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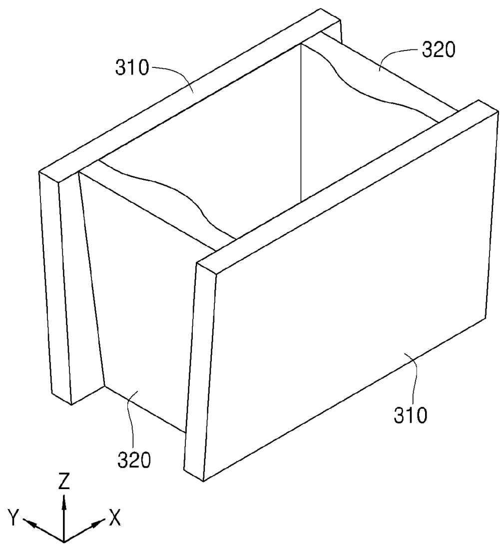
(54) **MOLD**

(57) In accordance with an exemplary embodiment, a mold that solidifies molten steel injected to an inner space thereof includes a body having the inner space and a convex member that protrudes in a direction from an inner surface of the body to the inner space and has a protruding length gradually decreasing in a direction from the inner surface to the inner space.

The mold in accordance with exemplary embodiments may suppress or prevent a surface defect and break out caused by contraction of a solidification cell in comparison with the related art. That is, the mold in accordance with the exemplary embodiments has an improved compensation rate with respect to the contraction of the solidification cell in comparison with the related art. Particularly, the mold in accordance with the exemplary embodiments has an improved compensation rate with respect to contraction in a short side direction of the solidification cell. Thus, a gap between an inner surface of the mold and the solidification cell may be suppressed or prevented to thereby suppress or prevent a solidification retarded phenomenon.

FIG. 2



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Description

TECHNICAL FIELD

[0001] The present disclosure relates to a mold, and more particularly, to a mold capable of suppressing or preventing a defect generated in a slab and a damage on the slab.

BACKGROUND ART

[0002] In general, a slab is manufactured as molten steel accommodated in a mold is cooled while passing through a cooling bed. For example, a continuous casting process manufactures various shaped products such as a slab, a bloom, a billet, and a beam blank by injecting molten steel to a mold having a predetermined inner shape and continuously drawing a semi-solidified slab through a lower side of the mold. The slab is manufactured by using a rectangular mold obtained by assembling long side parts and short side parts.

[0003] When the molten steel is supplied into the mold through a nozzle, a solidification cell is formed from a surface of the molten steel in the mold, and a thickness of the solidification cell gradually increases in a downward direction. Also, solidification contraction is generated because a temperature gradually decreases in the downward direction. When the solidification contraction is not compensated by the mold, an air layer is generated between the mold and the slab. When the air layer is formed, a heat transfer performance between the mold and the molten steel or the slab is reduced to generate a solidification retarded phenomenon, thereby generating break out and a crack in the slab.

[0004] To resolve the above-described limitations, the mold is inclined by decreasing a lower width of the mold to be less than an upper width of the mold. That is, a solidification contraction rate of a long side of the slab is compensated by inclining a short side part of the mold to decrease a lower width of the long side part in comparison with an upper width of the long side part, and a solidification contraction rate of a short side of the slab is compensated by inclining a side surface of the short side contacting the long side part of the mold to decrease a lower width of the short side in comparison with an upper width of the short side.

[0005] Here, one pair of long side parts are coupled by adjusting an inclination of the short side to compensate the solidification contraction rate of the long side of the slab as described above. Also, the short side is manufactured to have a width gradually decreasing from an upper portion to a lower portion thereof by inclining the side surface of the short side contacting the long side part to compensate a solidification contraction rate in a short side direction of the slab. Here, the solidification contraction rate of the long side of the slab may be adjusted by adjusting or changing the entire inclination of the short side part when the long side part and the short side part are coupled. However, the inclination of the side surface of the short side part may not be changed.

[0006] Thus, the solidification contraction rate of the long side of the slab is compensated by adjusting an installation inclination of the short side part or providing multi-taper to one short side part so that tapered amounts of upper and lower portions are differentiated. However, a compensation degree of the solidification contraction rate of in the short side direction of the slab is typically less than that of the long side, and the same amount is compensated instead of adjusting the compensation degree for each of upper and lower portions.

[0007] Thus, the installation inclination of the short side part of the mold of the related art is larger to increase the compensation amount for the solidification contraction rate in the short side direction of the slab. In this case, however, wear between the short side of the slab and the short side part of the mold is generated to reduce a lifespan of the mold and degrade a quality of the slab.

(Related art document)

[0008] Korean Publication Patent No. 10-2013-0074898

DISCLOSURE OF THE INVENTION

TECHNICAL PROBLEM

[0009] The present disclosure provides a mold capable of improving a lifespan thereof and suppressing wear with a slab.

[0010] The present disclosure also provides a mold capable of compensating a solidification contraction rate of a solidification cell.

TECHNICAL SOLUTION

[0011] In accordance with an exemplary embodiment, a mold that solidifies molten steel injected to an inner space thereof includes: a body having the inner space; and a convex member that protrudes in a direction from an inner surface of the body to the inner space and has a protruding length gradually decreasing in a direction from the inner surface to the inner space.

[0012] The convex member may have the same width in a vertical direction.

[0013] The convex member may have a width that gradually decreases in a downward direction.

[0014] The convex member may have a width less than that of the body.

[0015] The convex member may have the same width as that of the body.

[0016] The width of the convex member may gradually decrease in the downward direction with a constant rate.

[0017] A boundary line between the inner surface of the body and the convex member may be a straight line.

[0018] The width of the convex member may gradually decrease in the downward direction with an inconstant rate.

[0019] A boundary line between the inner surface of the body and the convex member may be a curve

[0020] The boundary line may have a convex shape in an outside direction of the convex member.

[0021] The boundary line may has a concave shape in an inside direction of the convex member.

[0022] An upper portion of the convex member and an upper portion of the body may be positioned at the same height, and the convex member may have a vertical extension length less than that of the body.

[0023] An upper portion of the convex member and an upper portion of the body may be positioned at the same height, and the convex member may have a vertical extension length equal to that of the body.

[0024] The body may include: one pair of long side members each extending in one direction and installed to face each other in a direction crossing the extended direction; and one pair of short side members extending to cross the long side members, respectively, and installed to face each other, thereby sealing a portion between the one pair of long side members.

[0025] The one pair of short side members may be inclined so that a spaced distance between the one pair of short side members gradually decreases in the downward direction.

[0026] A side surface of the short side member, which contacts the long side member, may be gradually inclined to a center in a width direction of the short side member in the downward direction.

[0027] The body may include a protruding member formed at each of both side ends in an extension direction of the short side member to form a chamfered surface at an edge of the casted slab.

ADVANTAGEOUS EFFECTS

[0028] The mold in accordance with the exemplary embodiments may suppress or prevent the surface defect and the break out caused by the contraction of the solidification cell in comparison with the related art. That is, the mold in accordance with the exemplary embodiments may have the improved compensation rate with respect to the contraction of the solidification cell in comparison with the related art. Particularly, the mold in accordance with the exemplary embodiments may have the improved compensation rate with respect to the contraction in the short side of the solidification cell in comparison with the related art. Thus, the generation of the gap between the inner surface of the mold and the solidification cell may be suppressed or prevented to thereby suppress or prevent the solidification retarded phenomenon.

[0029] Also, although the inclination of the side surface of the short side part is not further increased, the contraction compensation rate in the short side direction of the solidification cell may improve.

[0030] In the related art, the installation inclination of the short side part is further increased to improve the contraction compensation rate in the short side direction of the solidification cell. Here, wear between the short side part of the mold and the short side of the slab may be generated to reduce the lifespan of the mold and degrade the quality of the slab.

[0031] However, although the installation inclination of the short side part is not increased in the exemplary embodiments, the contraction compensation rate in the short side direction of the solidification cell may improve to suppress or prevent the damage on the mold caused by the wear.

BRIEF DESCRIPTION OF THE DRAWINGS

[0032]

FIG. 1 is a view illustrating a main portion of a general continuous casting apparatus.

FIG 2 is a three-dimensional view illustrating a mold in accordance with the exemplary embodiment.

FIG 3 is a front view for explaining a state in which one pair of short side parts have a spaced distance gradually decreasing in a downward direction in the mold in accordance with the exemplary embodiment.

FIG 4 is a front view for explaining an inclined shape of a side surface of a short side part contacting a long side part in the mold in accordance with the exemplary embodiment.

FIG. 5 is a view illustrating the short side part in accordance with the exemplary embodiment.

FIG 6 is a view for explaining a solidification cell (refer to (a) of FIG. 6) formed at an upper portion and a solidification cell (refer to (b) of FIG 6) formed at a lower portion in the mold in accordance with the exemplary embodiment.

FIG. 7 is a view for explaining a shape of a convex member, a width of the short side part, and a width of the convex member in the short side part in accordance with the exemplary embodiment.

FIG 8 is a view for explaining an extension length of an inner surface of the short side part in the short side part in accordance with the exemplary embodiment.

FIG. 9 is a view illustrating a short side part in accordance with a modified example of the exemplary embodiment.

FIG 10 is a view illustrating a short side part in accordance with another modified example of the exemplary embodiment.

FIG. 11 is a view illustrating a short side part in accordance with another exemplary embodiment.

FIG. 12 is a view illustrating a short side part in accordance with a modified example of the another exemplary embodiment.

FIG 13 is a view illustrating a short side part in accordance with another modified example of the another exemplary embodiment.

FIG. 14 is a view illustrating a short side part in accordance with a yet another exemplary embodiment.

FIG. 15 is a view illustrating a short side part in accordance with a modified example of the yet another exemplary embodiment.

FIG 16 is a view illustrating a short side part in accordance with another modified example of the yet another exemplary embodiment.

FIG. 17 is a view illustrating a short side part in accordance with a still another exemplary embodiment.

FIG. 18 is a view illustrating a short side part in accordance with a modified example of the still another exemplary embodiment.

FIG 19 is a view illustrating a short side part in accordance with another modified example of the still another exemplary embodiment.

FIG 20 is a view illustrating a short side part in accordance with a yet still another exemplary embodiment.

FIG 21 is a three-dimensional view illustrating a mold in accordance with a still even yet another exemplary embodiment.

FIG 22 is a three-dimensional view illustrating a mold in accordance with a still even further exemplary embodiment.

FIG. 23 is a three-dimensional view illustrating a short side part of the mold in accordance with a still even further exemplary embodiment.

FIG 24 is a three-dimensional view illustrating a mold of the related art.

FIG 25 is a view for explaining a solidification cell (refer to (a) of FIG. 6) formed at an upper portion and a solidification cell (refer to (b) of FIG 6) formed at a lower portion in the mold of the related art.

MODE FOR CARRYING OUT THE INVENTION

[0033] Hereinafter, embodiments will be described in detail with reference to the accompanying drawings. The present disclosure may, however, be embodied in many different forms and should not be construed as being limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the concept of the invention to those skilled in the art.

[0034] FIG. 1 is a view illustrating a main portion of a general continuous casting apparatus. FIG. 2 is a three-dimensional view illustrating a mold in accordance with an exemplary embodiment. FIG. 3 is a front view for explaining a state in which one pair of short side parts have a spaced distance gradually decreasing in a downward direction in the mold in accordance with an exemplary embodiment. FIG 4 is a front view for explaining an inclined shape of a side surface of a short side part contacting a long side part in the mold in accordance with an exemplary embodiment.

[0035] (a) of FIG. 5 is a three-dimensional view that is viewed in an inner surface direction in the short side part in accordance with an exemplary embodiment. (b) of FIG. 5 is a front view that is viewed in the inner surface direction in the short side part in accordance with an exemplary embodiment. (c) of FIG. 5 is a view that is viewed in a side surface direction in the short side part in accordance with an exemplary embodiment. ⓐ, ⓑ and ⓒ of (d) of FIG. 5 are top views at positions ⓐ, ⓑ and ⓒ in a vertical direction (a height direction or a Z-axis direction) of (c) of FIG 5.

[0036] FIG 6 is a view for explaining a solidification cell (refer to (a) of FIG. 6) disposed at an upper portion and a solidification cell (refer to (b) of FIG. 6) disposed at a lower portion in the mold in accordance with an exemplary embodiment.

[0037] FIG. 7 is a view for explaining a shape of a convex member, a width of the short side part, and a width of the convex member in the short side part in accordance with an exemplary embodiment. FIG. 8 is a view for explaining an extension length of the inner surface of the short side part in the short side part in accordance with an exemplary embodiment.

[0038] Referring to FIG. 1, the continuous casting apparatus includes: a ladle 10 storing molten steel refined in a steel making process; a tundish 20 receiving the molten steel through an injection nozzle connected to the ladle 10 and temporarily storing the molten steel; a mold 300 receiving the molten steel stored in the tundish 20 and initially solidifying the molten steel into a predetermined shape; and a submerged nozzle 22 (hereinafter, referred to as a nozzle) supplying the molten steel of the tundish 20 to the mold 300.

[0039] Also, the continuous casting apparatus includes a cooling bed 40 including a plurality of segments 50, which are consecutively arranged, for cooling a non-solidified slab 1, which is drawn from the mold 300, and performing a series of molding processes.

[0040] The mold 300 receives the molten steel from the tundish 20 and initially solidifies the molten steel into a predetermined shape. The mold 300 in accordance with an exemplary embodiment includes: a body having an inner space; and a convex member 322 protruding in a direction from an inner surface of the body to the inner space and having a protruding length from the inner surface to the inner surface, which gradually decreases in an inner space direction.

[0041] The body in accordance with an exemplary embodiment includes: one pair of long side parts 310 each extending in one direction and spaced apart from each other in a direction crossing or perpendicular to the extension direction; and one pair of short side parts 320 extending in a direction crossing or perpendicular to the long side parts 310, respectively, and spaced apart from each other in a direction crossing or perpendicular to the extension direction. Also, each of the one pair of short side parts 320 in accordance with an exemplary embodiment includes a convex member 322 protruding in the inner space direction and having a protruding length gradually decreasing in a downward direction.

[0042] When a constitution of the mold 300 in accordance with an exemplary embodiment is described again, the mold 300 includes: one pair of long side parts 310 each extending in one direction and spaced apart from each other in a direction crossing or perpendicular to the extension direction; and one pair of short side parts 320 extending in a direction crossing or perpendicular to the long side parts 310, respectively, spaced apart from each other in a direction crossing or perpendicular to the extension direction, and each including the convex member 322 protruding in the inner space direction.

[0043] Hereinafter, the extension direction of each of the long side parts 310 is defined as a X-axis direction, and the extension direction of each of the short side parts 320 is defined as a Y-axis direction. Thus, the spaced direction of the one pair of long side parts 310 is the Y-axis direction, and the spaced direction of the one pair of short side parts 320 is the X-axis direction.

[0044] As described above, the one pair of long side parts 310 each extend in the X-axis direction and are spaced apart from each other in the Y-axis direction crossing the X-axis direction. Thus, the one pair of long side parts 310 face each other in the Y-axis direction. Hereinafter, the one pair of long side parts 310 are referred to as first and second long side parts 310.

[0045] The one pair of short side parts 320 each extend in the Y-axis direction and are spaced apart from each other in the X-axis direction perpendicular to the Y-axis direction or the extension direction of the long side parts 310. Thus, the one pair of short side parts 320 face each other in the X-axis direction. Here, a spaced distance between the one pair of short side parts 320 may be less than an extension length of each of the long side parts 310. However, the exemplary embodiment is not limited thereto. For example, the spaced distance between the one pair of short side parts 320 may be equal to the extension length of each of the long side parts 310. Hereinafter, the one pair of short side parts 320 are referred to as first and second short side parts 320.

[0046] The mold 300 is constituted as the short side parts 320 and the long side parts 310 are connected or coupled to each other. For example, the first short side part 320 has one end connected to an inner surface of the first long side part 310 and the other end connected to an inner surface of the second long side part 310 in the extension direction, and the second short side part 320 has one end connected to the inner surface of the first long side part 310 and the other end connected to the inner surface of the second long side part 310 in the extension direction.

[0047] When molten steel M is injected into the mold 300, solidification is firstly initiated along an inner surface of the mold 300, and thus a solidification cell C is formed along the inner surface of the mold 300. Also, the solidification cell C has a thickness gradually increasing in a downward direction and is contracted due to cooling caused by the mold 300 and cooling caused by the outside of the mold 300.

[0048] Here, the solidification cell C is mainly contracted in an extension direction of the inner surface of the mold 300. That is, the solidification cell C is contracted in the extension direction of the long side part 310 and the extension direction of the short side part 320 of the mold 300. When described in more detail with reference to FIG. 25, the solidification cell (hereinafter, referred to as a long side solidification cell LC) formed along the long side part 310 of the mold 300 is mainly contracted in the extension direction (the X-axis direction) of the long side part 310, and the solidification cell (hereinafter, referred to as a short side solidification cell SC) formed along the short side part 320 of the mold 300 is mainly contracted in the extension direction (the Y-axis direction) of the short side part 320. Also, as illustrated in (a) of FIG. 25 and (b) of FIG. 25, the solidification cell C has a thickness gradually increasing in the downward direction, and each of the long side solidification cell LC and the short side solidification cell SC of a lower portion of the mold 300 has a thickness greater than that of an upper portion of the mold 300.

[0049] Due to the above-described solidification contraction of the solidification cell C, the long side solidification cell LC has an extension length (a length in the X-axis direction) gradually decreasing from the upper portion to the lower portion, and the short side solidification cell SC has an extension length (a length in the Y-axis direction) gradually decreasing from the upper portion to the lower portion. Here, each of the long side solidification cell LC and the short side solidification cell SC is contracted in a central direction of the extension direction thereof. Thus, as illustrated in (a) of FIG. 25 and (b) of FIG. 25, each of the long side solidification cell LC and the short side solidification cell SC of the lower portion has a length less than that of the upper portion.

[0050] The contraction of the solidification cell C generates a gap or an air layer between the inner surface of the mold 300 and the solidification cell C. Since the contraction is generated mainly in the central direction of the extension direction, the gap is mainly generated at corners of the mold 300 (refer to (b) of FIG. 25). Thus, a heat transfer performance between the mold 300 and the molten steel M or between the mold 300 and the solidification cell C is reduced to cause a solidification retarded phenomenon and thus generate break out and a crack in the slab.

[0051] To resolve the above-described limitation, the mold 300 having an inner width gradually decreasing in the downward direction is generally prepared.

[0052] In more detail, when the first and second short side parts 320 face each other, as illustrated in FIGS. 2 and 3, each of the first and second short side parts 320 is gradually inclined in the downward direction and becomes adjacent to a center of the extension direction (the X-axis direction) of the long side part 310 as illustrated in FIGS. 2 and 3. In other words, the first and second short side parts 320 are inclined so that a spaced distance between the first short side part 320 and the second short side part 320 gradually decreases in the downward direction. Thus, a lower spaced distance SL between the first short side part 320 and the second short side part 320 is shorter than an upper spaced distance SL. The above-described variation of the spaced distance between the first short side part 320 and the second short side part 320 eventually represents that a length of the long side of the slab gradually decreases in the downward direction.

[0053] Here, when the spaced distance between the first and second short side parts 320 gradually decreases in the downward direction, an inclination angle thereof may be varied in accordance with a contraction rate of the long side solidification cell LC. That is, the inclination angle may be adjusted so that the spaced distance between the one pair of short side parts 320 gradually decreases in the downward direction in accordance with the contraction rate in which the extension length of the long side solidification cell LC gradually decreases in the downward direction.

[0054] Thus, although the long side solidification cell LC is gradually contracted in the downward direction, the gap between the solidification cell C and an inner wall of the mold, more particularly between the short side part 320 and both ends of the long side solidification cell LC may be prevented or suppressed due to the one pair of short side parts 320 having the spaced distance gradually decreasing in the downward direction.

[0055] Here, the feature in which the one pair of short side parts 320 are disposed so that the spaced distance therebetween gradually decreases in the downward direction may represent that contraction in the direction of the long side of the solidification cell C is compensated. Thus, a surface defect and break out in accordance with solidification contraction of the long side solidification cell LC may be prevented or suppressed.

[0056] Also, each of the first and second short side parts 320 has an extension length SW gradually decreasing in the downward direction. In other words, as illustrated in FIG. 4, each of the first and second short side parts 320 has the extension length (an extension length in the Y-axis direction) gradually decreasing in the downward direction.

[0057] Hereinafter, the length in the Y-axis direction of the short side part 320 is referred to as a width SW of the short side part. When the width of the short side part 320 is described again, the width SW gradually decreases in the downward direction. Thus, each of the first and second short side parts 320 has the lower width SW less than the upper width SW. Thus, the spaced distance between the first and second sides 310 gradually decreases in the downward direction.

[0058] Here, the feature in which each of the first and second short side parts 320 has the width SW gradually decreasing in the downward direction may represent that both side surfaces of the short side part 320, which contact the long side part 310, are inclined surfaces. That is, as illustrated in FIG. 4, each of both side surfaces of each of the first and second short side parts 320 may have an inclined shape so that a spaced distance between a center in the width direction of the short side part 320 and each of the both side surfaces gradually decreases from an upper portion to a lower portion thereof. Thus, each of the first and second short side parts 320 has a length in the Y-axis direction, i.e., the width SW, in the downward direction.

[0059] As described above, as the side surface of the short side part 320 of the mold 300 is inclined, the spaced distance between the long side parts 310 disposed to contact the short side parts gradually decreases in the downward direction to suppress generation of the surface defect and the break out caused by the contraction of the short side solidification cell SC.

[0060] That is, since the extension length of the short side solidification cell SC gradually decreases in the downward direction due to the contraction, the both side surfaces of the short side part 320 are inclined to be gradually close to each other in the downward direction, and the spaced distance between the first and second long side parts 310 gradually decreases in the downward direction. Thus, the mold 300 and the solidification cell C, more particularly, generation of the gap between the both ends of the short side solidification cell SC and the long side part 310 is prevented or suppressed.

[0061] Here, the feature in which the both side surfaces of the short side part 320 are inclined or the spaced distance between the first and second long side parts 310 gradually decreases in the downward direction may represent compensation for the contraction in the short side direction of the solidification cell C. Thus, the generation of the surface defect and the break out caused by the solidification contraction of the short side solidification cell SC is suppressed.

[0062] As described above, the compensation for the contraction in the short side direction of the solidification cell C or the slab may be adjusted by adjusting the inclination so that the spaced distance between the first and second short side parts 320 gradually decreases in the downward direction.

[0063] However, the inclination of each of the both side surfaces of the short side part 320 may be determined when manufactured and may not be varied when coupled with the long side part 310. Also, since the solidification contraction rate is varied depending on the kind of steel and operation conditions, the side surface of the short side part 320 may not have a sufficiently large inclination. This may represent that the inclination of each of the both side surfaces of the short side part 320 is not large enough to sufficiently compensate the solidification contraction rate in the short side direction of the solidification cell C.

[0064] Thus, although the spaced distance between the first and second long side parts 310 gradually decreases in the downward direction as the both side surfaces of the short side part 320 are inclined to be gradually close to each other, a decrease rate of the gradually decreasing spaced distance between the first and second long side parts 310 in the downward direction may not be coincided to or synchronized with the contraction rate of the short side solidification cell SC, and a difference therebetween may be great.

[0065] Thus, although the both side surfaces of the short side part 320 are inclined to be gradually close to each other, the mold 300 may not sufficiently compensate the contraction in the short side direction of the solidification cell C to still generate the gap as illustrated in (b) of FIG. 25.

[0066] Thus, in accordance with an exemplary embodiment, the mold 300 capable of preventing or further suppressing generation of the gap between the inner surface of the mold 300 and the solidification cell C therein is provided. In other words, the mold 300 allowing the inner surface of the mold 300 and the solidification cell C to smoothly contact each other without the generation of the gap or the spaced distance therebetween.

[0067] To this end, in accordance with an exemplary embodiment, as illustrated in FIGS. 2 and 5, the inner surface of the short side part 320 of the mold 300 has a protruding or convex shape toward the inner space of the mold 300, and an upper portion of the inner surface protrudes further than a lower portion thereof.

[0068] Hereinafter, the short side part 320 in accordance with an exemplary embodiment will be described in more detail. First, a shape of the short side part 320 in the width direction, i.e., the Y-axis direction, will be described.

[0069] The short side part 320 has one surface of both surfaces in the X-axis direction, which is exposed to the outside of the mold 300, and the other surface exposed to the inner space of the mold 300 to directly contact the molten steel M or the solidification cell C. The inner surface of the short side part 320 in accordance with an exemplary embodiment may have an upward inclined shape in a direction from both edges in the width direction to the center, i.e., a convex shape of which the inclination has a curvature.

[0070] Hereinafter, for convenience of description, the short side part 320 will be described to include: a short side member 321 extending in the Y-axis direction so that the short side part 320 crosses or is perpendicular to the long side part 310; and a convex member 322 protruding in the direction from the inner surface of the short side member 321 to the inner space of the mold 300 or the X-axis direction and extending in the Y-axis direction that is the extension direction of the short side member 321.

[0071] Also, a length of the convex member 322 in the Y-axis direction is referred to as a width PW of the convex member 322. Also, a protruding length from the short side member 321 to the inner space of the mold 300 of the convex member 322, i.e., a length in the X-axis direction, is referred to as a protruding length A. Also, in the both side surfaces of the convex member 322 in the X-axis direction, one surface contacts or is connected to the short side member 321, and the other surface faces the inner space of the mold 300 to contact the molten steel M or the solidification cell C. The other surface is the inner surface of the convex member 322 or the short side part 320.

[0072] When the convex member 322 extends in the extension direction of the short side member 321, i.e., the width direction (the Y-axis direction), the protruding length A gradually increases from both ends to the center of the extension direction. In the width direction of the convex member 322, a point or an area having the maximum protruding length A may be a central point of the width direction of the convex member 322. Thus, the inner surface of the convex member 322 may have an upward inclined shape from the both ends to the center of the width direction.

[0073] In other words, the convex member 322 may have a shape in which the protruding length A of the convex member 322 gradually decreases from the center to the both ends of the width direction, and the inner surface of the convex member is inclined downward from the center to the both ends of the width direction.

[0074] Thus, the convex member 322 in accordance with an exemplary embodiment may have a convex shape toward the inner space of the mold 300. Also, when the inner surface of the short side part 320 or the convex member 322 has an inclination in the width direction, and the inclination is varied in the Y-axis direction.

[0075] Also, the width PW of the convex member 322 may be less than the width SW of the short side member 321 as illustrated in FIGS. 5 and 7. Here, the center of the convex member 322 in the width direction and the center of the short side member 321 in the width direction may be concentric with each other. Thus, referring to FIG. 7, an outer area of the both ends in the width direction of the convex member 322 may be a flat surface that is the inner surface of the short side member.

[0076] As described above, when the width PW of the convex member 322 is less than the width SW of the short side member 321, and the center of the convex member 322 in the width direction and the center of the short side member 321 in the width direction are concentric with each other, the inner surface of the short side part 320 includes the inner surface of the convex member 322 and the inner surface of the short side member 321 corresponding to an outer side of the inner surface of the convex member 322.

[0077] Hereinafter, a vertical direction of the short side part 320 in accordance with an exemplary embodiment, i.e., the Z-axis direction, will be described.

[0078] The inner surface of the short side part 320 or the convex member 322 in accordance with an exemplary embodiment has the protruding length A that gradually increases from the both ends to the center in the Y-axis direction. Here, in the vertical direction (the Z-axis direction) of the convex member 322 the upper protruding length A is greater than the lower protruding length A as illustrated (a) to (d) of FIG. 5. In other words, the lower protruding length A is shorter than the upper protruding length A of the convex member 322. Here, variation of the protruding length A in the vertical direction may have a shape that continuously decreases from the upper portion to the lower portion without an area having a constant inclination (refer to (c) of FIG. 5). However, the exemplary embodiment is not limited thereto. Although the variation of the protruding length A in the vertical direction (the Z-axis direction) gradually decreases from the upper portion to the lower portion, the variation of the protruding length A in the vertical direction may have a step shape in which the protruding length A is varied in a partial area in the vertical direction and is not varied in the other partial area.

[0079] When the convex member 322 is formed on the inner surface of the short side member 321 to protrude or be convex in an inward direction of the mold 300, and the protruding length A of the convex member 322 has the upper portion greater than the lower portion and gradually decreases in the downward direction, at least a portion of the inner surface of the short side part 320, particularly the length of the upper portion, extends further than that of the related art.

[0080] That is, in the short side part 320 of each of the exemplary embodiment and the related art, the widths SW thereof may be equal to each other. However, in case of the mold 300 in accordance with an exemplary embodiment, the convex member 322 protruding from the short side member 321 to the inner space of the mold 300 is formed and extends downward from the upper portion. Thus, an inner surface extension length SIL of the short side part 320 on which the convex member 322 is formed is greater than an inner surface extension length SIL of the short side part 320 of the related art (refer to FIG. 8). That is, the inner surface extension length SIL of the short side part 320 increases as many as the protruding length A of the convex member 322.

[0081] Here, the inner surface extension length SIL of the short side part 320 represents a length of a path from one end E1 that is one of both ends in the Y-axis direction to the other end E2 or a path from the other end to the one end. The inner surface of the short side part 320 in accordance with an exemplary embodiment has a curved shape having at least one bent portion instead of a straight line shape, and a length of a path from one end to the other end of a curve is greater than that of a path from one end to the other end of a straight line. Thus, since the inner surface extension length of the short side part 320 has a path from the one end E1 to the other end E2, which increases as the protruding length A of the convex member 322 increases, the inner surface extension length SIL of the short side part 320 increases.

[0082] More specifically, when the inner surface extension length SIL of the short side part 320 in accordance with an exemplary embodiment is compared with that of the short side part 320 having an entirely flat inner surface without the convex member 322 of the related art, the inner surface extension length SIL of the upper portion of the inner surface of the short side part 320 in accordance with an exemplary embodiment is greater than that of an upper portion of the inner surface of the short side part 320 of the related art. Also, the inner surface extension length SIL of the lower portion of the inner surface of the short side part 320 in accordance with an exemplary embodiment may be the same as or similar to that of a lower portion of the inner surface of the short side part 320 of the related art. Thus, a difference between the inner surface extension length of the upper area and the inner surface extension length of the lower area of the short side part 320 in accordance with an exemplary embodiment is greater than that of the related art.

[0083] This is because the width SW gradually decreases in the downward direction, and additionally, the inner surface extension length SIL of the short side part directly contacting the molten steel or the solidification cell gradually decreases in the downward direction in the exemplary embodiment while only the width SW of the short side part 320 of the related art gradually decreases in the downward direction. Thus, a decreasing rate in which the inner surface extension length SIL of the short side part 320 of the related art gradually decreases in the downward direction is greater than that in which the inner surface extension length SIL of the short side part 320 in accordance with an exemplary embodiment gradually decreases in the downward direction.

[0084] As described above, the feature of forming the short side part 320 to have the convex member 322 and forming the inner surface extension length SIL of the short side part 320 to gradually decrease in the downward direction is to additionally further compensate the solidification contraction rate of the short side direction of the solidification cell C.

[0085] A variation rate in which the protruding length A of the convex member 322 gradually decreases in the downward direction is adjusted in accordance with variation of the contraction rate of the solidification cell C in the vertical direction. That is, the variation rate is adjusted so that the decreasing rate in which the inner surface extension length SIL of the short side part 320 decreases as the protruding length A of the convex member 322 gradually decreases in the downward direction is equal to, synchronized with, or corresponded to the contraction rate in which the length in the Y-axis direction of the short side solidification cell SC gradually decreases in the downward direction as the short side solidification cell SC is contracted.

[0086] The variation of the protruding length A of the convex member 322 may be obtained through a plurality of experiments according to the kind of steel, a casting speed, or casting equipment.

[0087] In the related art, the contraction rate of the short side direction of the solidification cell C is compensated only through variation of the width SW of the short side part 320. That is, the contraction in the short side direction of the solidification cell C is compensated as the both side surfaces of the short side part 320 is gradually close to each other in the downward direction. However, as described above, the inclination of the side surface of the short side part 320 is determined when the short side part 320 is manufactured, and when the inclination is large, a limitation in operation may occur. Thus, compensation for the contraction in the short side direction of the solidification cell C is limited.

[0088] However, in accordance with an exemplary embodiment, a contraction compensation rate of the short side direction of the solidification cell C may improve further than that of the related art by providing the short side part 320 including the convex member 322 to protrude toward the inner space of the mold 300.

[0089] Thus, the generation of the gap between the short side solidification cell SC and the long side part 310 may be prevented or suppressed more than the related art due to the contraction in the short side direction of the solidification cell C or the contraction of the short side solidification cell SC. Thus, the generation of the surface crack and the break out caused by the contraction of the solidification cell C may be suppressed or prevented.

[0090] Hereinafter, a shape of a convex member in accordance with an exemplary embodiment and a modified example of an exemplary embodiment will be described with reference to FIGS. 5 and 9 to 19.

[0091] (a) of FIG. 9 is a three-dimensional view that is viewed in an inner surface direction in a short side part in accordance with a modified example of an exemplary embodiment. (b) of FIG. 9 is a front view that is viewed in the inner surface direction in the short side part in accordance with the modified example of the exemplary embodiment. (c) of FIG. 9 is a view that is viewed in a side surface direction of the short side part in the short side part in accordance with the modified example of the exemplary embodiment. ⓐ, ⓑ and ⓒ of (d) of FIG 9 are top views at positions ⓐ, ⓑ and ⓒ in the vertical direction (the height direction or the Z-axis direction) of (c) of FIG. 9.

[0092] (a) of FIG. 10 is a three-dimensional view that is viewed in an inner surface direction in a short side part in accordance with another modified example of the exemplary embodiment. (b) of FIG 10 is a front view that is viewed in the inner surface direction in the short side part in accordance with the another modified example of the exemplary embodiment. (c) of FIG. 10 is a view that is viewed in a side surface direction of the short side part in the short side part in accordance with the another modified example of the exemplary embodiment. ⓐ, ⓑ, and ⓒ of (d) of FIG. 10 are top views at positions ⓐ, ⓑ, and ⓒ in the vertical direction (the height direction or the Z-axis direction) of (c) of FIG. 10.

[0093] (a) of FIG. 11 is a three-dimensional view that is viewed in an inner surface direction in a short side part in accordance with another exemplary embodiment. (b) of FIG 11 is a front view that is viewed in the inner surface direction in the short side part in accordance with the another exemplary embodiment. (c) of FIG. 11 is a view that is viewed in a side surface direction of the short side part in the short side part in accordance with the another exemplary embodiment. ⓐ, ⓑ, and ⓒ of (d) of FIG. 11 are top views at positions ⓐ, ⓑ, and ⓒ in the vertical direction (the height direction or the Z-axis direction) of (c) of FIG 11.

[0094] (a) of FIG. 12 is a three-dimensional view that is viewed in an inner surface direction in a short side part in accordance with a modified example of the another exemplary embodiment. (b) of FIG 12 is a front view that is viewed in the inner surface direction in the short side part in accordance with the modified example of the another exemplary embodiment. (c) of FIG. 12 is a view that is viewed in a side surface direction of the short side part in the short side part in accordance with the modified example of the another exemplary embodiment. ⓐ, ⓑ, and ⓒ of (d) of FIG. 12 are top views at positions ⓐ, ⓑ, and ⓒ in the vertical direction (the height direction or the Z-axis direction) of (c) of FIG. 12.

[0095] (a) of FIG. 13 is a three-dimensional view that is viewed in an inner surface direction in a short side part in accordance with another modified example of the another exemplary embodiment. (b) of FIG. 13 is a front view that is viewed in the inner surface direction in the short side part in accordance with the another modified example of the another exemplary embodiment. (c) of FIG. 13 is a view that is viewed in a side surface direction of the short side part in the short side part in accordance with the another modified example of the another exemplary embodiment. ⓐ, ⓑ, and ⓒ of (d) of FIG. 13 are top views at positions ⓐ, ⓑ, and ⓒ in the vertical direction (the height direction or the Z-axis direction) of (c) of FIG. 13.

[0096] The convex member 322 in accordance with exemplary embodiments has a protruding length A that gradually decreases in the downward direction. Also, a vertical extension length H_2 the convex member 322 may be equal to or less than a vertical extension direction H_1 of the short side member 321. Also, a width PW of the convex member 322 may not be varied in the vertical direction or gradually decrease in the downward direction.

[0097] That is, as illustrated in (a) to (c) of FIG. 5, the vertical extension length H_2 of the convex member 322 in accordance with an exemplary embodiment may be shorter than the vertical extension length H_1 of the short side member 321, and a height of the lower end of the convex member 322 may be higher than that of the lower end of the short side member 321. Thus, since an area corresponding to the lower side of the convex member 322 in the inner surface of the short side member 321 is an area on which the convex member is not formed, the inner surface of the short side part 320 contacting the molten steel or the solidification cell has a flat shape.

[0098] Here, the vertical extension length H_2 of the convex member 322 in accordance with the exemplary embodiment may be greater than 0.5 times of and less than 1 times of the vertical extension length H_1 of the short side member 321. More specifically, the vertical extension length H_2 of the convex member 322 may be 0.9 times of the vertical extension length H_1 of the short side member 321 (refer to (a) and (b) of FIG. 5). Also, the convex member 322 has the same upper height as the short side member 321. When a lowermost end of the short side member 321 of the short side part 320 is 0, and an uppermost end thereof is 1, the convex member 322 is formed from a 0.1 point in the vertical direction of the short side member 321, and a flat shape is formed at an area below the 0.1 point instead of the convex member 322.

[0099] However, the exemplary embodiment is not limited to the vertical extension length H_2 of the convex member 322. The vertical extension length H_2 of the convex member 322 may be 0.5 times of the vertical extension length H_1 of the short side member 321 like the modified example of the exemplary embodiment illustrated in (a) to (c) of FIG. 9. In case of the modified example in FIG. 9, the convex member 322 is formed in the upper area from a 0.5 point of the vertical direction of the short side member 321, and a flat shape is formed in the lower area from the 0.5 point.

[0100] However, the exemplary embodiment is not limited thereto. The vertical extension length H_2 of the convex member 322 may be shorter than the vertical extension length H_1 of the short side member 321, more particularly, less than 0.5 times of the vertical extension length H_1 of the short side member 321.

[0101] Also, the vertical extension length H_2 of the convex member 322 may be equal to the vertical extension length H_1 of the short side member 321 like the another modified example illustrated in FIG. 10. That is, the convex member 322 may be formed over the entire short side member 321 from the upper portion to the lower portion thereof.

[0102] The convex member 322 in accordance with the exemplary embodiments has the constant width PW. That is, positions of the both ends (one end and the other end) in the width direction of the convex member 322 may be equal to each other in accordance with the height thereof.

[0103] Hereinafter, a line connecting one end of the convex member 322 continuously formed in the height direction of the convex member 322 and the other end of the convex member 322 continuously formed in the height direction of the convex member 322 is defined as a 'boundary line DL'. In other words, the boundary line DL may represent a line at which the inner surface of the short side member 321 meets an outermost side of the convex member 322. The convex member 322 in accordance with the exemplary embodiments may have the boundary line DL that is a straight line without a curvature. This may represent that the width decreases with a constant rate when the width PW of the convex member 322 gradually decreases in the downward direction. Also, the entire shape of the convex member 322 formed on the inner surface of the short side member 321 may have a rectangular shape having no variation in width or area (refer to FIGS. 5 to 10).

[0104] As described in the above-described exemplary embodiment and modified examples thereof, each of the variation rate of the protruding length A of the convex member 322 in the vertical direction and the vertical extension length H_2 of the convex member 322 is adjusted to be equal to, synchronized with, or corresponded to the contraction rate in the Y-axis direction, which gradually varied less in the downward direction as the short side solidification cell SC is contracted.

[0105] In the above-described exemplary embodiment and modified examples thereof, the protruding length A of the convex member 322 gradually decreases in the downward direction, but the width PW thereof is constant in the vertical direction instead of being varied.

[0106] However, the exemplary embodiment is not limited thereto. The width PW of the convex member 322 may gradually decreases in the downward direction like the another embodiment illustrated in FIGS. 11 to 13. That is, the protruding length A of the convex member 322 in accordance with the another embodiment gradually decreases in the downward direction and the width PW thereof also gradually decreases in the downward direction.

[0107] Here, the vertical extension length H_2 of the convex member 322 may be less than the vertical extension length H_1 of the short side member 321 like the another exemplary embodiment and the modified example thereof illustrated in FIGS. 11 and 12. Thus, the area on which the convex member 322 is not formed in the inner surface of the short side member 321, i.e., the lower area of the short side member 321, may have a flat shape.

[0108] Also, the vertical extension length H_2 of the convex member 322 may be equal to the vertical extension length H_1 of the short side member 321 like the another modified example illustrated in FIG. 13. Thus, the convex member 322 in accordance with the another modified example of the another exemplary embodiment may be formed over the entire short side member 321 from the upper portion to the lower portion thereof.

[0109] Also, the convex member 322 in accordance with the another exemplary embodiments has the constant width PW that gradually decreases in the downward direction. Thus, in the width direction of the convex member 322, positions of the both ends are gradually close to the center of the short side member 321 in the downward direction.

[0110] That is, the positions of the both ends (one end and the other end) in the width direction may be different from each other in accordance with the height thereof. Thus, when a line connecting one end of the convex member 322 continuously formed in the height direction of the convex member 322 and the other end of the convex member 322 continuously formed in the height direction of the convex member 322 is defined as a 'boundary line DL', a shape formed by the boundary line DL may be a reverse triangular shape (refer to FIGS. 11 to 13) or a reverse trapezoidal shape (refer to (c) of FIG. 11).

Also, the convex member 322 in accordance with the another exemplary embodiment may have the boundary lien that is a straight line without a curvature. Also, the entire shape of the convex member 322 may have a reverse triangular shape or a reverse trapezoidal shape having a width or an area that gradually decreases in the downward direction.

[0111] Here, each of the vertical extension length of the convex member 322 and the variation rate of the protruding length of the convex member 322 in the vertical direction is adjusted to be equal to, synchronized with, or corresponded to the contraction rate in which the length in the Y-axis direction of the short side solidification cell SC gradually decreases less in the downward direction as the short side solidification cell SC is contracted.

[0112] (a) of FIG. 14 is a three-dimensional view that is viewed in an inner surface direction in a short side part in accordance with yet another exemplary embodiment. (b) of FIG. 14 is a front view that is viewed in the inner surface direction in the short side part in accordance with the yet another exemplary embodiment. (c) of FIG. 14 is a view that is viewed in a side surface direction of the short side part in the short side part in accordance with the yet another exemplary embodiment. ⓐ, ⓑ, and ⓒ of (d) of FIG. 14 are top views at positions ⓐ, ⓑ, and ⓒ in the vertical direction (the height direction or the Z-axis direction) of (c) of FIG. 14.

[0113] (a) of FIG. 15 is a three-dimensional view that is viewed in an inner surface direction in a short side part in accordance with a modified example of the yet another exemplary embodiment. (b) of FIG. 15 is a front view that is viewed in the inner surface direction in the short side part in accordance with the modified example of the yet another exemplary embodiment. (c) of FIG. 15 is a view that is viewed in a side surface direction of the short side part in the short side part in accordance with the modified example of the yet another exemplary embodiment. ⓐ, ⓑ, and ⓒ of (d) of FIG. 15 are top views at positions ⓐ, ⓑ, and ⓒ in the vertical direction (the height direction or the Z-axis direction) of (c) of FIG 15.

[0114] (a) of FIG. 16 is a three-dimensional view that is viewed in an inner surface direction in a short side part in accordance with another modified example of the yet another exemplary embodiment. (b) of FIG. 16 is a front view that is viewed in the inner surface direction in the short side part in accordance with the another modified example of the yet another exemplary embodiment. (c) of FIG. 16 is a view that is viewed in a side surface direction of the short side part in the short side part in accordance with the another modified example of the yet another exemplary embodiment. ⓐ, ⓑ, and ⓒ of (d) of FIG. 16 are top views at positions ⓐ, ⓑ and ⓒ in the vertical direction (the height direction or the Z-axis direction) of (c) of FIG 16.

[0115] In the above-described convex member 322 in accordance with the another exemplary embodiment, the boundary line LD connecting one end of the convex member 322 continuously formed in the height direction of the convex member 322 and the other end of the convex member 322 continuously formed in the height direction of the convex member 322 is the straight line without a curvature.

[0116] However, the another exemplary embodiment is not limited thereto. For example, the boundary line may have a curvature like the yet another embodiment illustrated in FIGS. 14 to 16. Here, the boundary line DL of the convex member 322 in accordance with the yet another embodiment may have a shape protruding to the outside of the convex member 322 or a shape having a positive curvature. In other words, the width PW of the convex member 322 gradually decreases in the downward direction, and the decreasing rate is not constant.

[0117] Here, in case of the yet another exemplary embodiment and the modified example of the yet another exemplary embodiment illustrated in FIGS. 14 and 15, the vertical extension length H_2 of the convex member 322 is less than the vertical extension length H_1 of the short side member 321. Also, in case of the another modified example of the yet another exemplary embodiment in FIG. 16, the vertical extension length H_2 of the convex member 322 is equal to the vertical extension length H_1 of the short side member 321.

[0118] Also, the boundary line DL of the convex member 322 in accordance with the yet another embodiment may have an approximately triangular shape that protrudes to the outside of the convex member 322 or has a positive curvature.

[0119] (a) of FIG. 17 is a three-dimensional view that is viewed in an inner surface direction in a short side part in accordance with still another exemplary embodiment. (b) of FIG 17 is a front view that is viewed in the inner surface direction in the short side part in accordance with the still another exemplary embodiment. (c) of FIG 17 is a view that is viewed in a side surface direction of the short side part in the short side part in accordance with the still another exemplary embodiment. ⓐ, ⓑ, and ⓒ of (d) of FIG. 17 are top views at positions ⓐ, ⓑ and ⓒ in the vertical direction (the height direction or the Z-axis direction) of (c) of FIG. 17.

[0120] (a) of FIG. 18 is a three-dimensional view that is viewed in an inner surface direction in a short side part in accordance with a modified example of the still another exemplary embodiment. (b) of FIG. 18 is a front view that is viewed in the inner surface direction in the short side part in accordance with the modified example of the still another exemplary embodiment. (c) of FIG. 18 is a view that is viewed in a side surface direction of the short side part in the short side part in accordance with the modified example of the still another exemplary embodiment. ⓐ, ⓑ, and ⓒ of (d) of FIG 18 are top views at positions ⓐ, ⓑ, and ⓒ in the vertical direction (the height direction or the Z-axis direction) of (c) of FIG 18.

[0121] (a) of FIG. 19 is a three-dimensional view that is viewed in an inner surface direction in a short side part in accordance with another modified example of the still another exemplary embodiment. (b) of FIG. 19 is a front view that is viewed in the inner surface direction in the short side part in accordance with the another modified example of the still another exemplary embodiment. (c) of FIG. 19 is a view that is viewed in a side surface direction of the short side part in the short side part in accordance with the another modified example of the still another exemplary embodiment. ⓐ, ⓑ, and ⓒ of (d) of FIG. 19 are top views at positions ⓐ, ⓑ and ⓒ in the vertical direction (the height direction or the Z-axis direction) of (c) of FIG 19.

[0122] In the above-described convex member 322 in accordance with the yet another exemplary embodiment, the boundary line connecting one end of the convex member 322 continuously formed in the height direction of the convex member 322 and the other end of the convex member 322 continuously formed in the height direction of the convex member 322 has a shape protruding to the outside of the convex member 322 or a shape having a positive curvature. However, the yet another exemplary embodiment is not limited thereto. For example, the boundary line DL of the convex member may have a shape concave inward the convex member 322 or a shape having a negative curvature like the still another exemplary embodiment illustrated in FIGS. 17 to 19.

[0123] Here, in case of the still another exemplary embodiment and the modified example of the still another exemplary embodiment illustrated in FIGS. 17 and 18, the vertical extension length H_2 of the convex member 322 is less than the vertical extension length H_1 of the short side member 321. Also, in case of the another modified example of the still another exemplary embodiment in FIG. 19, the vertical extension length H_2 of the convex member 322 is equal to the vertical extension length H_1 of the short side member 321.

[0124] The convex member 322 in accordance with the exemplary embodiment to the still another exemplary embodiment has the width PW less than that of the short side member 321.

[0125] However, the exemplary embodiments are not limited thereto. For example, the width PW of the convex member 322 may correspond to or be equal to the width SW of the short side member 321 like a yet still another exemplary embodiment in FIG. 20.

[0126] In this case, the width PW of the convex member 322 in the vertical direction is not the same as the above-described exemplary embodiment and varied along the variation of the width SW of the short side member 321. That is, the width PW of the convex member 322 may decrease to be equal to or synchronized with the variation rate of the width SW of the short side member 321 gradually decreasing in the downward direction.

[0127] However, since the protruding length A of the convex member 322 gradually decreases in the downward direction, the inner surface extension length SIL of the short side part 320 gradually decreases in the downward direction.

[0128] FIG 21 is a three-dimensional view illustrating a mold having a convex member disposed on each of a long side part and a short side part in accordance with a still even yet another exemplary embodiment. FIG 22 is a three-dimensional view illustrating a mold having chamfered corners in accordance with a still even further exemplary embodiment. FIG. 23 is a three-dimensional view illustrating a short side part of the mold in accordance with a still even further exemplary embodiment.

[0129] As described above, the short side part 320 of the mold is configured to include the convex member 322. That is, the inner surface of the short side part 320 has the shape protruding or convex to the inside of the mold 300.

[0130] However, the exemplary embodiment is not limited thereto. For example, the long side part 310 of the mold 300 may include a convex member 312. That is, as illustrated in the still even yet another exemplary embodiment in FIG. 21, the long side part 310 includes a long side member 311 extending in the X-axis direction to cross or be perpendicular to the short side part 320 and a convex member 312 protruding in the Y-axis direction or the inner space direction of the mold 300 from the inner surface of the long side member 311 and extending in the X-axis direction that is an extension direction of the long side member 311.

[0131] Also, features of the exemplary embodiment to the yet still another exemplary embodiment described in FIGS. 5, and 9 to 20 may be applied to the convex member 312 of the long side part 310.

[0132] Although each of the long side part 310 and the short side part 320 includes the convex member 312 and 322 in the still even yet another exemplary embodiment, the still even yet another exemplary embodiment is not limited thereto. For example, only the long side part 310 may include the convex member 312 (not shown).

[0133] As described above, the feature in which the inner surface of the short side part 320 protrudes or is convex to the inner space of the mold 300 may be applied to the chamfered mold as in the still even further exemplary embodiment in FIG. 22.

[0134] Hereinafter, when the mold 300 in accordance with the still even further exemplary embodiment is described, features overlapped with the above-described exemplary embodiment will be omitted or simply described.

[0135] The mold 300 in accordance with the still even further exemplary embodiment includes: one pair of long side parts 310 each extending in one direction and spaced apart from each other in a direction crossing or perpendicular to an extension direction thereof; and one pair of short side parts 320 extending in a direction crossing or perpendicular to the long side parts, respectively, and spaced apart from each other in a direction crossing or perpendicular to the extension direction thereof.

[0136] The short side part 320 includes a protruding member 323 protruding to the inside of the mold 300. That is, the short side part 320 in accordance with the still even further exemplary embodiment includes: a short side member 321 extending in the Y-axis direction; one pair of protruding members 323 each extending in a direction from an inner surface of each of both edges in the Y-axis direction of the short side member 321 to the inner space of the mold 300; and a convex member 322 protruding in the X-axis direction or a direction from an inner surface of the short side member 321 to the inner space of the mold 300 between the one pair of protruding members 323.

[0137] The protruding member 323 may provide a chamfered shape to the mold 300 and be referred to as a chamfered protruding member 323.

[0138] Here, the features of the exemplary embodiment to the yet still another exemplary embodiment described in FIGS. 5, and 9 to 20 may be applied to the convex member 322 of the short side part 320.

[0139] Also, in the chamfered mold, the convex member 322 may be additionally provided to the long side part 310 or provided only to the long side part 310.

[0140] In the above-described exemplary embodiments, it is described that the mold 300 has the approximately rectangular shape in which the long side part 310 and the short side part 320 have different lengths from each other. For example, the exemplary embodiments are not limited thereto. For example, the mold 300 may have a square shape.

[0141] In the above-described exemplary embodiments, it is described that the short side part 320 includes the short side member 321 and the convex member 322, which are separated, or the long side part 310 includes a long side member 311 and the convex member 312, which are separated. However, the short side member 321 and the convex member 322 may be integrated with each other, and the long side member 311 and the convex member 312 may be integrated with each other.

[0142] As described above, the mold 300 in accordance with the exemplary embodiments may suppress or prevent the surface defect and the break out caused by the contraction of the solidification cell C in comparison with the related art. That is, the mold 300 in accordance with the exemplary embodiments may have the improved compensation rate with respect to the contraction of the solidification cell C in comparison with the related art. Particularly, the mold 300 in accordance with the exemplary embodiments has the improved compensation rate with respect to the contraction in the short side direction of the solidification cell C in comparison with the related art. Thus, the generation of the gap between the inner surface of the mold 300 and the solidification cell C may be suppressed or prevented to thereby suppress or prevent the solidification retarded phenomenon.

[0143] Also, although the inclination of the side surface of the short side part 320 is not further increased, the contraction compensation rate in the short side direction of the solidification cell C may improve.

[0144] In the related art, an installation inclination of the short side part 320 is further increased to improve the contraction compensation rate in the short side direction of the solidification cell C. Here, wear between the short side part 320 of the mold and a short side of the slab may be generated to reduce a lifespan of the mold 300 and degrade a quality of the slab.

[0145] However, in the exemplary embodiments, although the installation inclination of the short side part 320 is not further increased, the contraction compensation rate in the short side direction of the solidification cell C may improve to suppress or prevent damage on the mold 300 caused by the wear.

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[0146] The mold in accordance with the exemplary embodiments may suppress or prevent the surface defect and the break out caused by the contraction of the solidification cell in comparison with the related art. That is, the mold in accordance with the exemplary embodiments may have the improved compensation rate with respect to the contraction of the solidification cell in comparison with the related art. Particularly, the mold in accordance with the exemplary embodiments may have the improved compensation rate with respect to the contraction in the short side of the solidification cell in comparison with the related art. Thus, the generation of the gap between the inner surface of the mold and the solidification cell may be suppressed or prevented to thereby suppress or prevent the solidification retarded phenomenon.

Claims

1. A mold that solidifies molten steel injected to an inner space thereof, comprising:

   a body having the inner space; and
   a convex member that protrudes in a direction from an inner surface of the body to the inner space and has a protruding length gradually decreasing in a direction from the inner surface to the inner space.

2. The mold of claim 1, wherein the convex member has the same width in a vertical direction.

3. The mold of claim 1, wherein the convex member has a width that gradually decreases in a downward direction.

4. The mold of claim 1, wherein the convex member has a width less than that of the body.

5. The mold of claim 1, wherein the convex member has the same width as that of the body.

6. The mold of claim 3, wherein the width of the convex member gradually decreases in the downward direction with a constant rate.

7. The mold of claim 6, wherein a boundary line between the inner surface of the body and the convex member is a straight line.

8. The mold of claim 3, wherein the width of the convex member gradually decreases in the downward direction with an inconstant rate.

9. The mold of claim 8, wherein a boundary line between the inner surface of the body and the convex member is a curve.

10. The mold of claim 9, wherein the boundary line has a convex shape in an outside direction of the convex member.

11. The mold of claim 9, wherein the boundary line has a concave shape in an inside direction of the convex member.

12. The mold of claim 1, wherein an upper portion of the convex member and an upper portion of the body are positioned at the same height, and
the convex member has a vertical extension length less than that of the body.

13. The mold of claim 1, wherein an upper portion of the convex member and an upper portion of the body are positioned at the same height, and
the convex member has a vertical extension length equal to that of the body.

14. The mold of any one of claims 1 to 13, wherein the body comprises:

    one pair of long side members each extending in one direction and installed to face each other in a direction crossing the extended direction; and
    one pair of short side members extending to cross the long side members, respectively, and installed to face each other, thereby sealing a portion between the one pair of long side members.

15. The mold of claim 14, wherein the one pair of short side members are inclined so that a spaced distance between the one pair of short side members gradually decreases in the downward direction.

16. The mold of claim 14, wherein a side surface of the short side member, which contacts the long side member, is gradually inclined to a center in a width direction of the short side member in the downward direction.

17. The mold of claim 14, wherein the body comprises a protruding member formed at each of both side ends in an extension direction of the short side member to form a chamfered surface at an edge of the casted slab.

FIG. 1

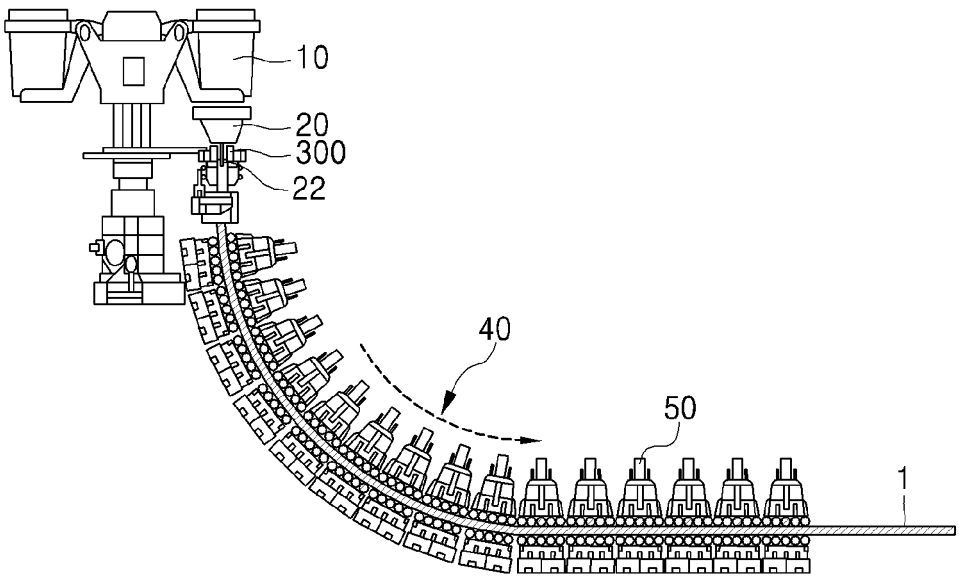

FIG. 2

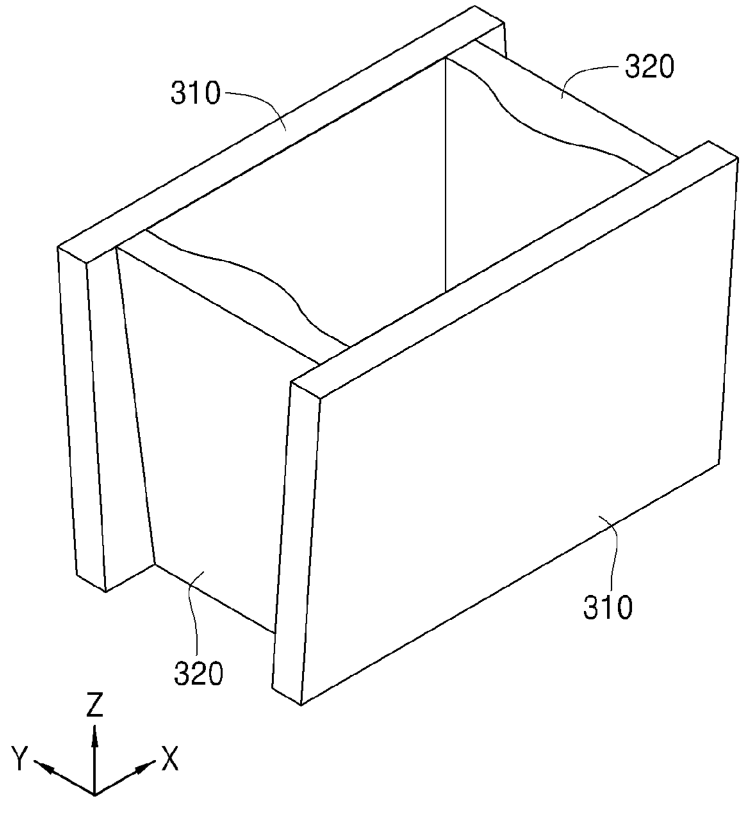

FIG. 3

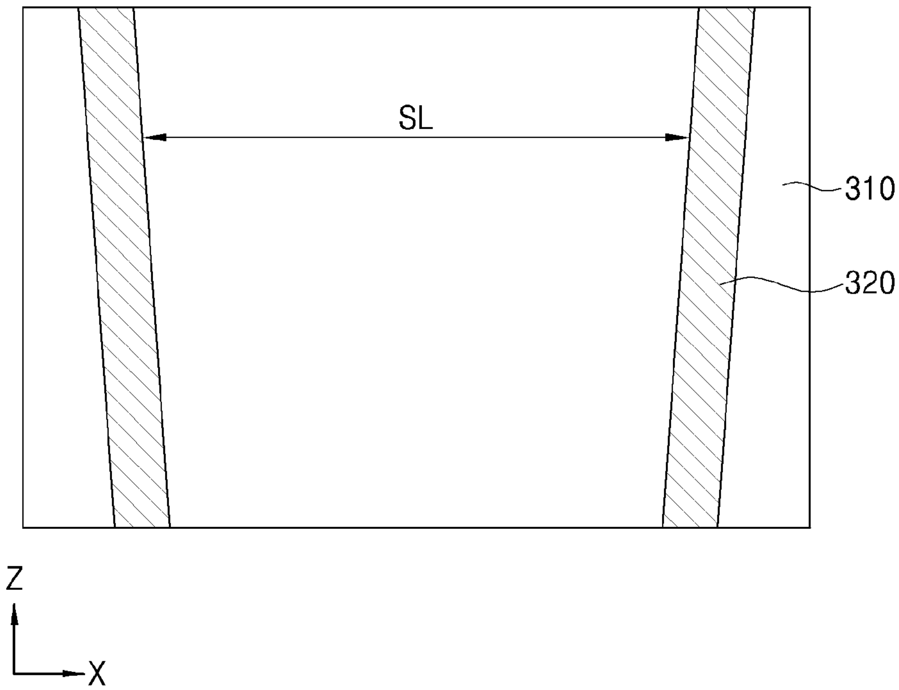

FIG. 4

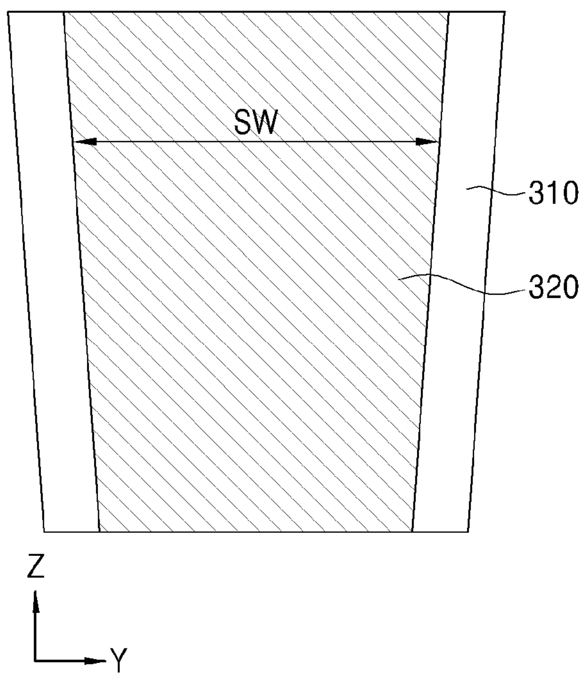

FIG. 5

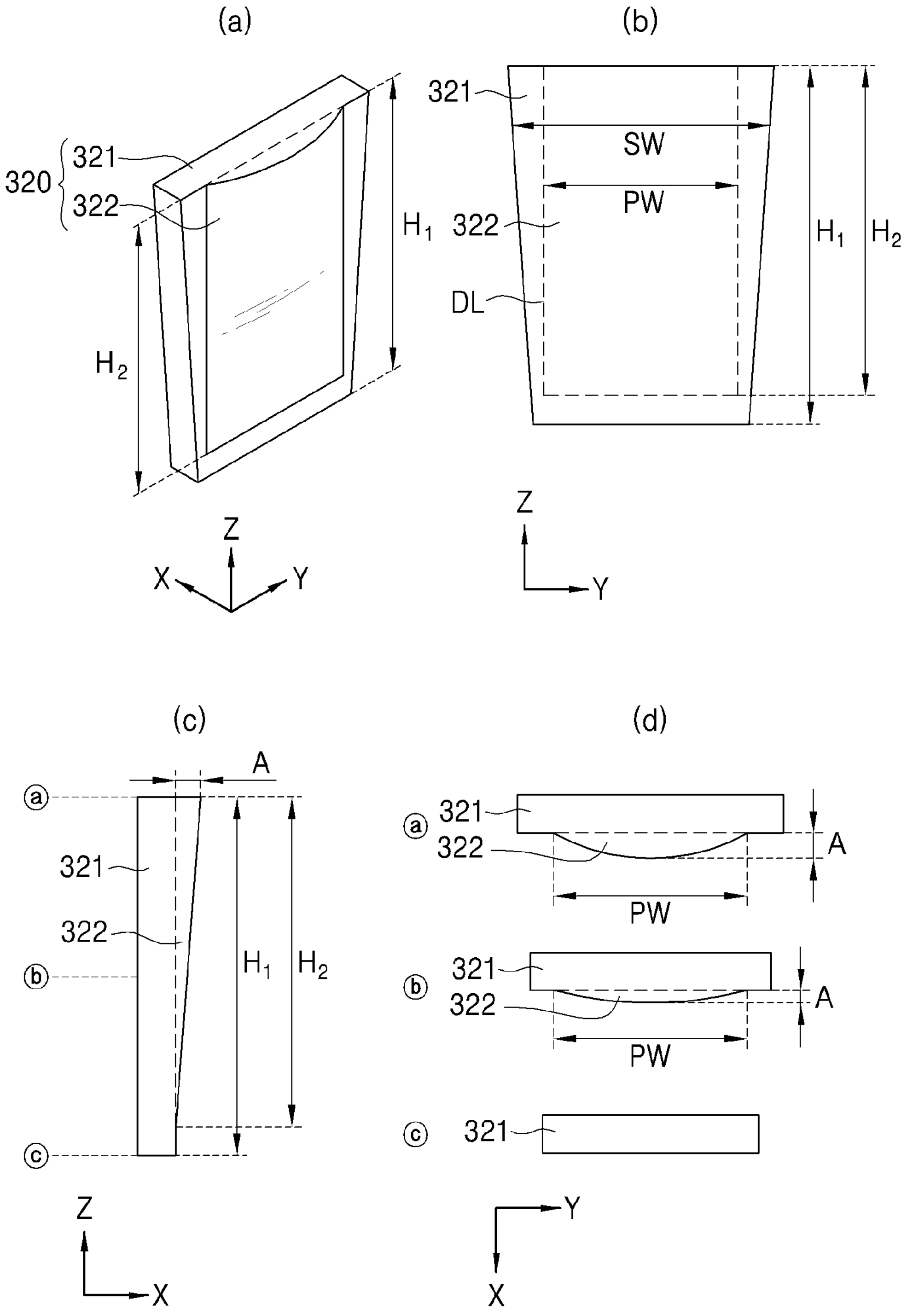

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FIG. 6

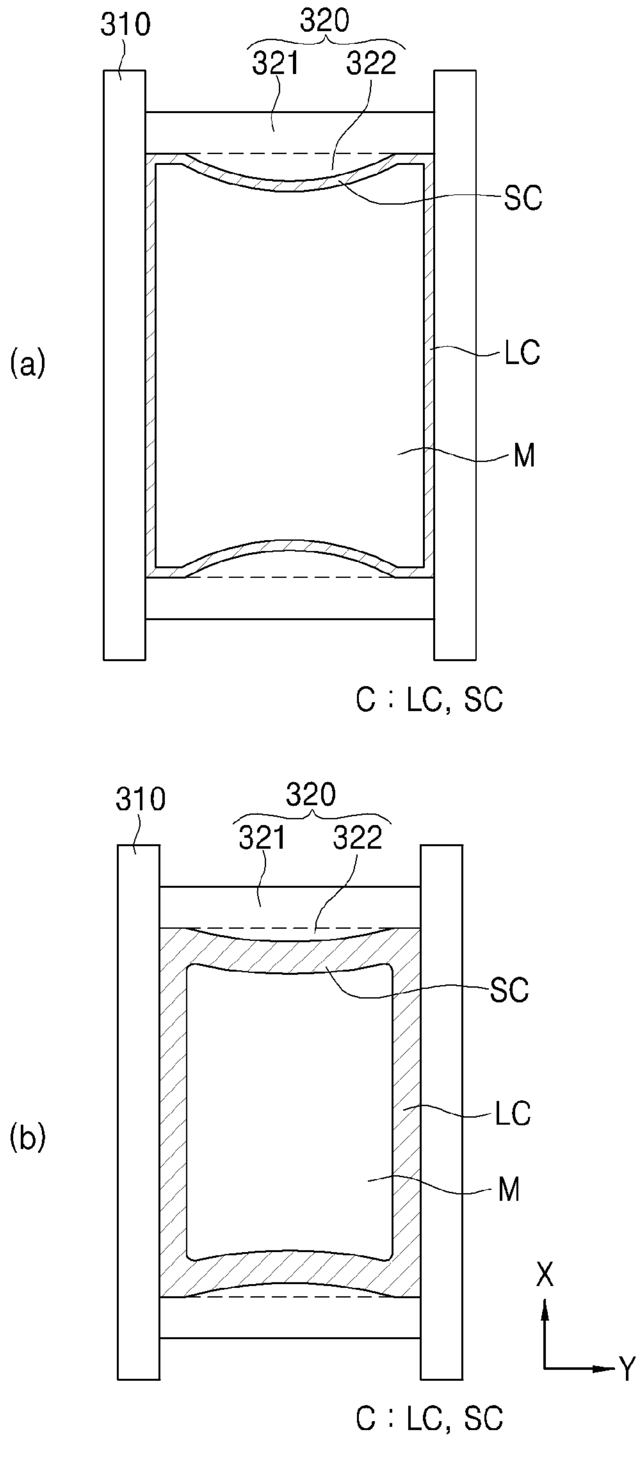

FIG. 7

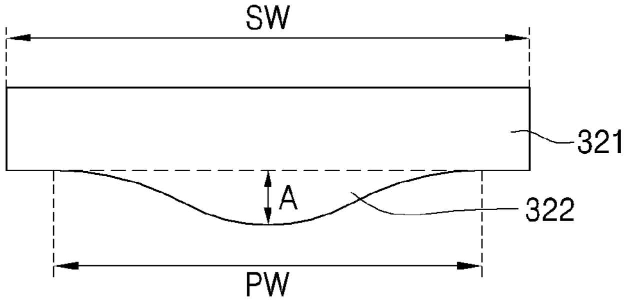

FIG. 8

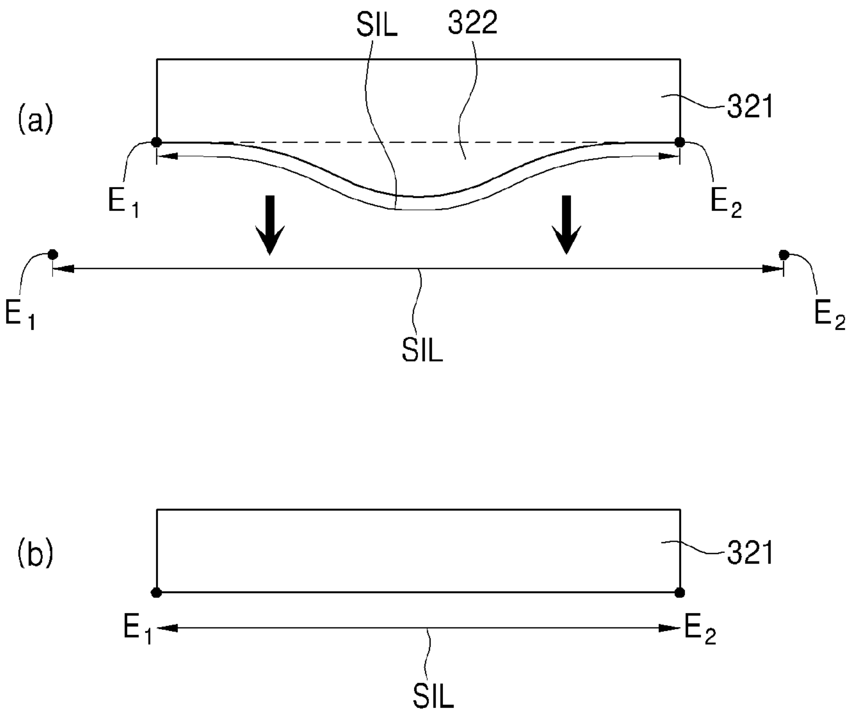

FIG. 9

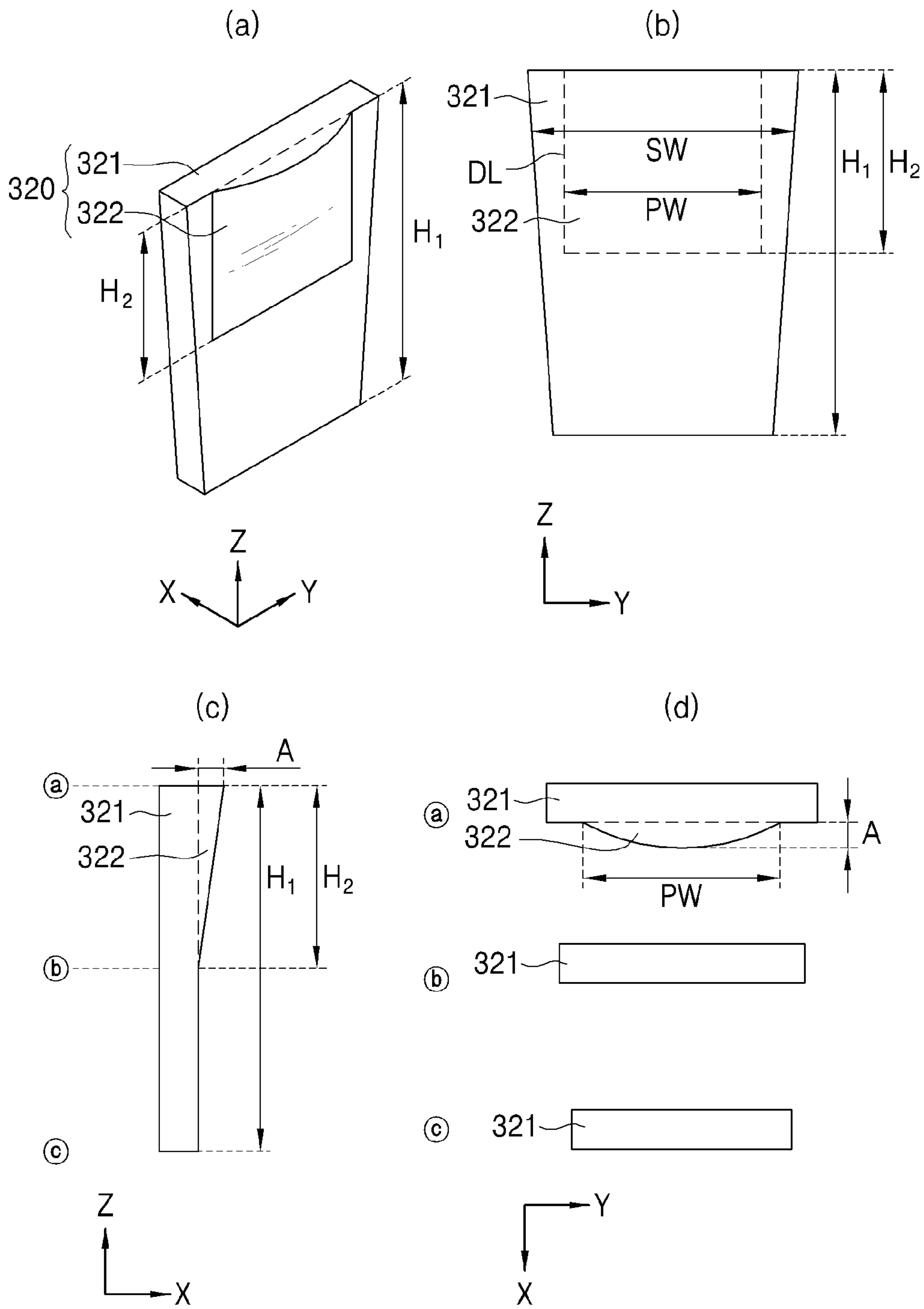
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FIG. 10

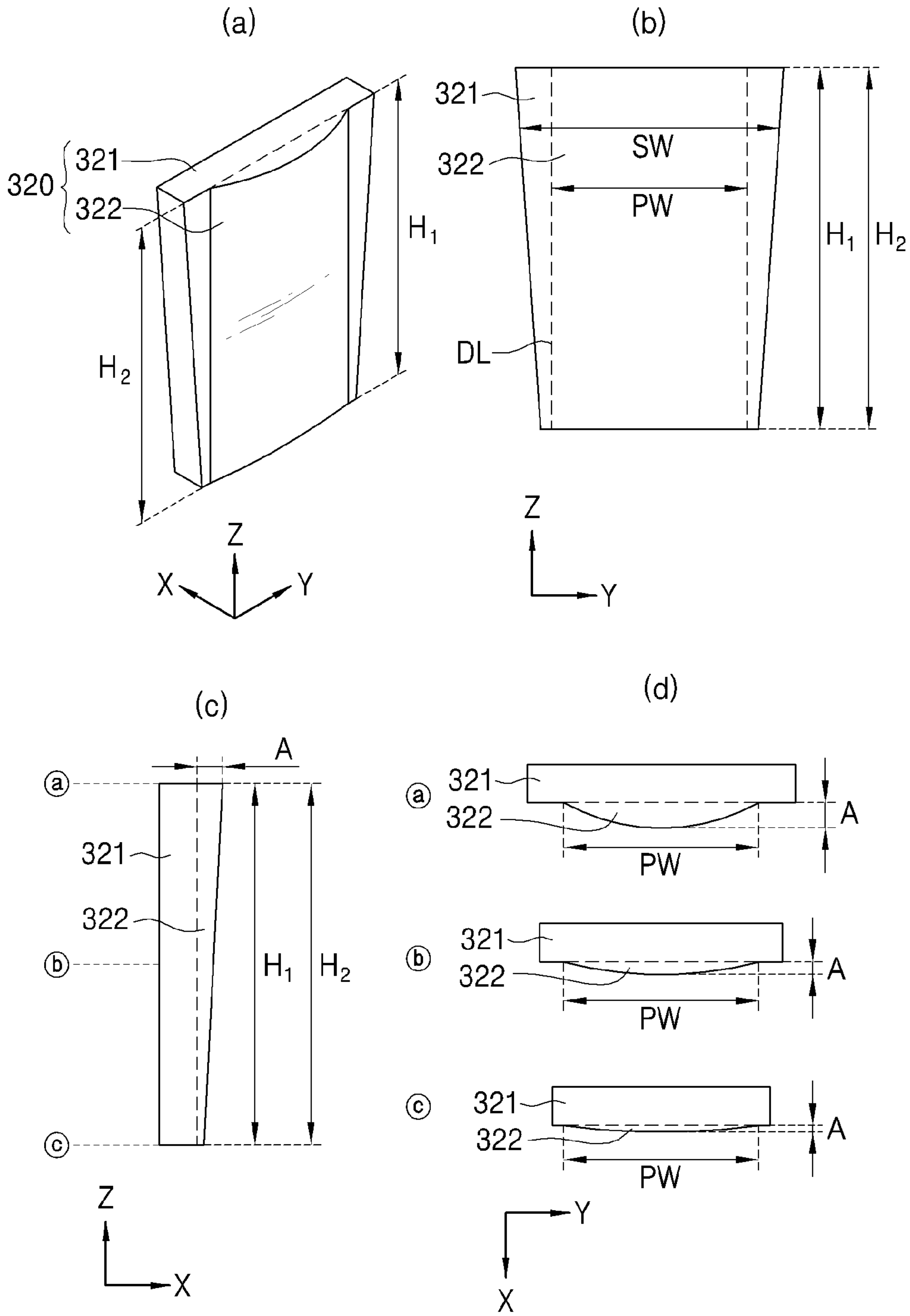
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FIG. 11

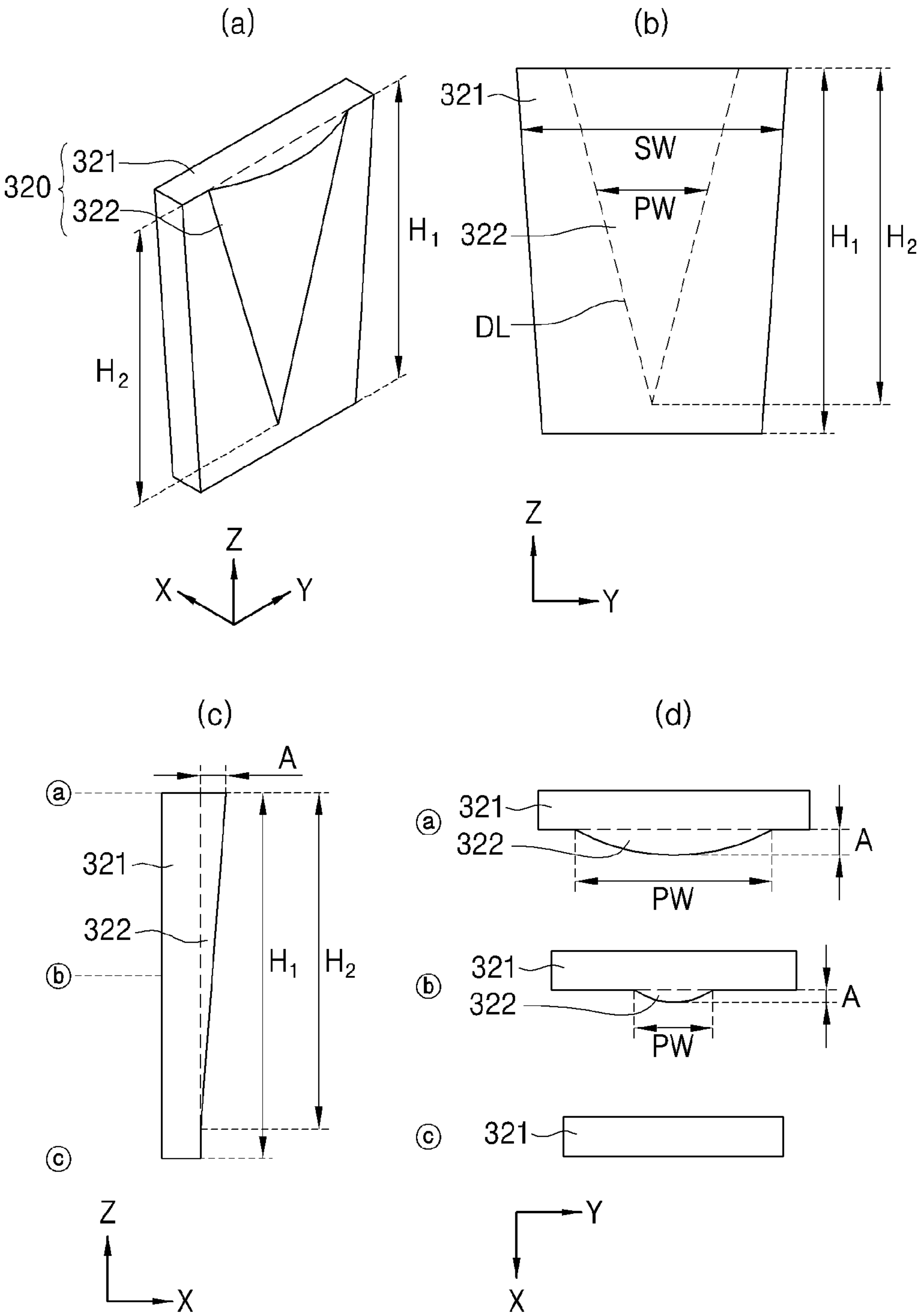

FIG. 12

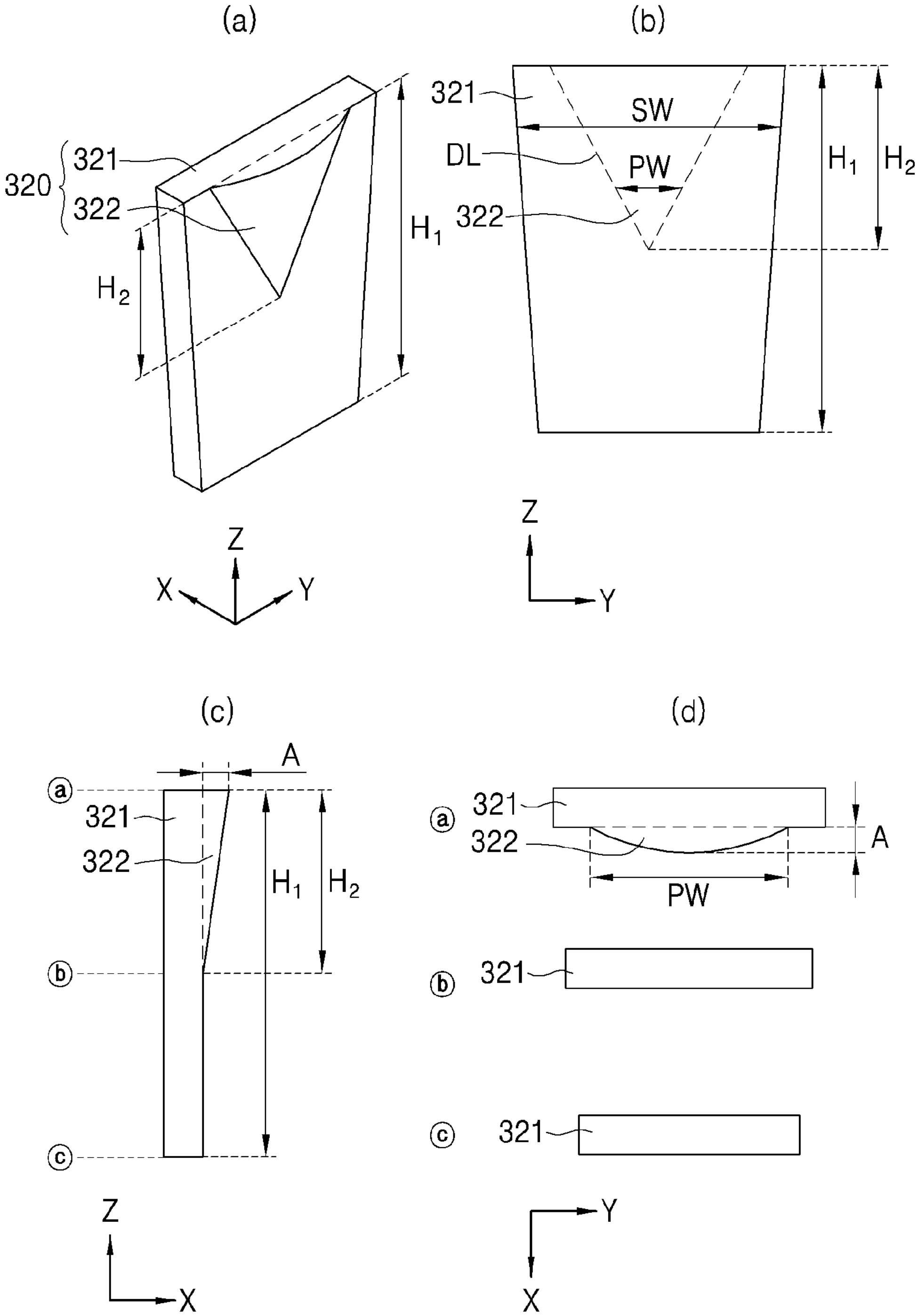
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FIG. 13

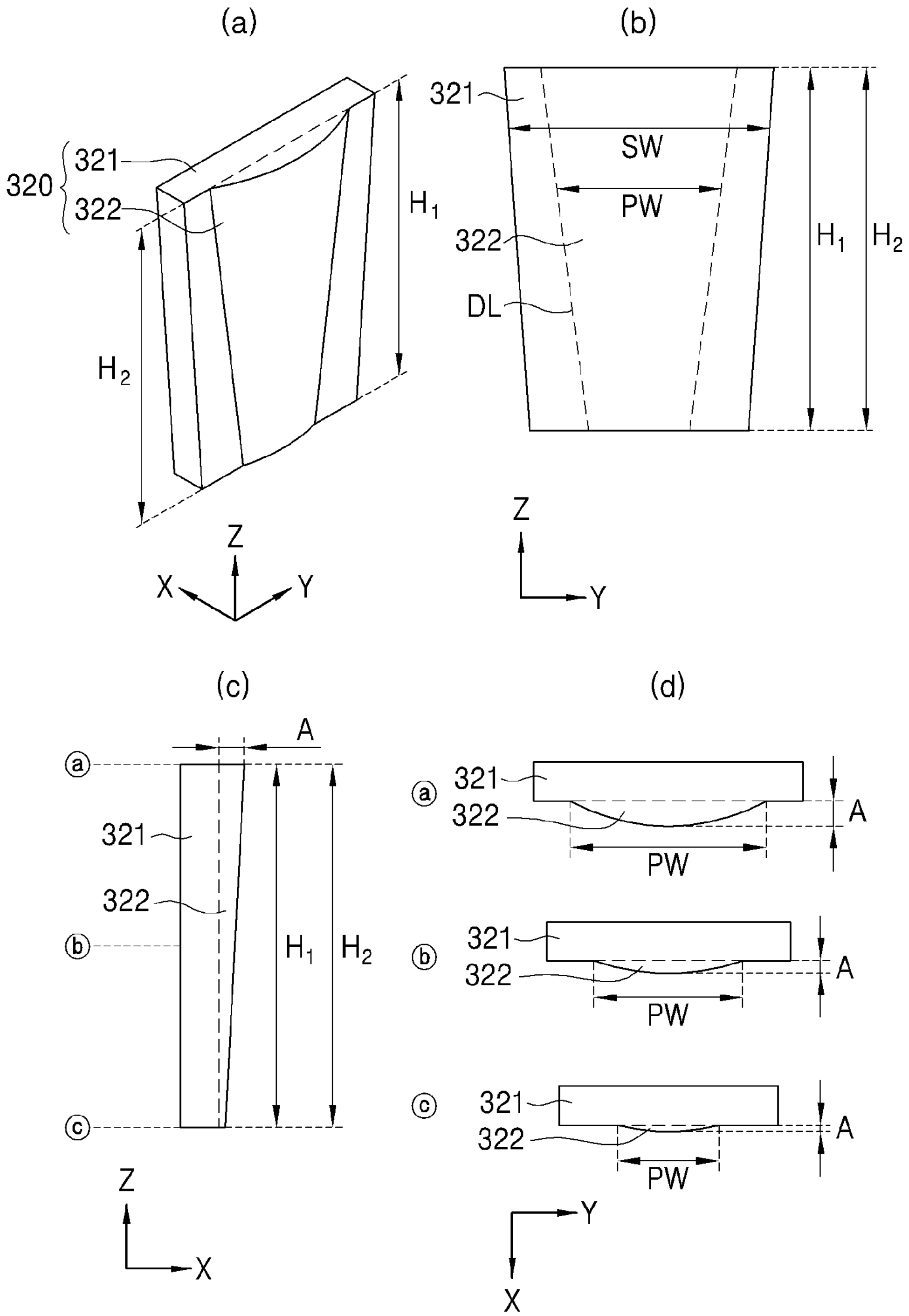

FIG. 14

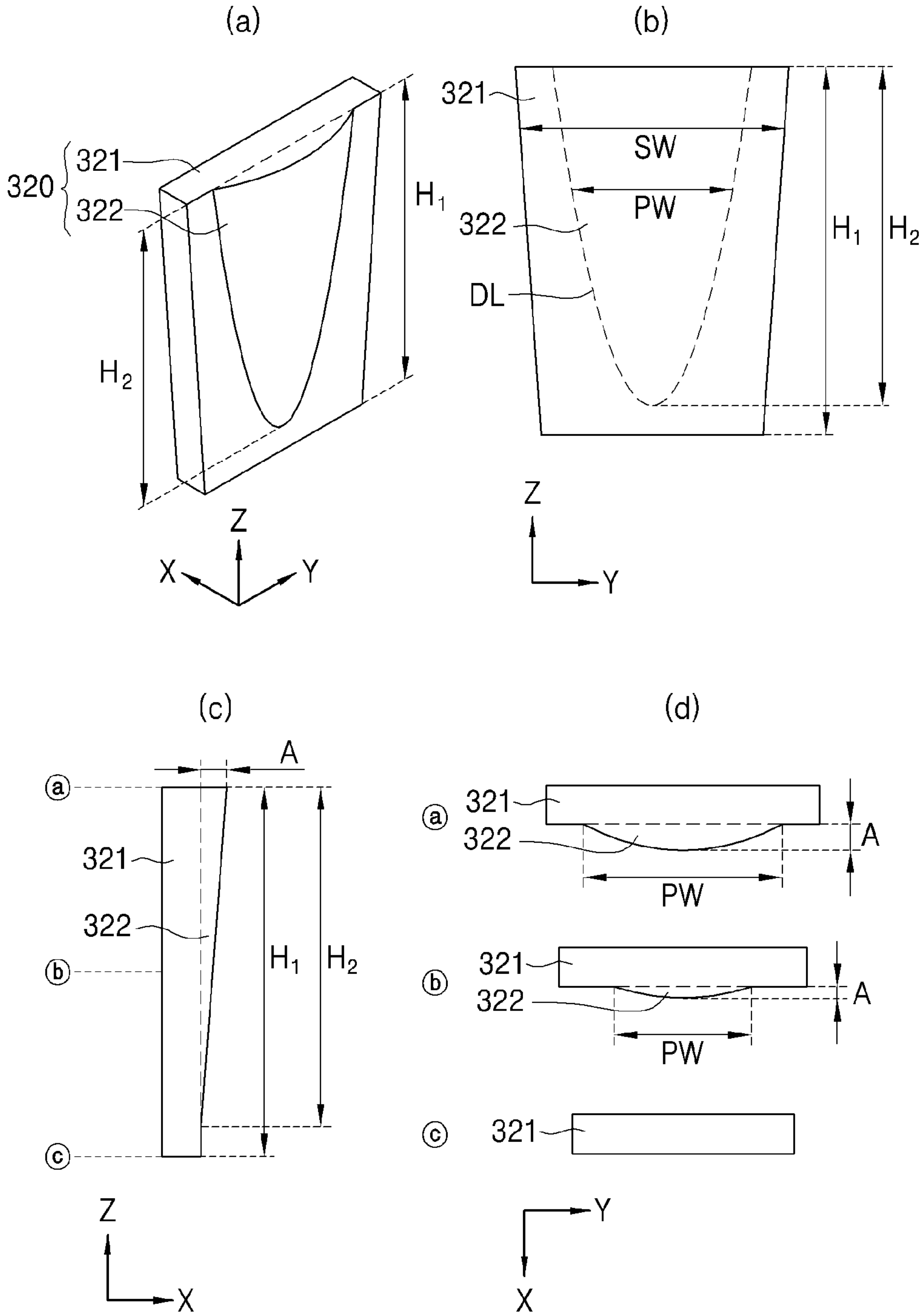
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FIG. 15

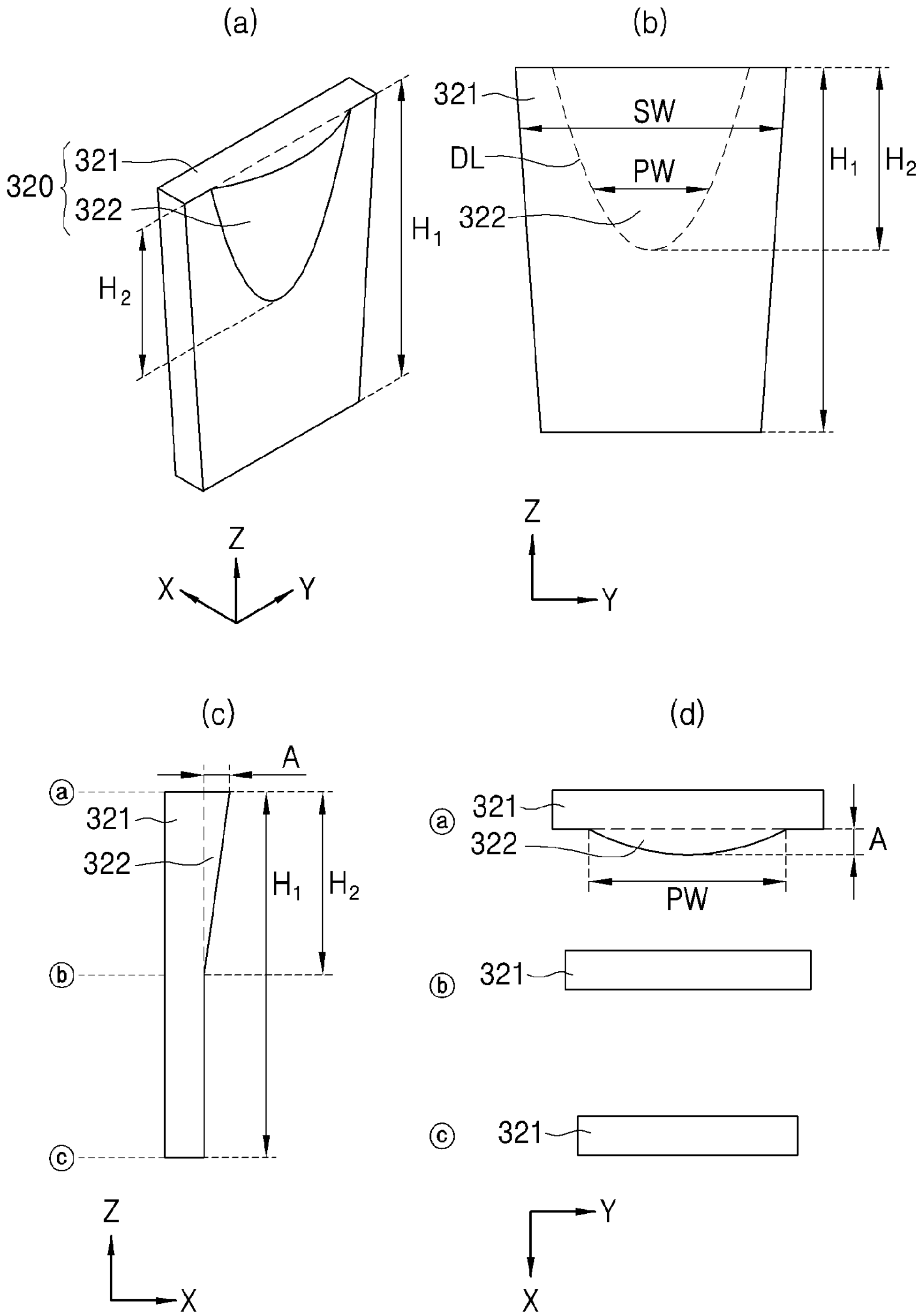
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FIG. 16

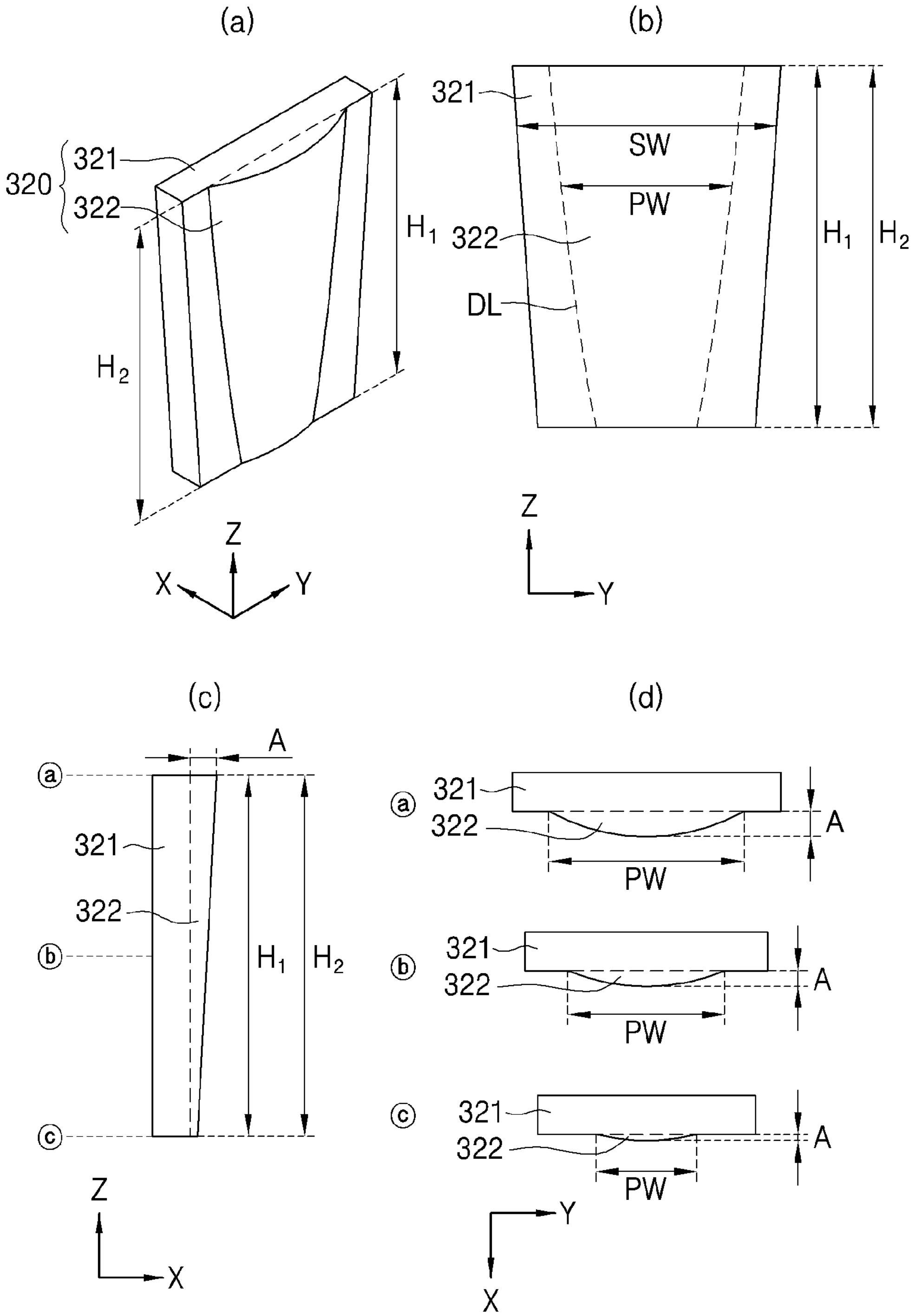
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FIG. 17

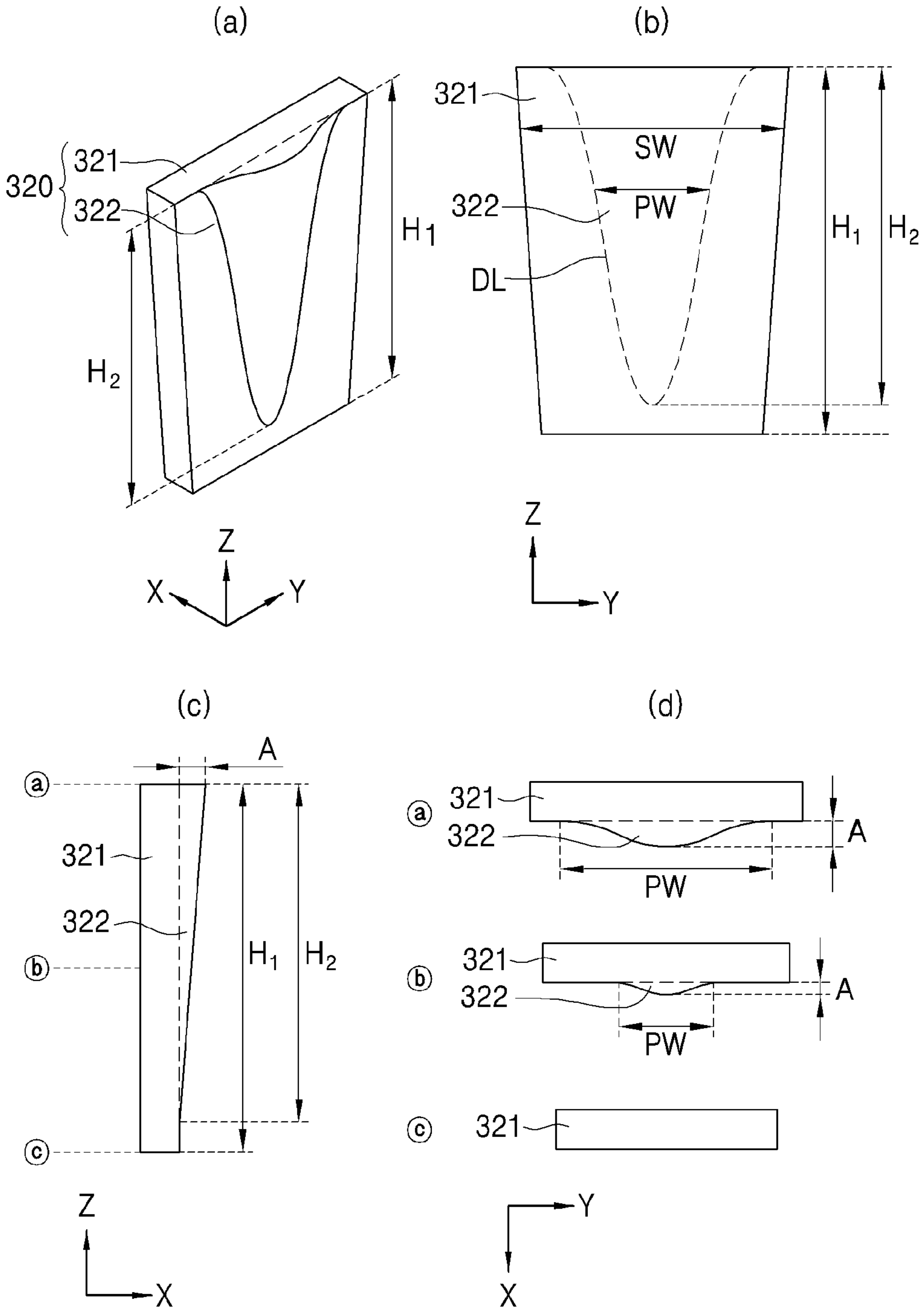
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FIG. 18

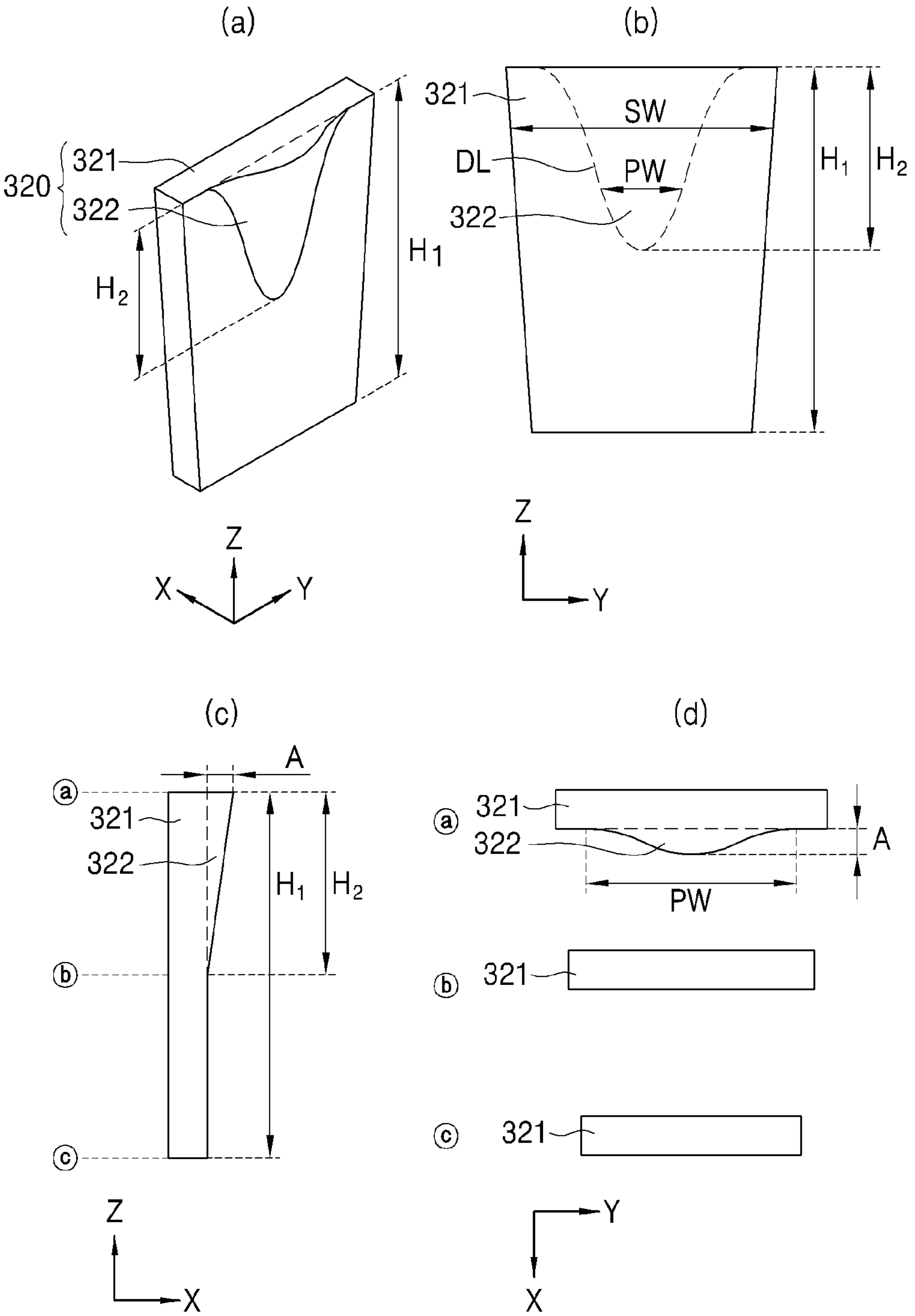


FIG. 19

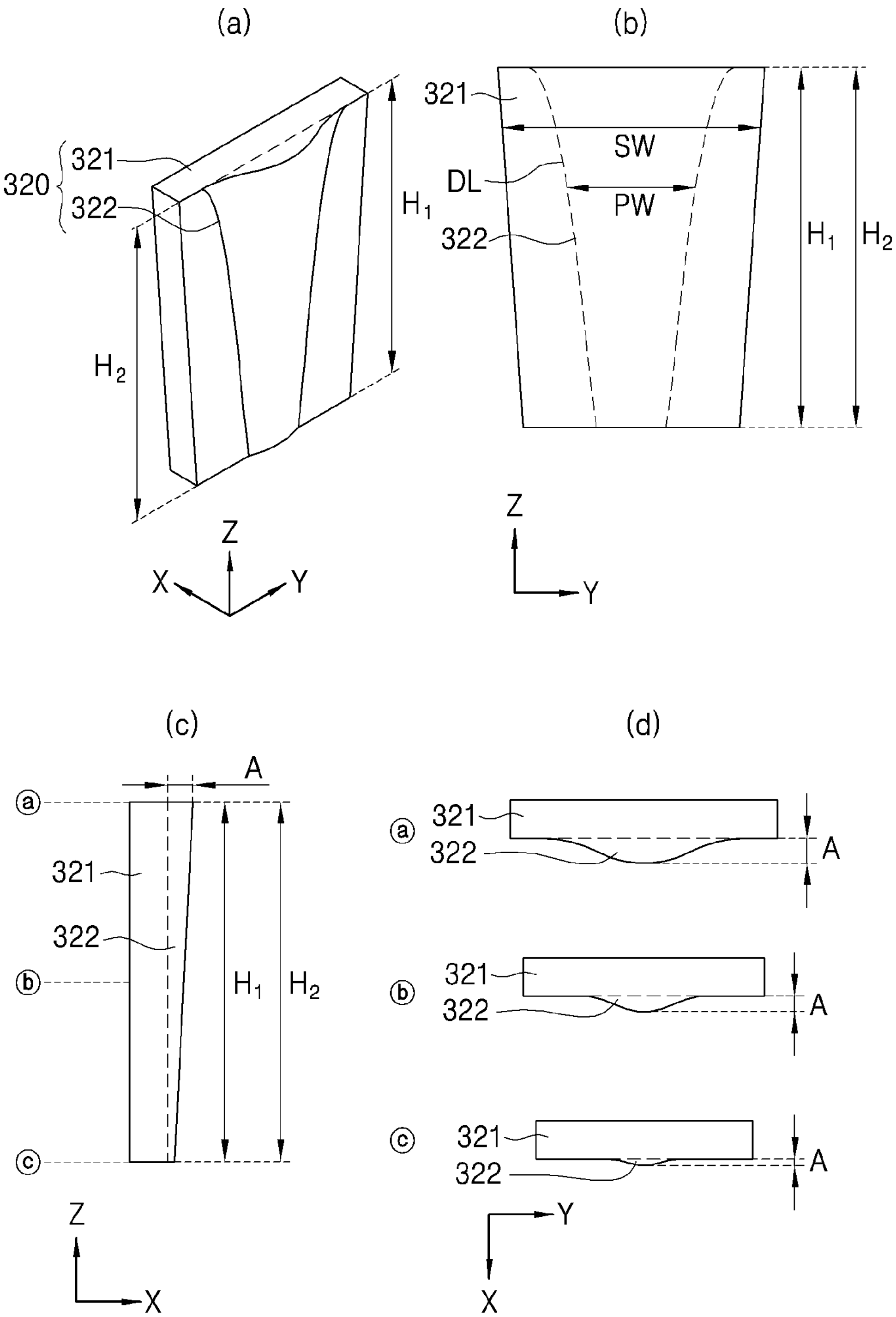


FIG. 20

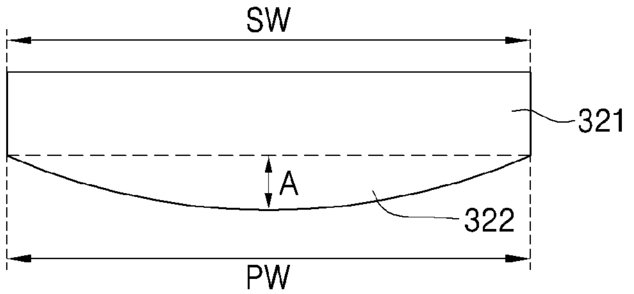


FIG. 21

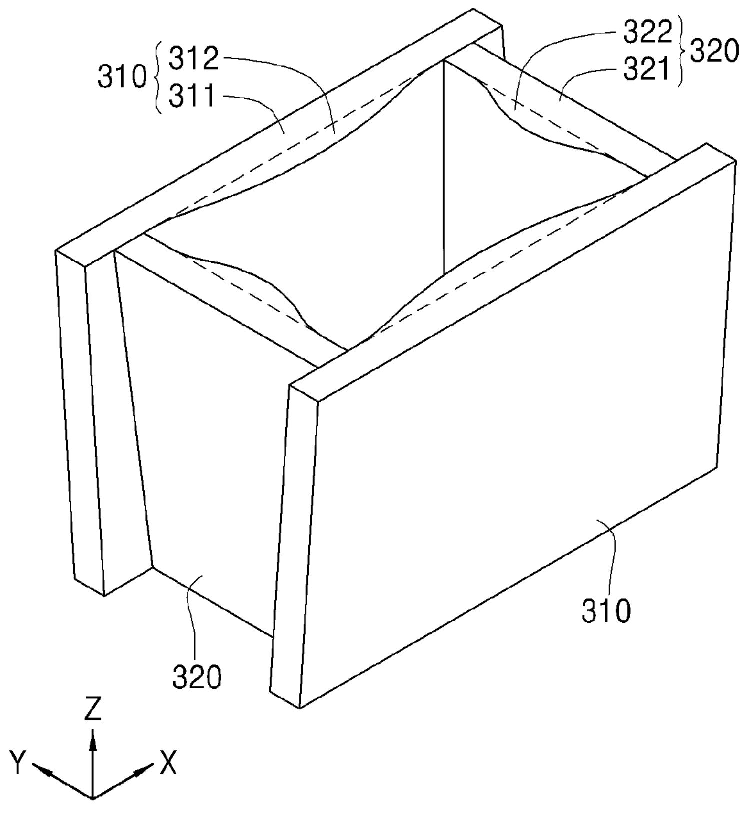


FIG. 22

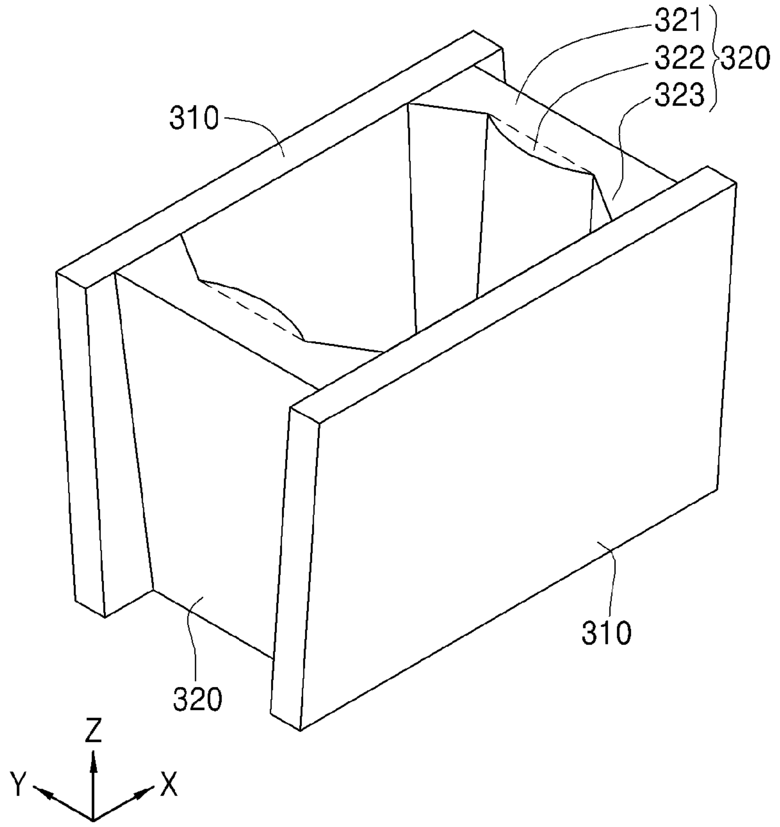


FIG. 23

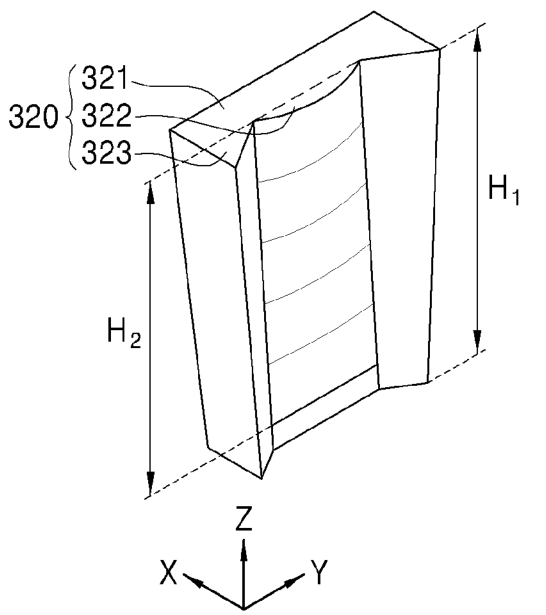


FIG.24

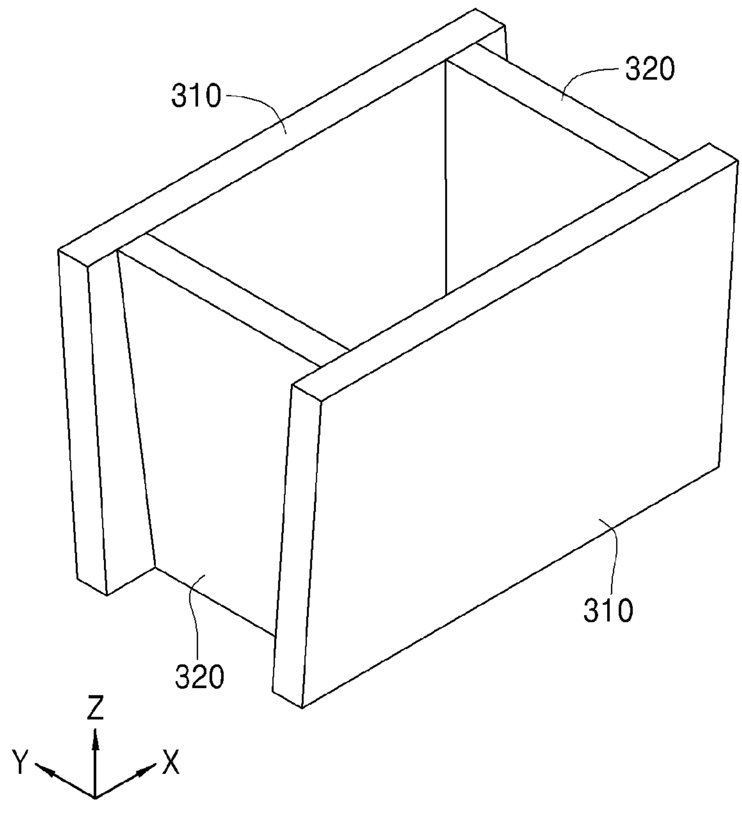
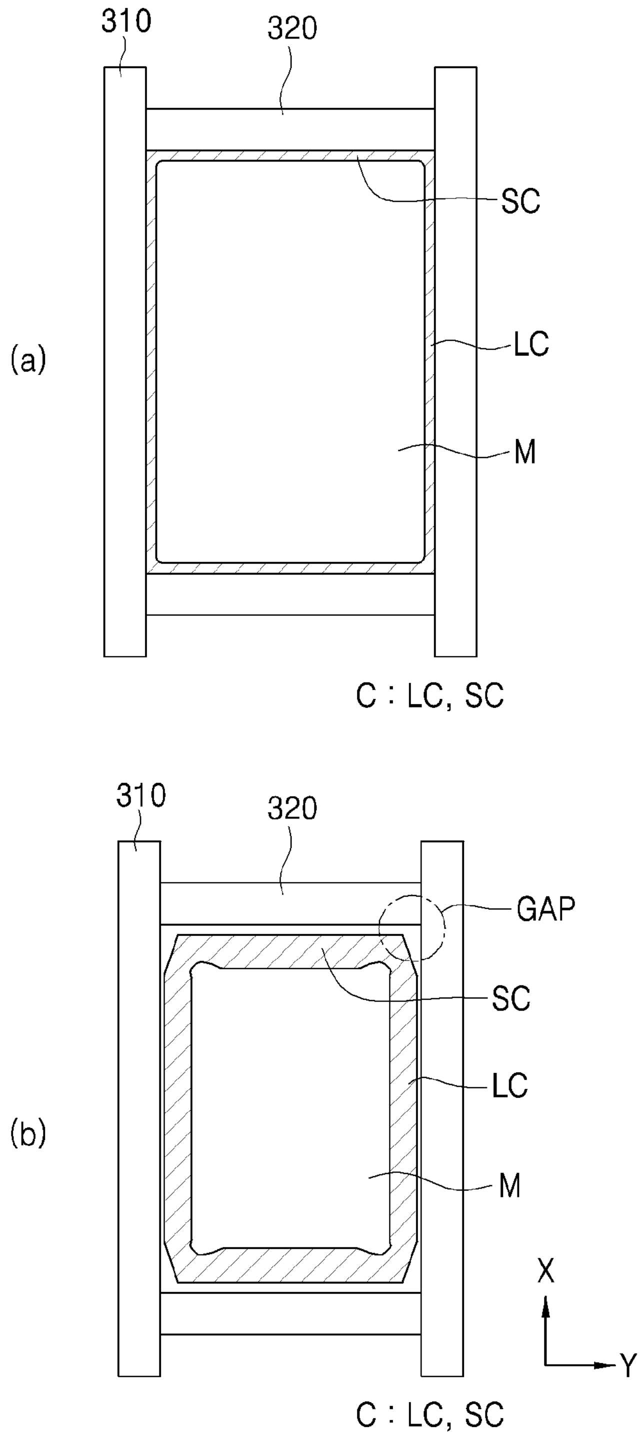


FIG. 25



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2019/005738

A. CLASSIFICATION OF SUBJECT MATTER

B22D 11/04(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)
B22D 11/04; B22D 11/128

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models: IPC as above
Japanese utility models and applications for utility models: IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS (KIPO internal) & Keywords: long side, short side, mold, width, length, protrusion

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3910342 A1 (JOHNSON, Lyle J.) 07 October 1975 See column 3, line 63-column 4, line 27, claims 1-5 and figures 1-2.	1-2,4-5,12-14
Y		3,6- 11,15-17
Y	KR 10-2013-0074898 A (POSCO) 05 July 2013 See paragraphs [0008], [0034]-[0035], [0040]-[0042] and figures 2-3, 5.	3,6- 11,15-17
A	JP 07-100591 A (KAWASAKI STEEL CORP. et al.) 18 April 1995 See paragraph [0009] and figure 1.	1-17
A	US 4023612 A (JACKSON, Charles Richard) 17 May 1977 See column 4, line 13-column 5, line 44 and figures 2, 5-6.	1-17
A	KR 10-1443788 B1 (POSCO) 23 September 2014 See claim 1 and figures 2-4.	1-17

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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 AUGUST 2019 (19.08.2019)	**20 AUGUST 2019 (20.08.2019)**

Name and mailing address of the ISA/KR	Authorized officer
Korean Intellectual Property Office Government Complex Daejeon Building 4, 189, Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea Facsimile No. +82-42-481-8578	Telephone No.

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR2019/005738

Patent document cited in search report	Publication date	Patent family member	Publication date
US 3910342 A	07/10/1975	None	
KR 10-2013-0074898 A	05/07/2013	CN 104023874 A	03/09/2014
		CN 104023874 B	25/11/2015
		EP 2799162 A1	05/11/2014
		EP 2799162 B1	22/03/2017
		JP 2015-503450 A	02/02/2015
		JP 5933751 B2	15/06/2016
		KR 10-1360564 B1	24/02/2014
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US 4023612 A	17/05/1977	None	
KR 10-1443788 B1	23/09/2014	KR 10-2014-0020544 A	19/02/2014

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- KR 1020130074898 **[0008]**