions for forming plate-like projections spaced face-to-face in a prescribed direction, the adjacent inner sides of every adjacent two of the depressions for forming plate-like projections being each formed of a part of a circular conical surface or a part of a hyperboloid.
 10. The casting mold part according to claim 9, wherein the cavity has a depression for forming a columnar projection extending as if to link the depressions for forming plate-like projections.
 11. The casting mold part according to claim 9 or 10, wherein the circular conical surface has a slope of 0.1 to 10 degrees.
 12. The casting mold part according to any one of claims 9 to 11, wherein the spacing between the adjacent inner sides is 1 to 50 mm.
 13. The casting mold part according to any one of claims 9 to 12, which comprises a fiber molded article.
 14. A casting mold assembly comprising a plurality of the casting mold parts according to any one of claims 9 to 13 with their base surfaces butted together.
 15. A drying and pressing mold comprising a male member and a female member which is used to produce the fiber molded article according to claim 5, the male and female members being configured to be butted together to form a clearance therebetween defining the outer contour of the fiber molded article to be produced.
 16. A male member constituting the drying and pressing mold according to claim 15, comprising a forming part comprising a base surface, a columnar projection having a longitudinal direction lying sideways on the base surface, and at least two plate-like projections at predetermined positions at a predetermined spacing in the longitudinal direction of the columnar projection, the facing inner sides of every adjacent two of the plate-like projections being each formed of a part of a circular conical surface or a part of a hyperboloid.
 17. A female member constituting the drying and pressing mold according to claim 15, comprising a concave forming part defining the contour of the fiber molded article to be produced, the concave molding part having at least two depressions corresponding to the plate-like projections of the fiber molded article at the predetermined positions at the predetermined spacing, the adjacent inner sides of every adjacent two of the depressions being each formed of a part of a circular conical surface or a part of a hyperboloid.
 18. A drying and pressing mold comprising a male member and a female member which is used to produce the casting mold part according to claim 9, the male and female members being configured to be butted together to form a clearance therebetween defining the outer contour of the casting mold part to be produced.

19. A male member constituting the drying and pressing mold according to claim 18, comprising a forming part comprising a base surface, a columnar projection having a longitudinal direction lying sideways on the base surface, and at least two plate-like projections at the predetermined positions at the predetermined spacing in the longitudinal direction of the columnar projection, the facing inner sides of every adjacent two of the plate-like projections being each formed of a part of a circular conical surface or a part of a hyperboloid.
20. A female member constituting the drying and pressing mold according to claim 18, comprising a concave forming part defining the contour of the casting mold part to be produced, the concave molding part having at least two depressions corresponding to the plate-like projections of the casting mold part at the predetermined positions at the predetermined spacing, the adjacent inner sides of every adjacent two of the depressions being each formed of a part of a circular conical surface or a part of a hyperboloid.
21. A method of producing a fiber molded article comprising the steps of forming a wet fiber mat from a raw material slurry using the papermaking mold according to claim 1, transferring the wet fiber mat to the female member according to claim 17, and press-forming the fiber mat between the female member and the male member according to claim 16.
22. A method of producing a casting mold part comprising the steps of forming a wet fiber mat from a raw material slurry using the papermaking mold according to claim 1, transferring the wet fiber mat to the female member according to claim 20, and press-forming the fiber mat between the female member and the male member according to claim 19.

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Fig. 1(a)

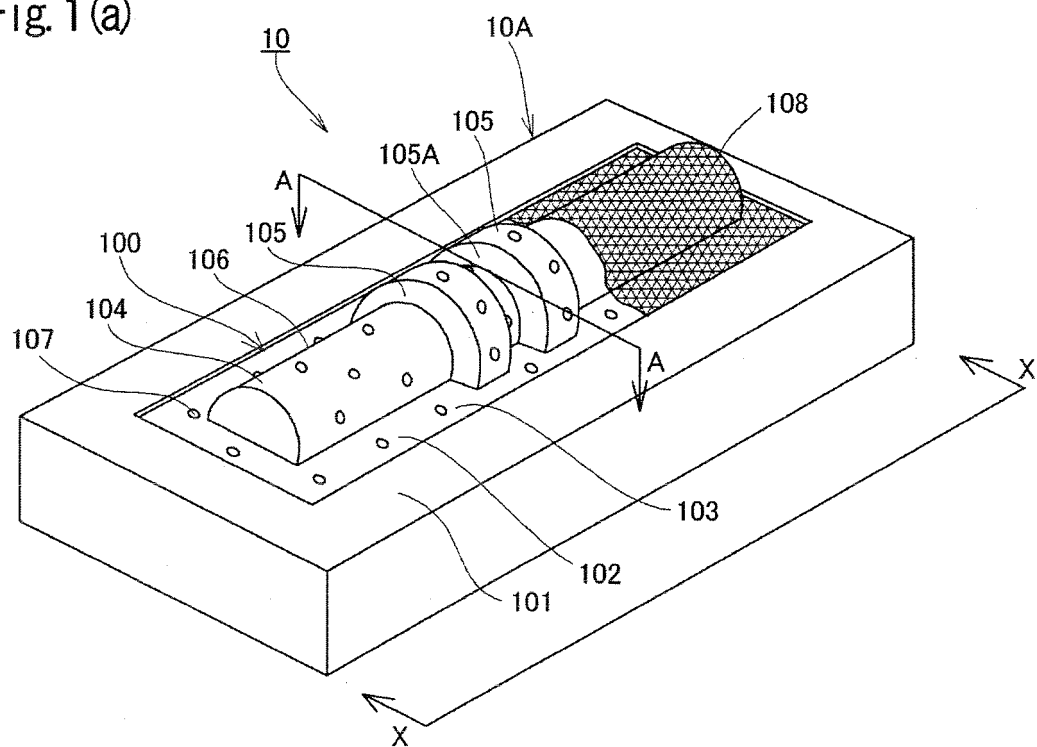


Fig. 1(b)

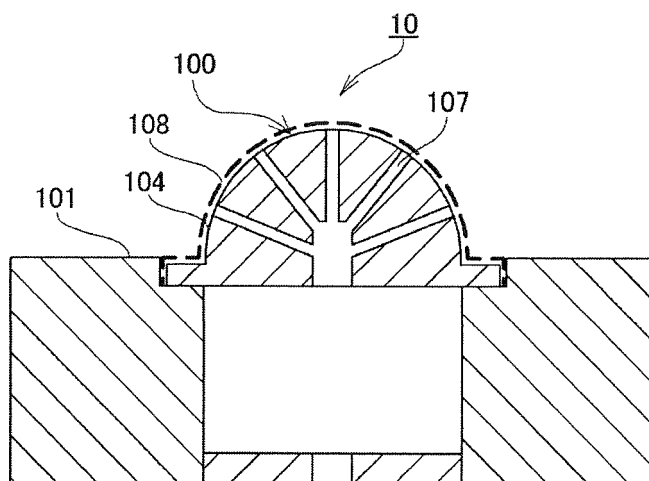


Fig 2(a)

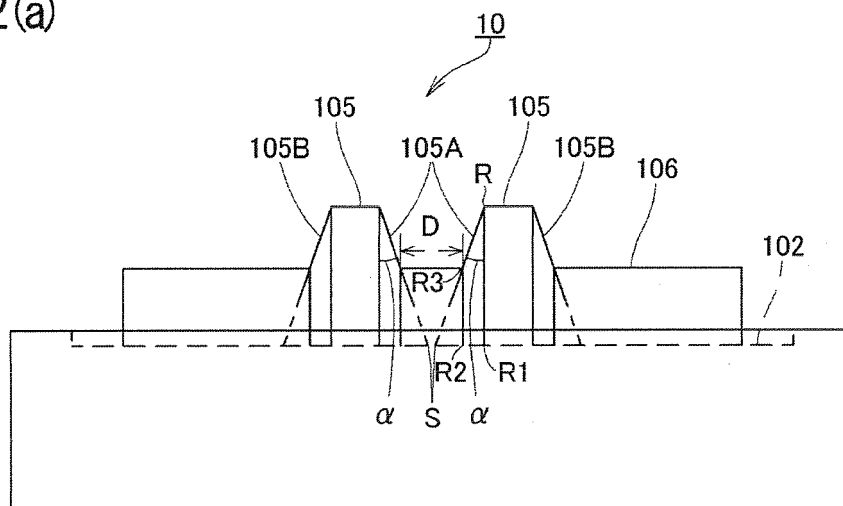


Fig 2(b)

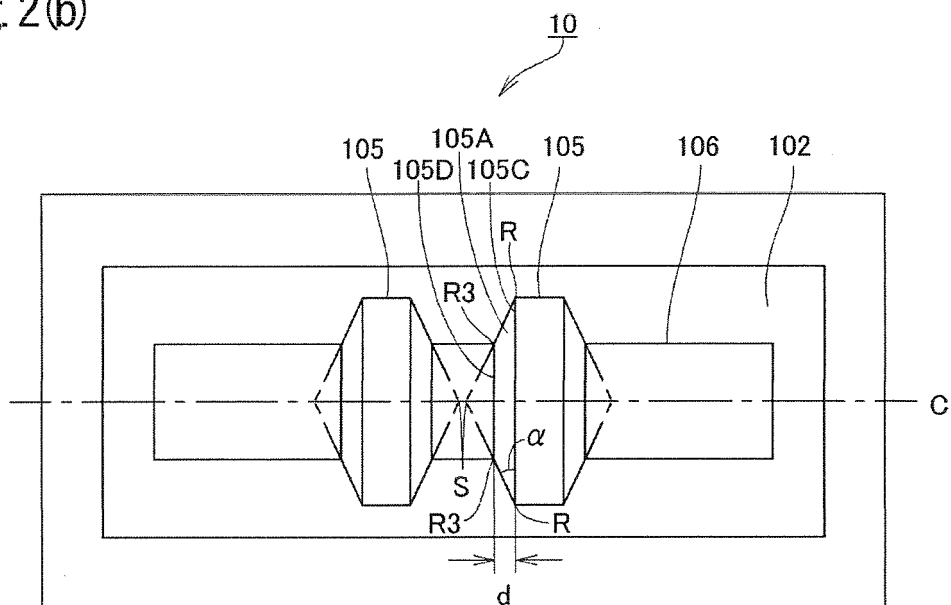


Fig. 3

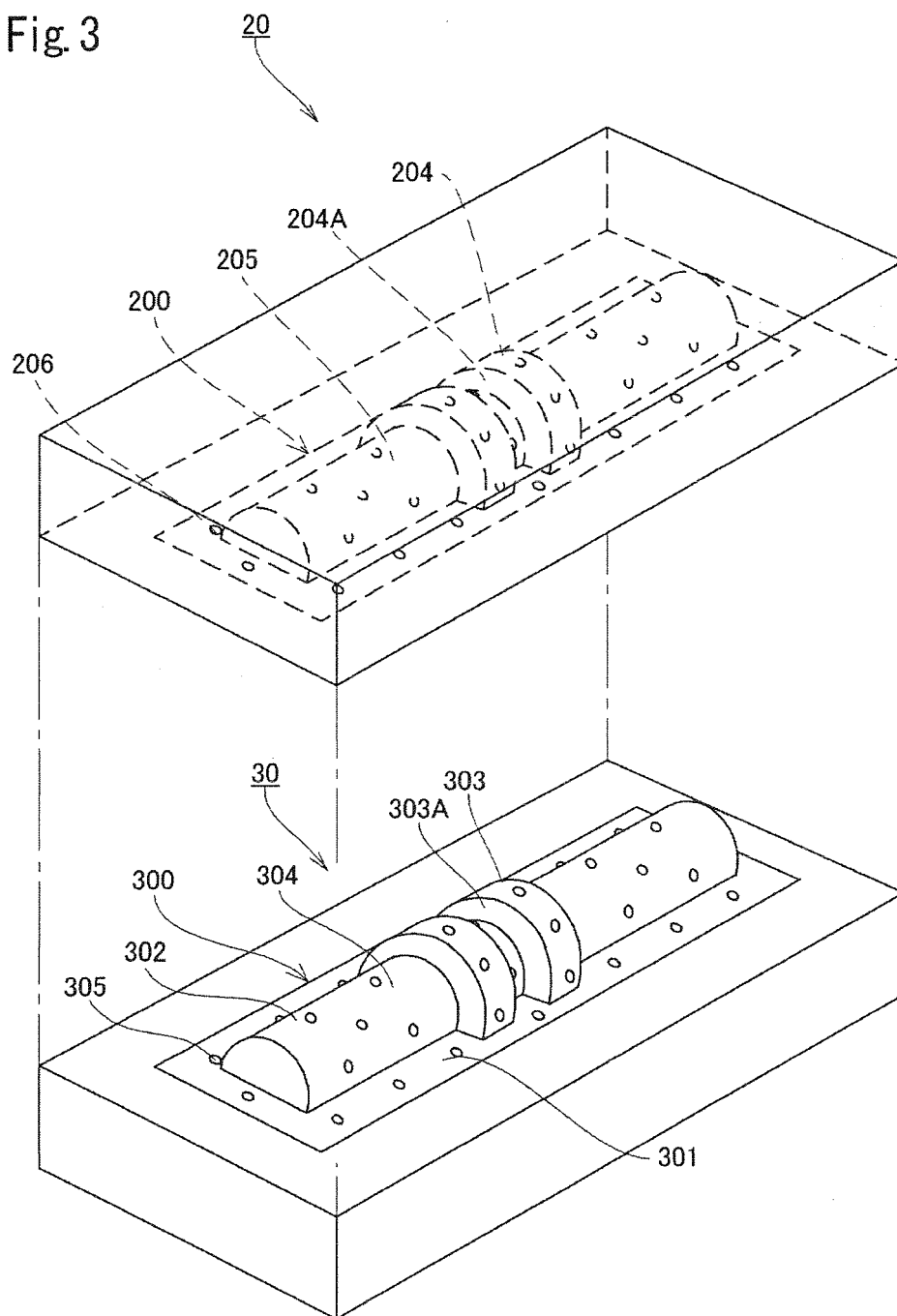


Fig. 4(a)

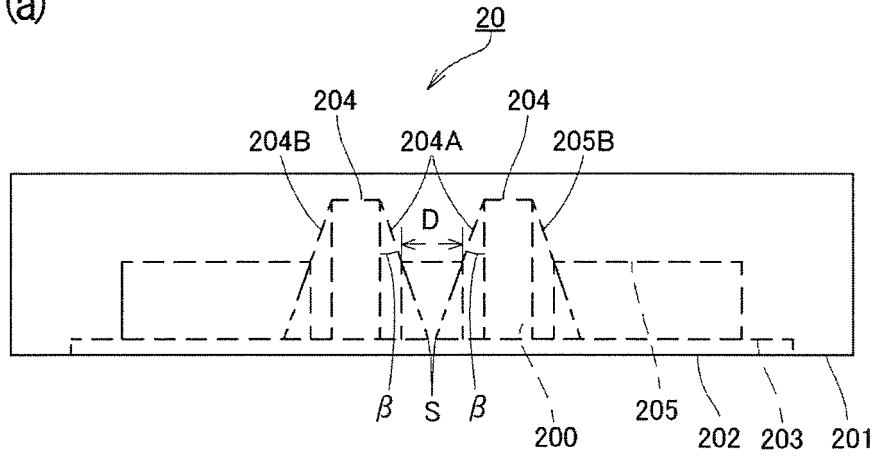


Fig. 4(b)

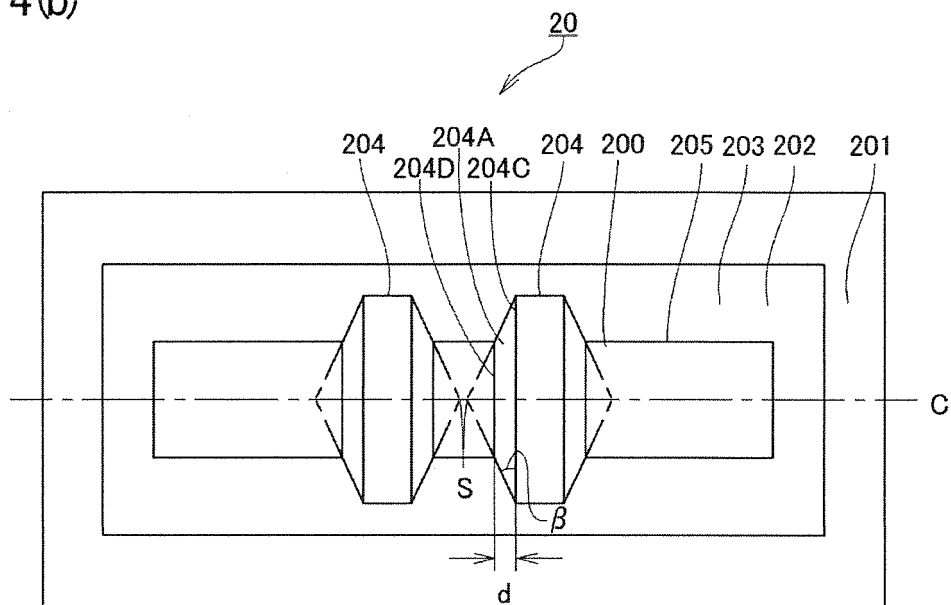


Fig 5(a)

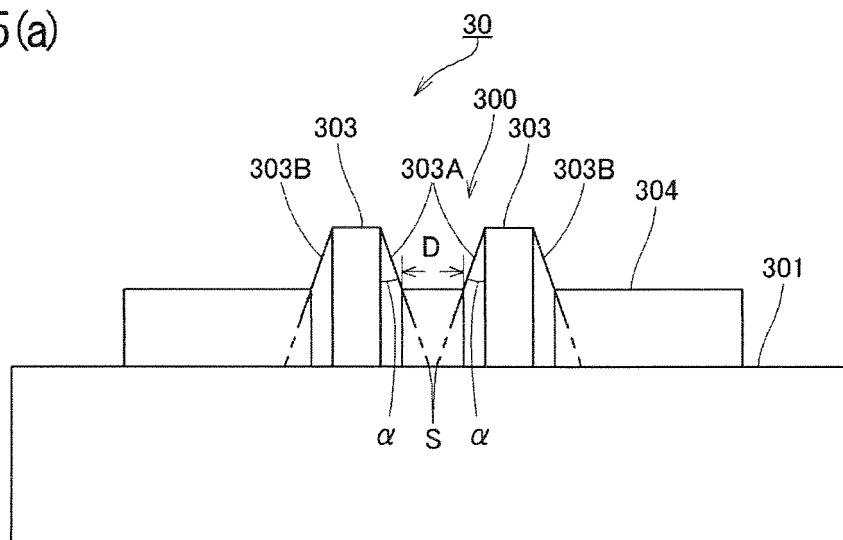


Fig 5(b)

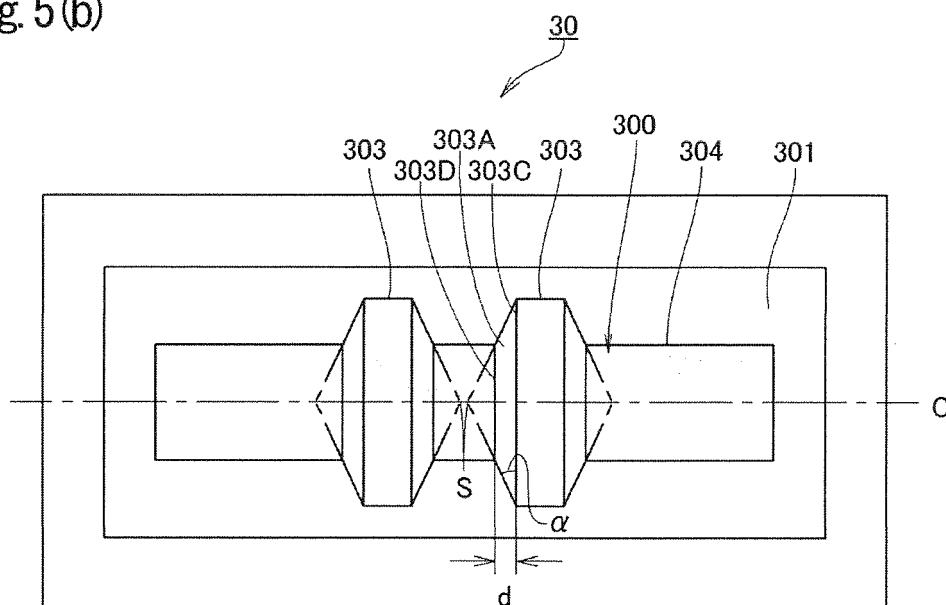


Fig. 6

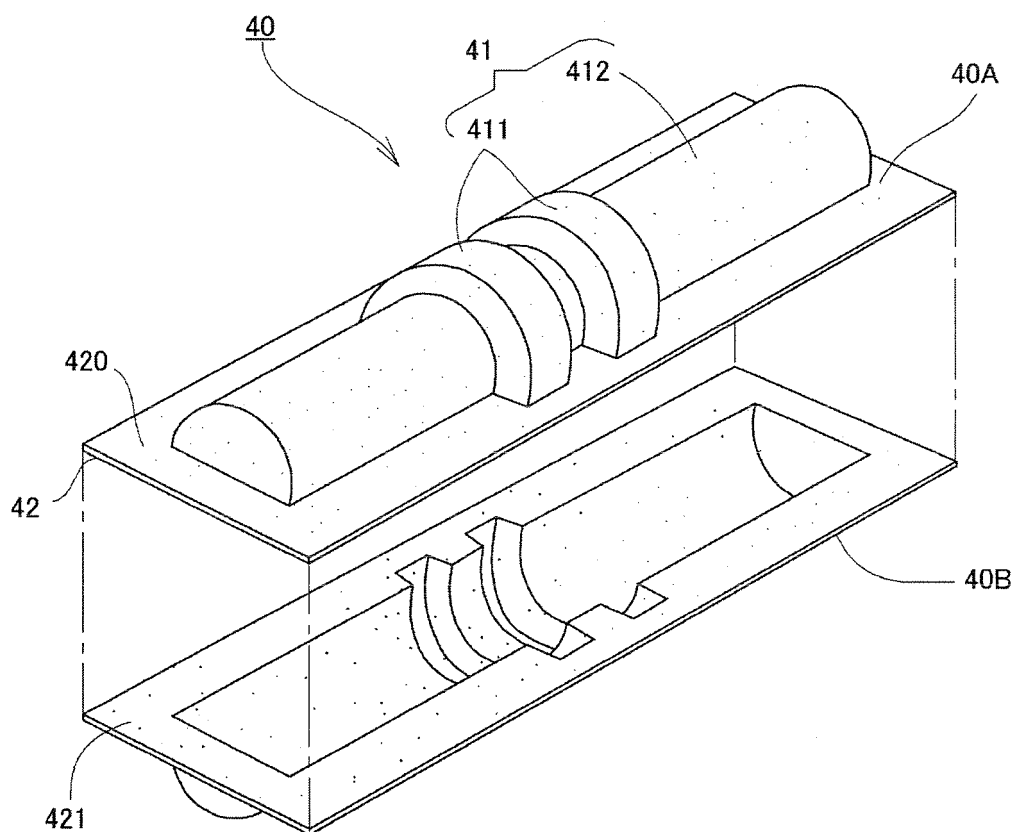


Fig. 7(a)

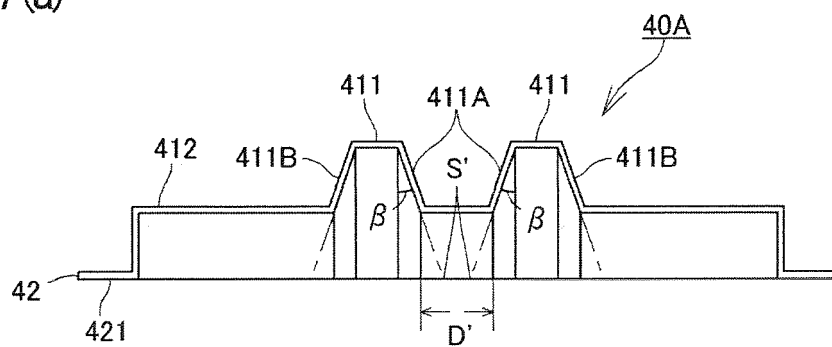


Fig. 7(b)

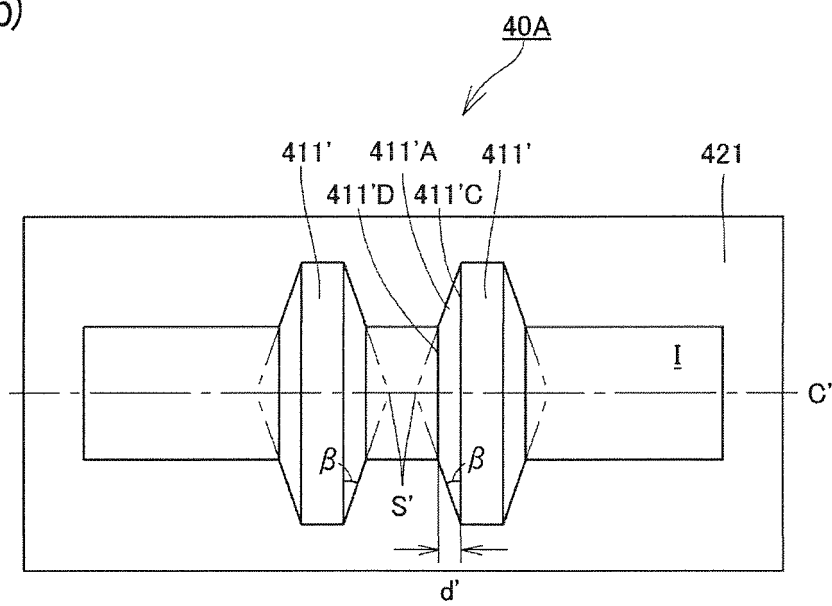


Fig. 8

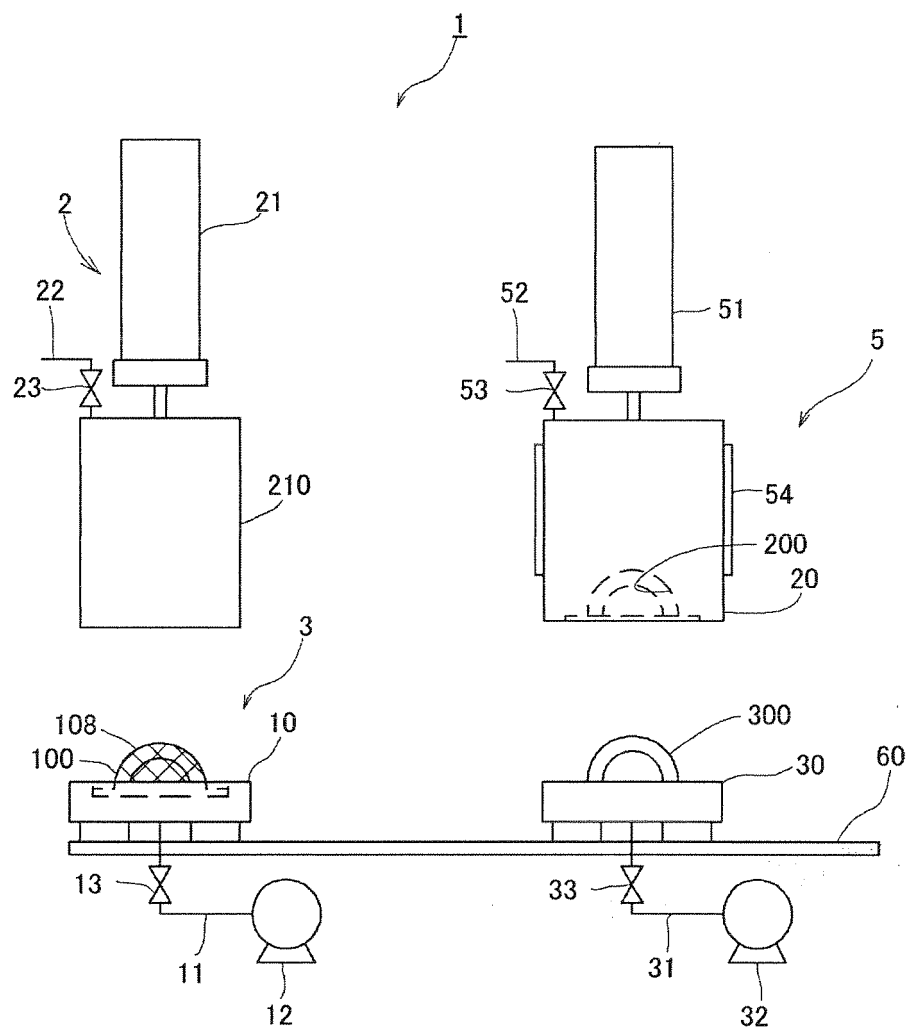


Fig. 9

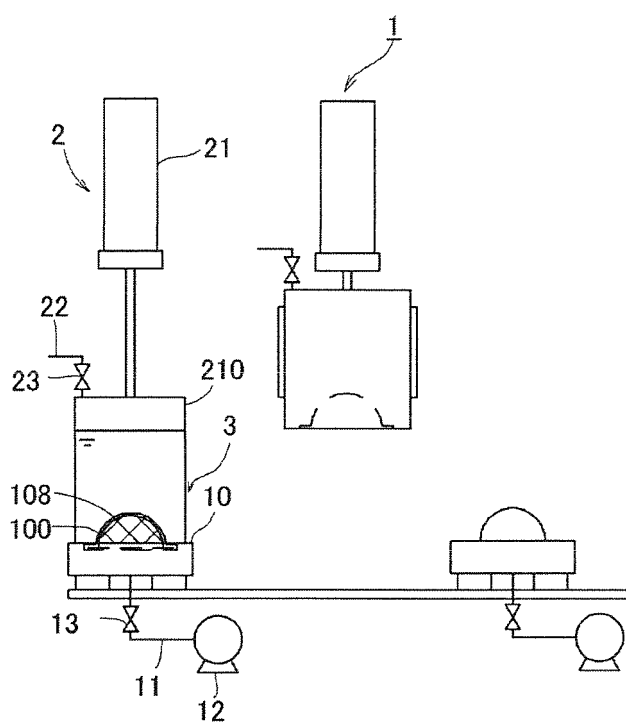


Fig. 10

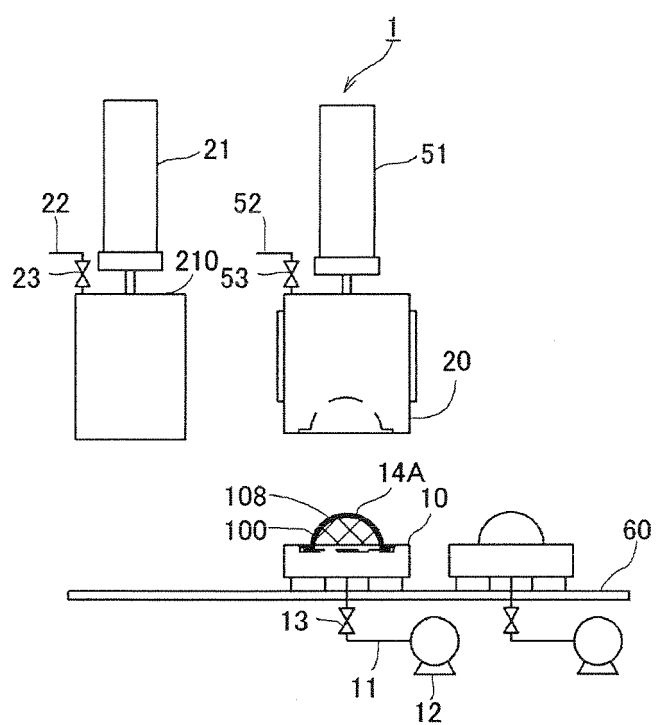


Fig. 11

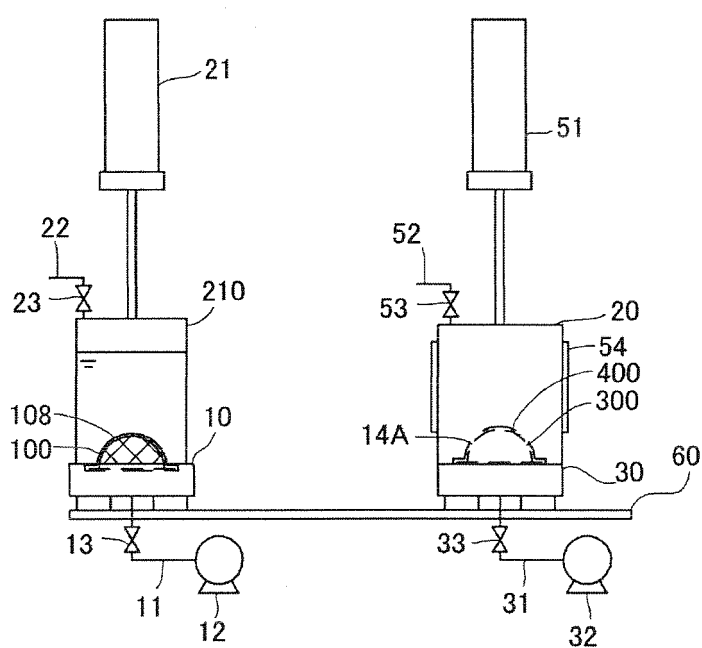


Fig. 12

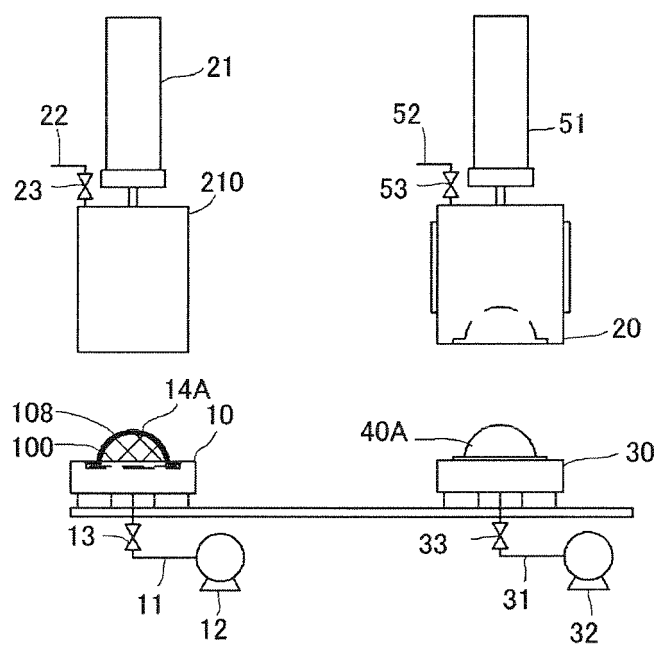


Fig. 13

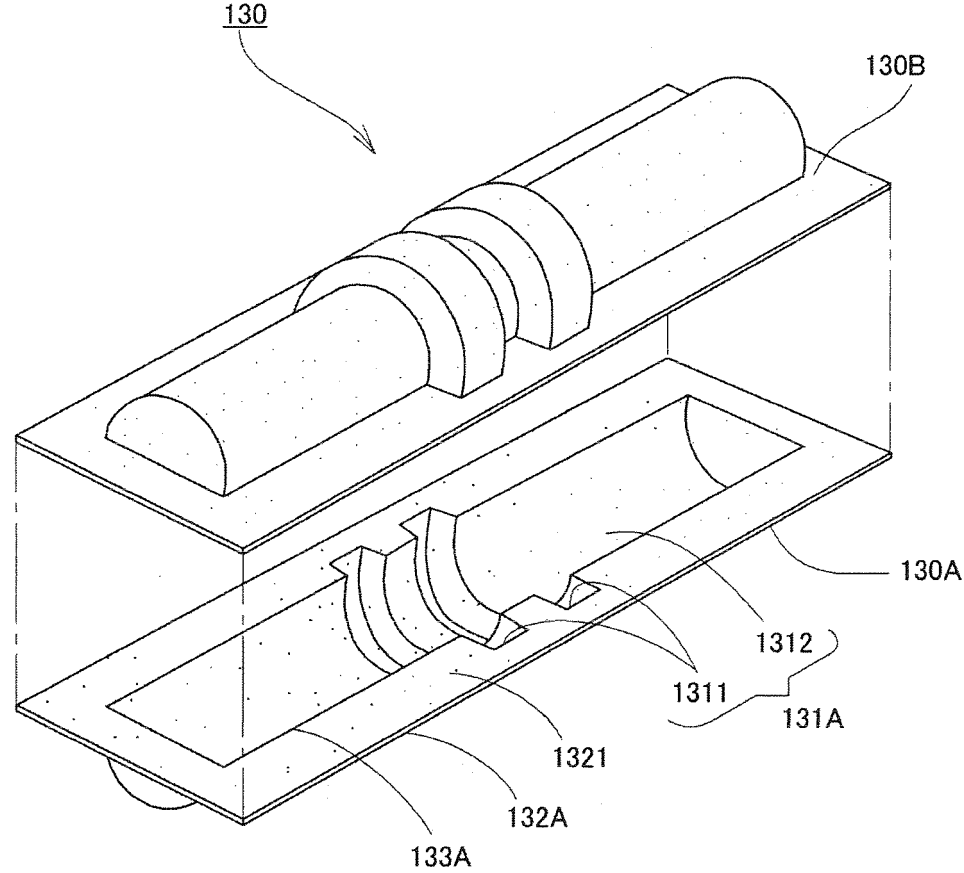


Fig. 14(a)

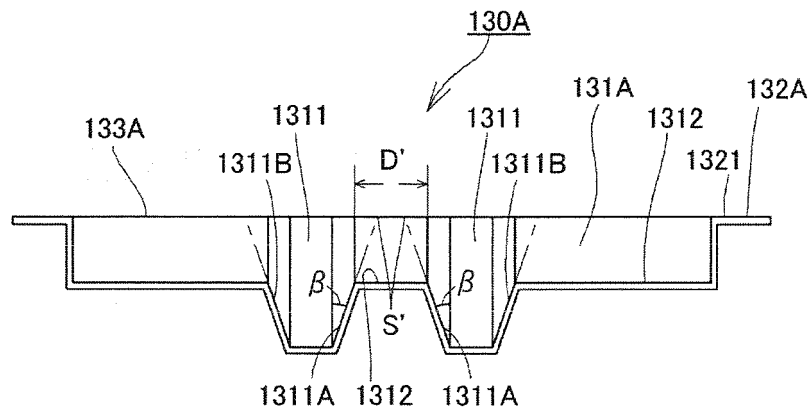


Fig. 14(b)

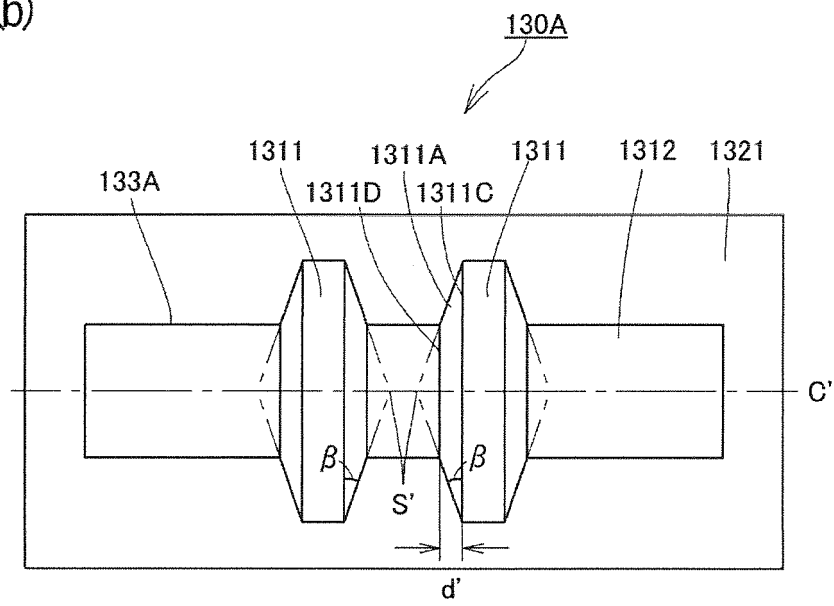


Fig. 15(a)

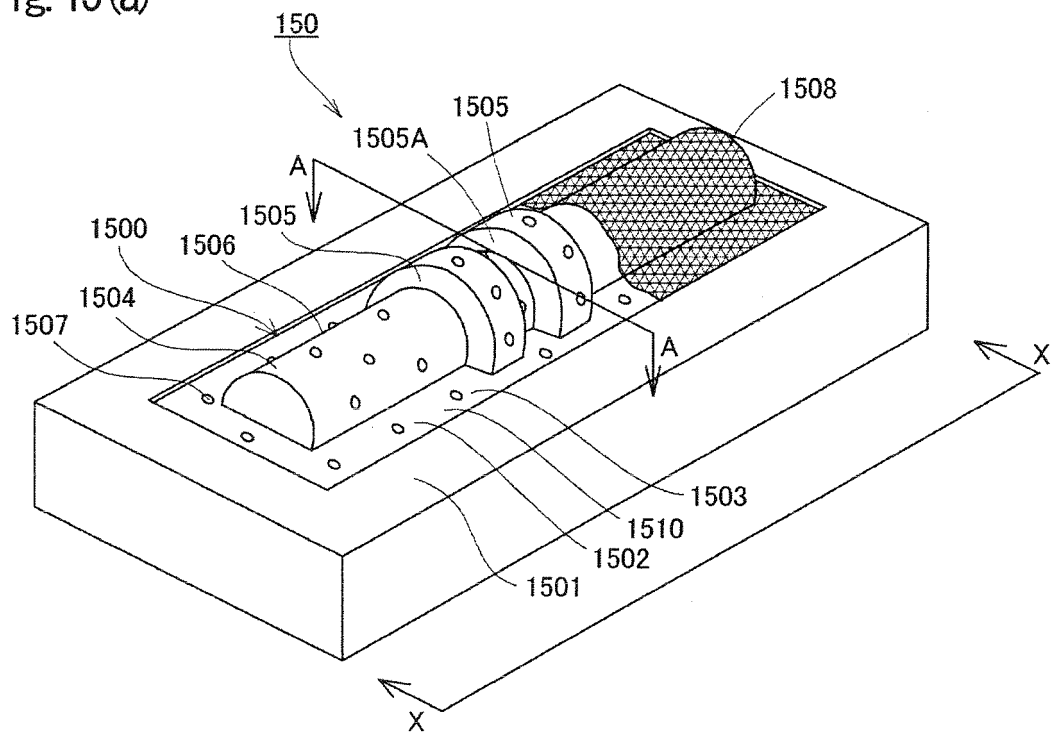


Fig. 15(b)

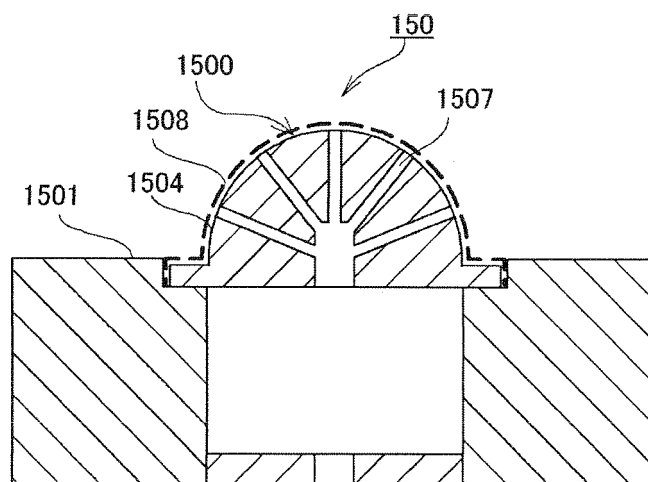


Fig. 16(a)

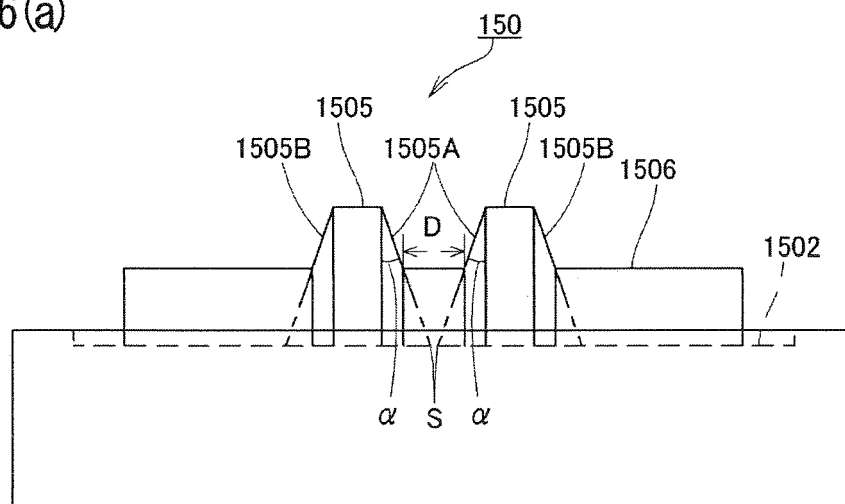


Fig. 16(b)

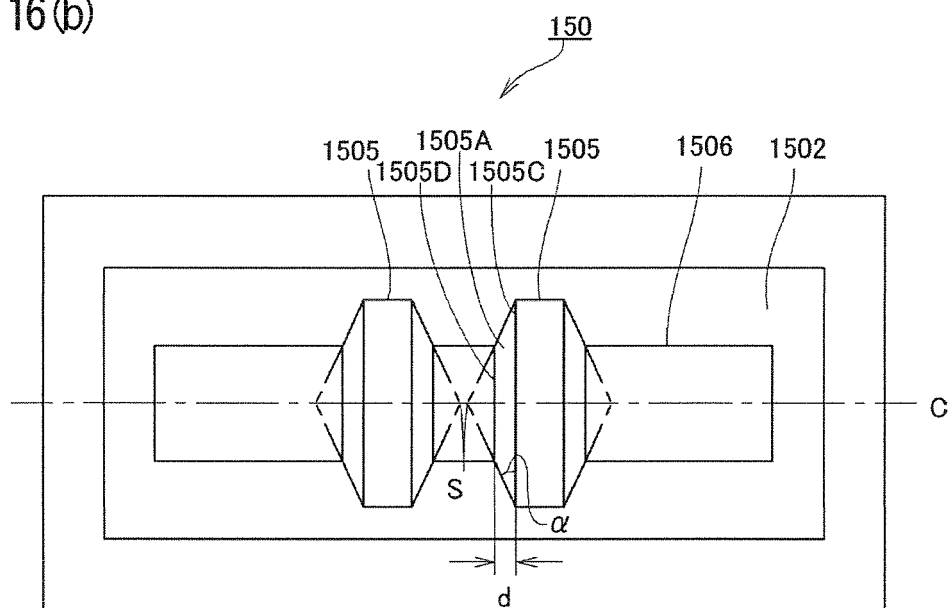


Fig. 17

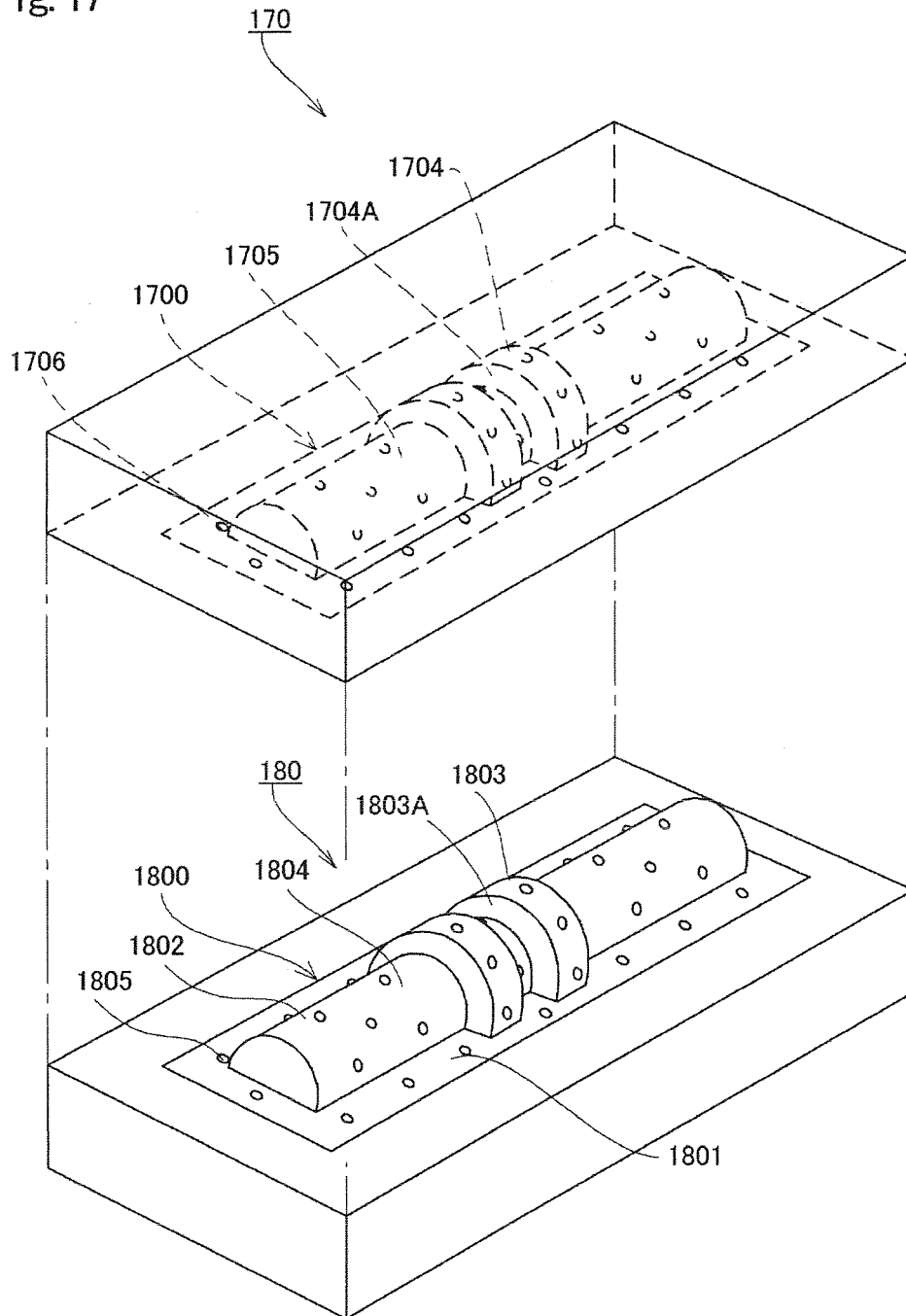


Fig. 18(a)

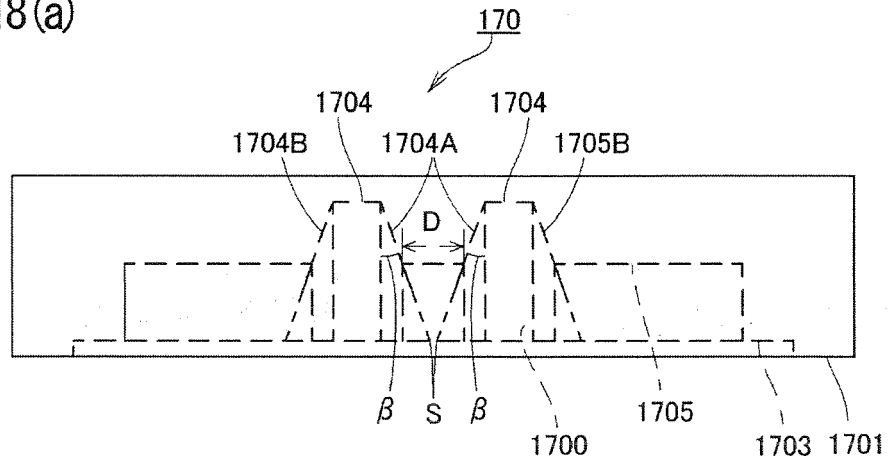


Fig. 18(b)

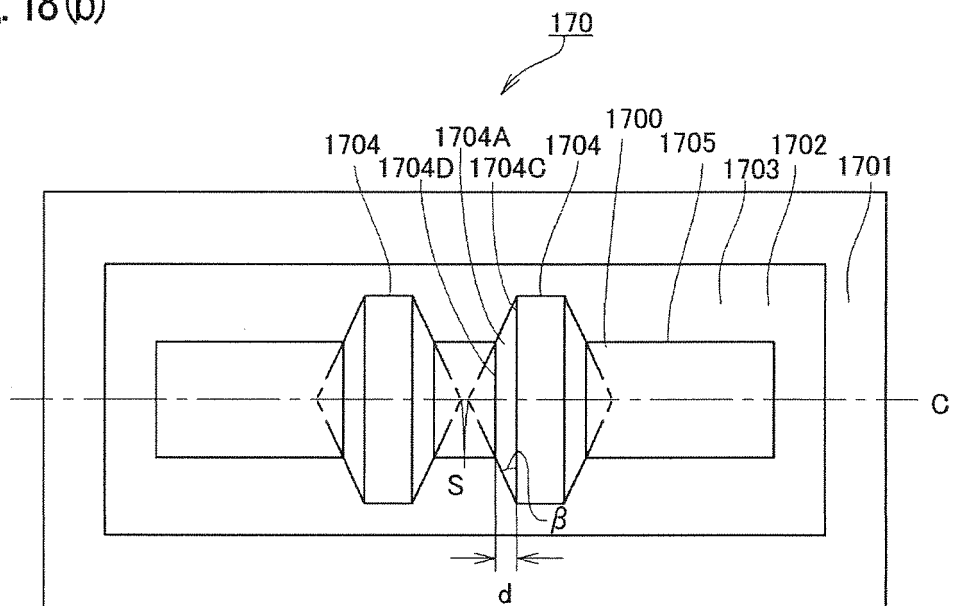


Fig. 19(a)

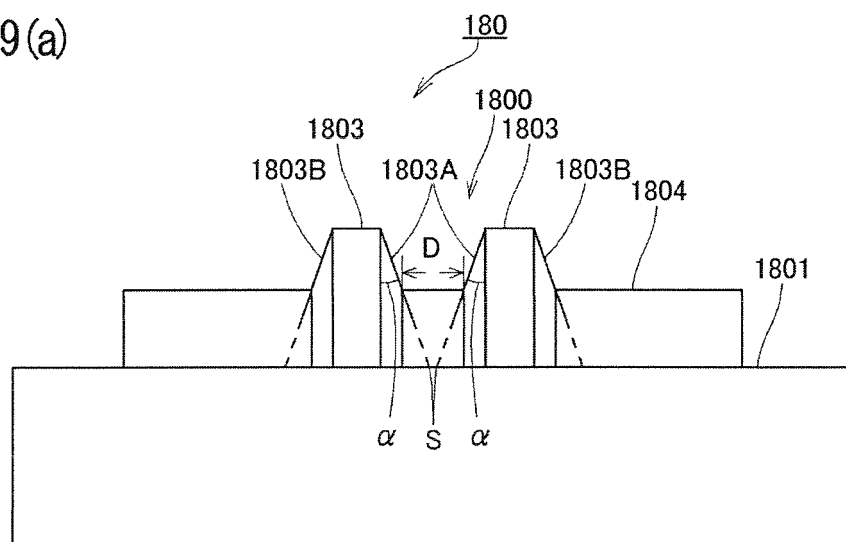


Fig. 19(b)

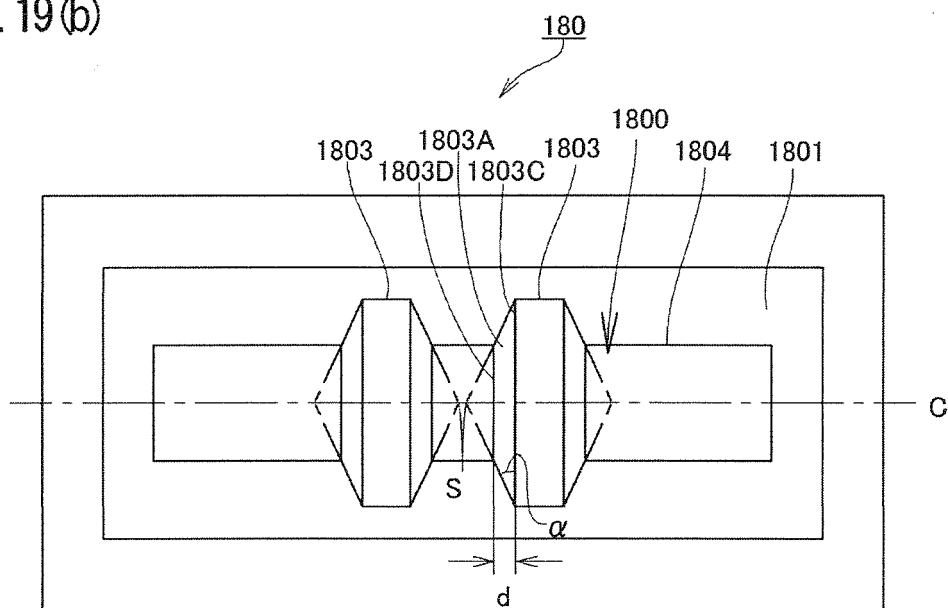


Fig. 20

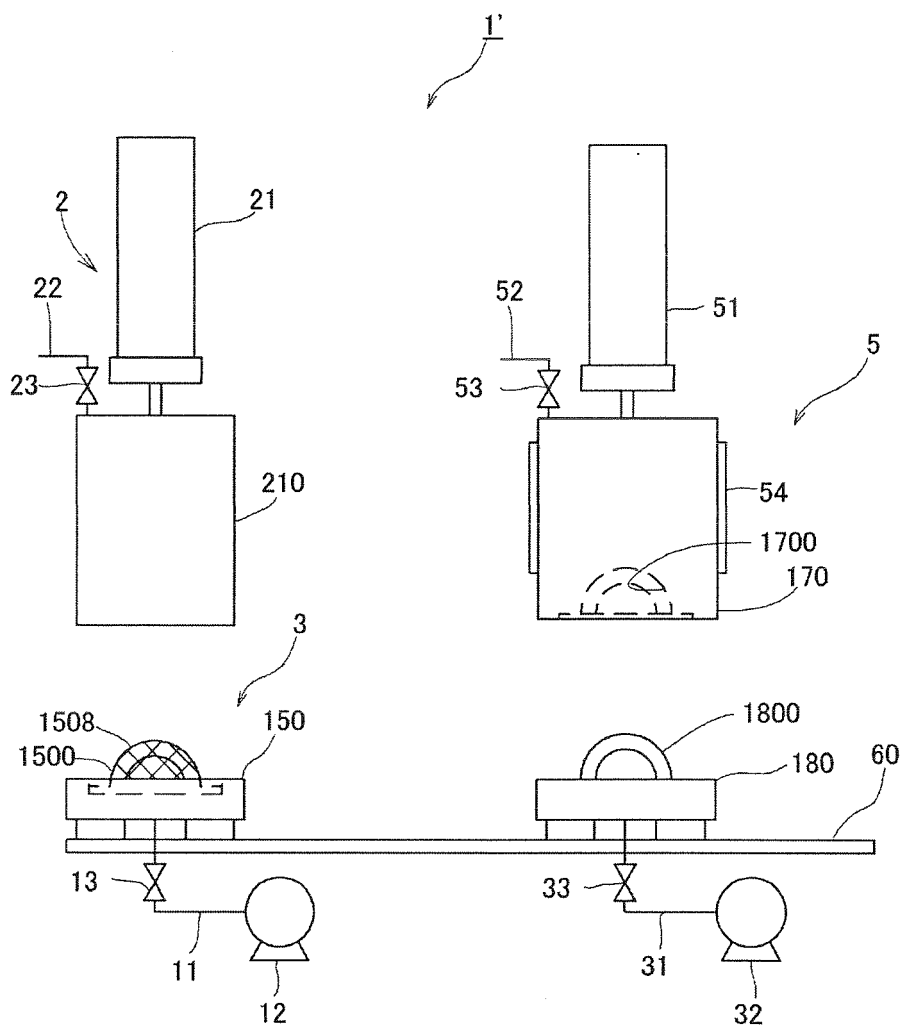


Fig. 21

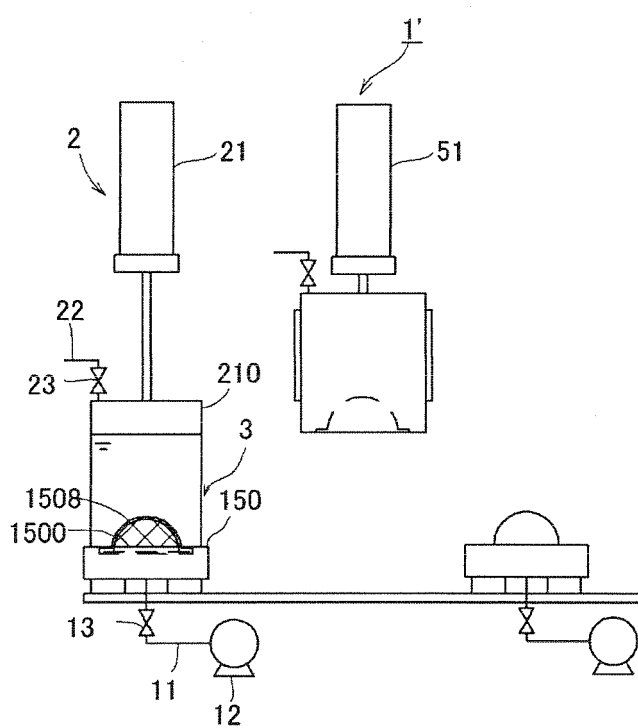


Fig. 22

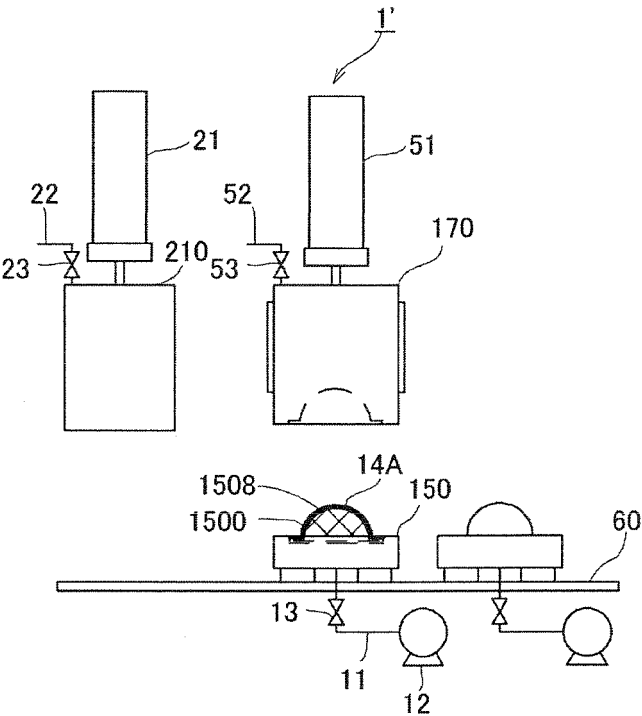


Fig. 23

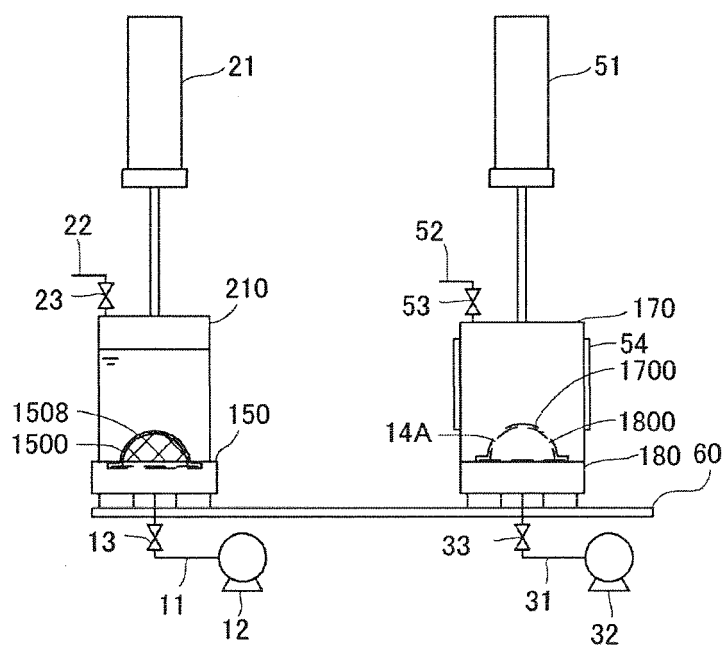


Fig. 24

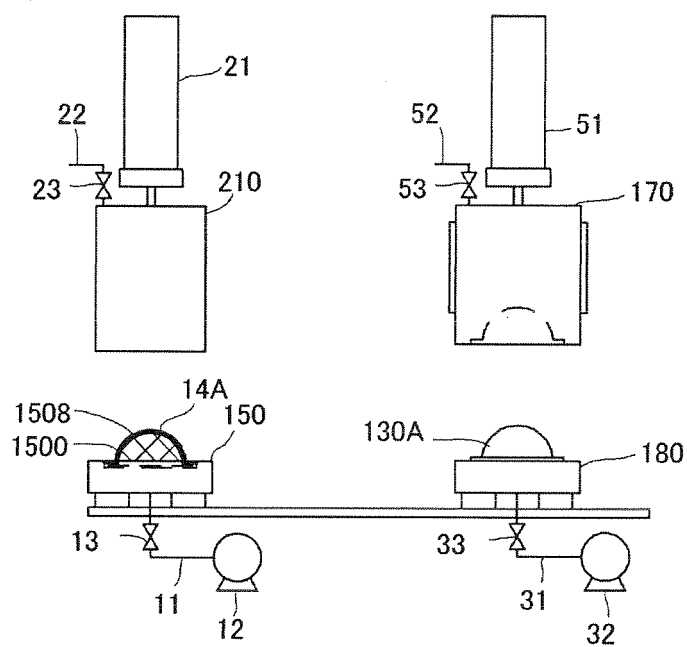


Fig. 25

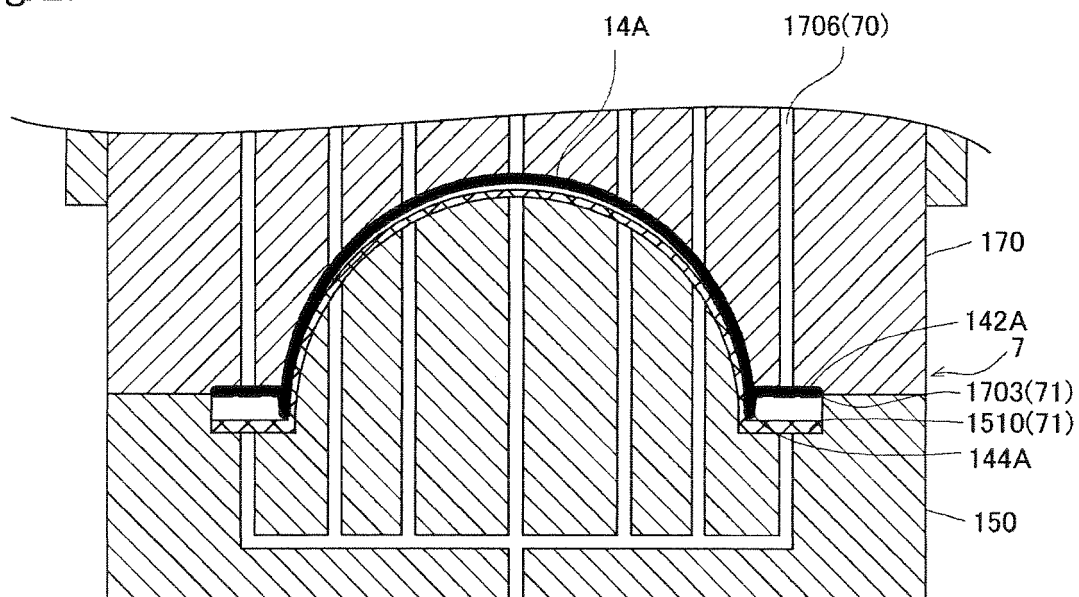


Fig. 26

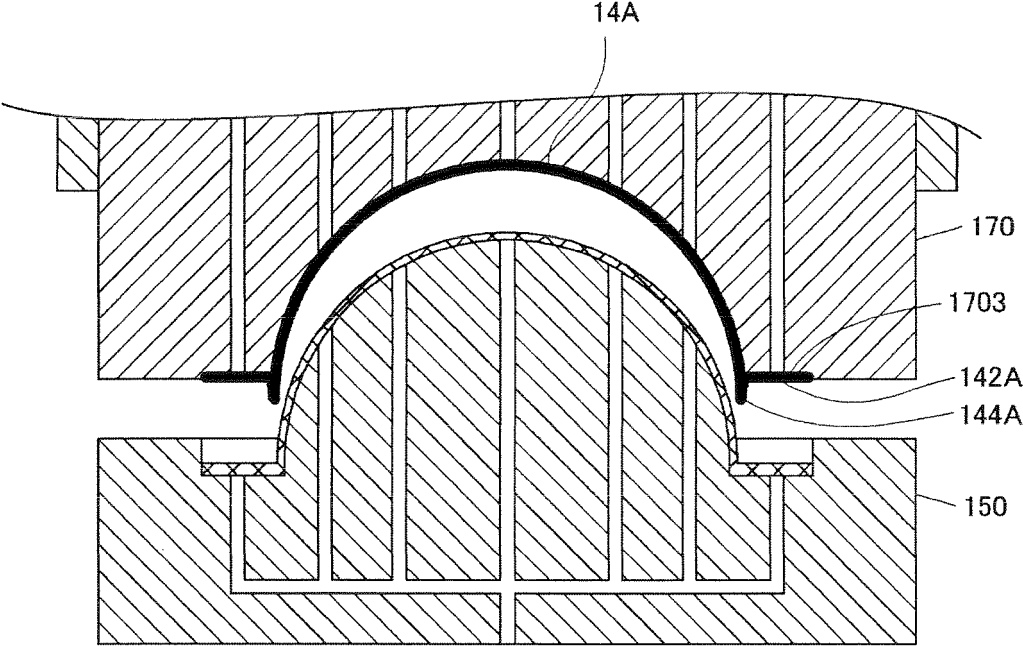


Fig. 27

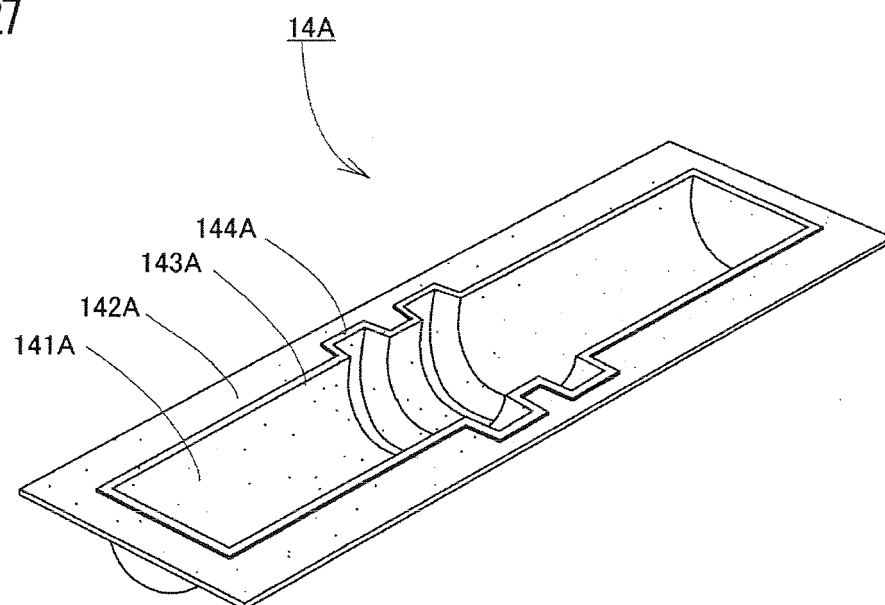


Fig. 28

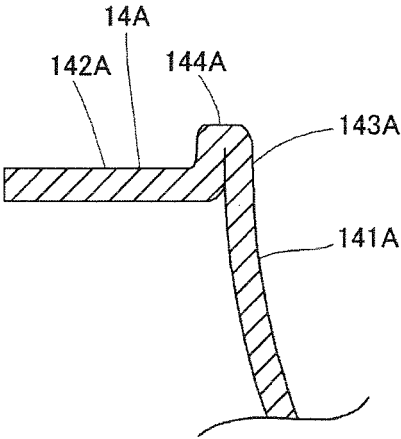


Fig. 29

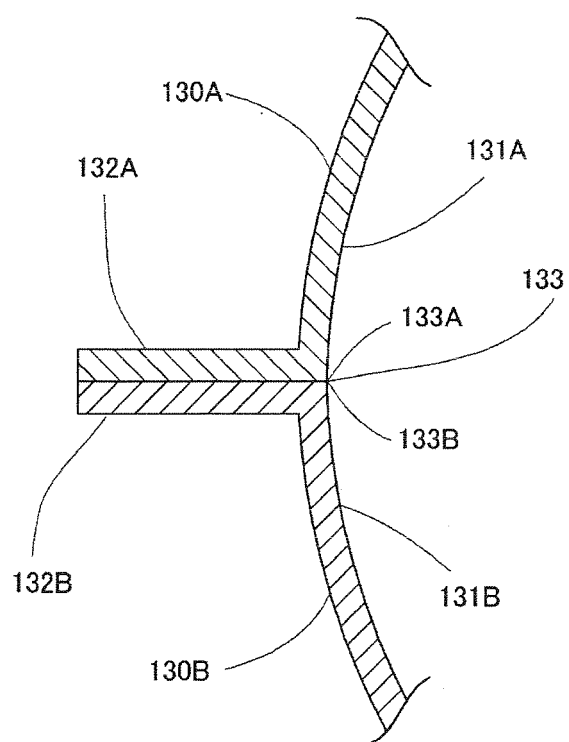


Fig. 30(a)

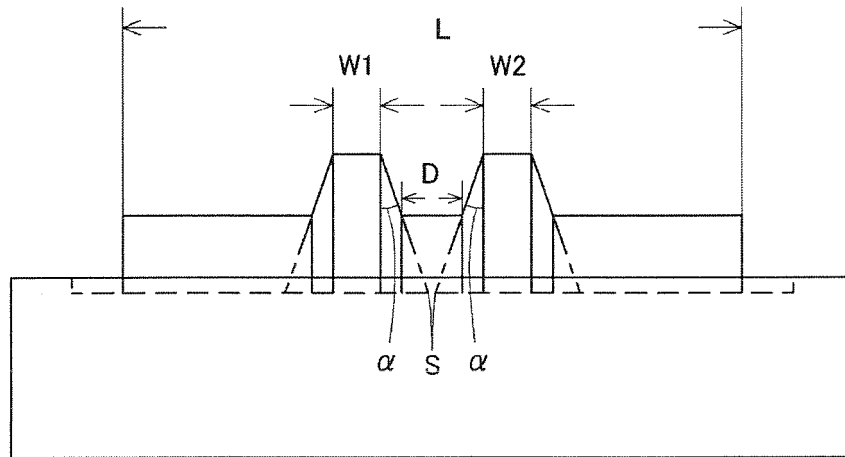


Fig. 30(b)

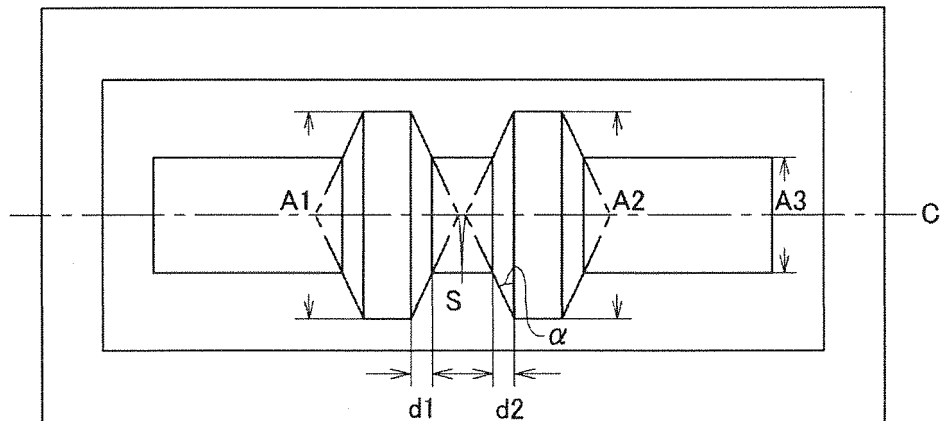


Fig. 31 (a)

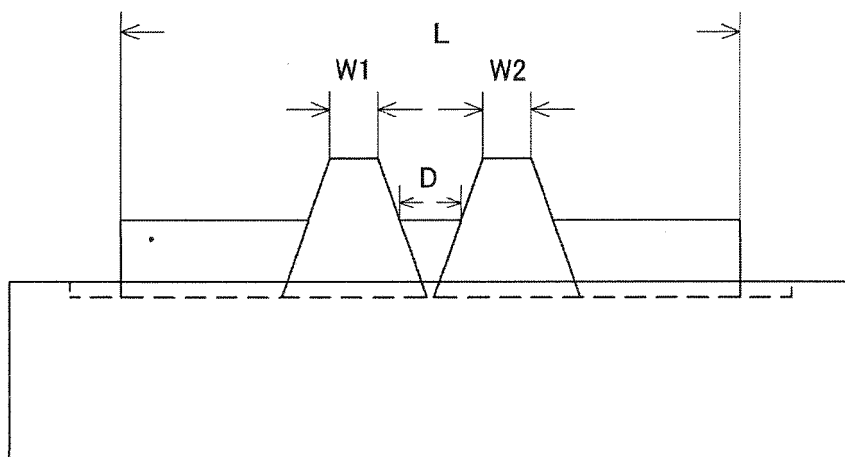


Fig. 31 (b)

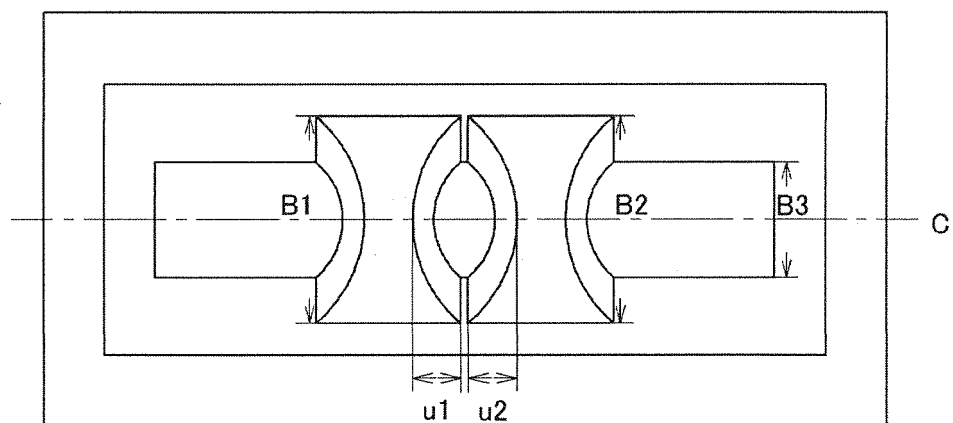


Fig. 32(a)

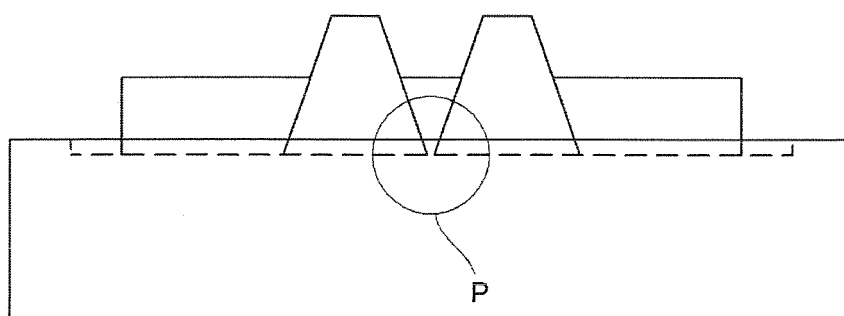
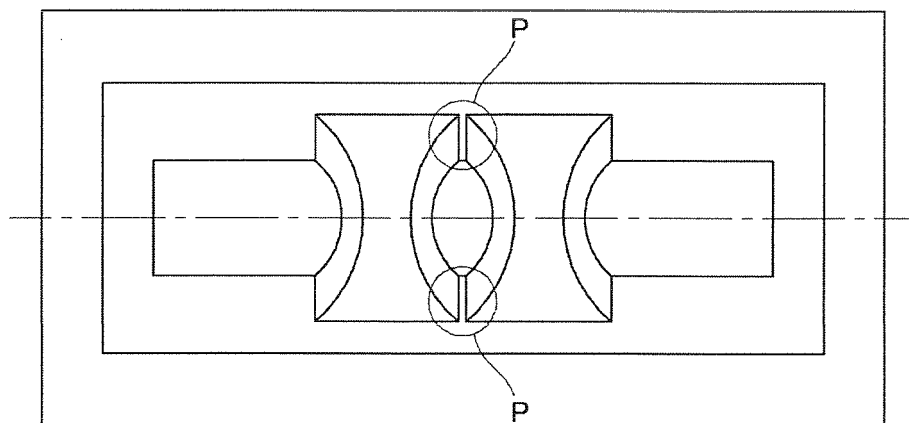


Fig. 32(b)



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2007/066863

A. CLASSIFICATION OF SUBJECT MATTER

B22C9/02(2006.01)i, B22C1/00(2006.01)i, D21J7/00(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B22C1/00-25/00, D21J1/00-7/00, B29C33/00-33/76

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	1996-2007
Kokai Jitsuyo Shinan Koho	1971-2007	Toroku Jitsuyo Shinan Koho	1994-2007

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2006-136939 A (Kao Corp.), 01 June, 2006 (01.06.06), & WO 2006/040976 A1 & EP 1806454 A1 & CN 1954121 A	1-22
A	JP 8-209600 A (Tomoku Co., Ltd.), 13 August, 1996 (13.08.96), (Family: none)	1-22

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

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"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
26 November, 2007 (26.11.07)Date of mailing of the international search report
04 December, 2007 (04.12.07)Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2005290600 A [0002] [0003] [0003] [0033] [0034]
- JP 2004195547 A [0034]