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(54) **EXTRUSION DIE FOR FORMING HOLLOW MATERIAL**

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(57) **ABSTRACT**

An extrusion die for forming a hollow material that extrudes a billet comprising a high-strength alloy having high extrusion force and forms a hollow material including a partition wall, comprises a male-type member that extrudes a billet on a downstream side and forms the inner shape of a material and a female-type member that forms the outer shape of the material, wherein a billet guide hole that guides one part of the billet toward the downstream side is provided to the central area of a mandrel section that constitutes the male-type member, four inner formation pieces are mounted in a fixed manner to positions that face the downstream-side opening of the billet guide hole, and the female-type member is provided with an outer formation die hole that faces all of the outer peripheral surfaces of the inner formation pieces and that forms the outer shape of the hollow material.

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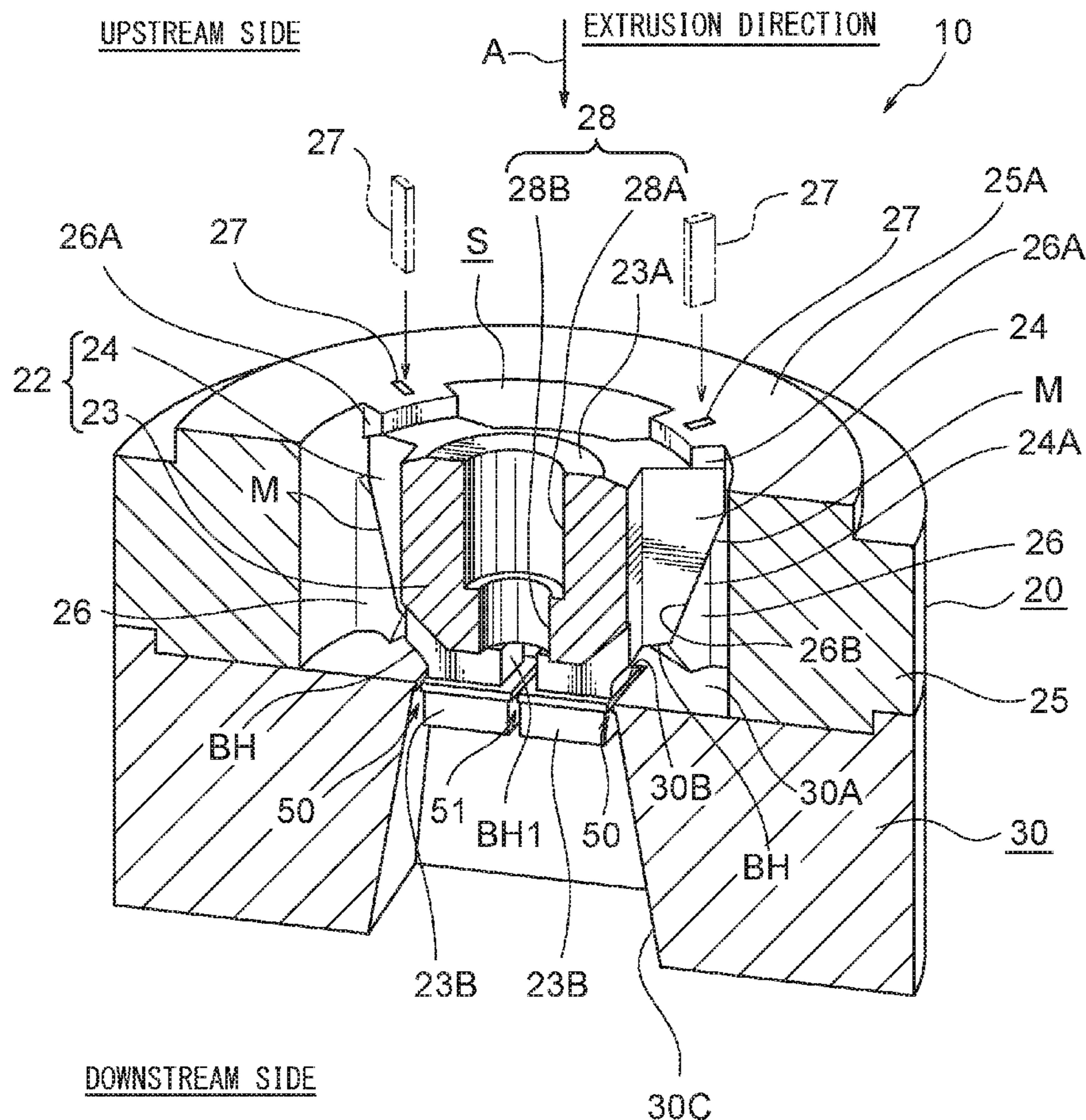


FIG. 2

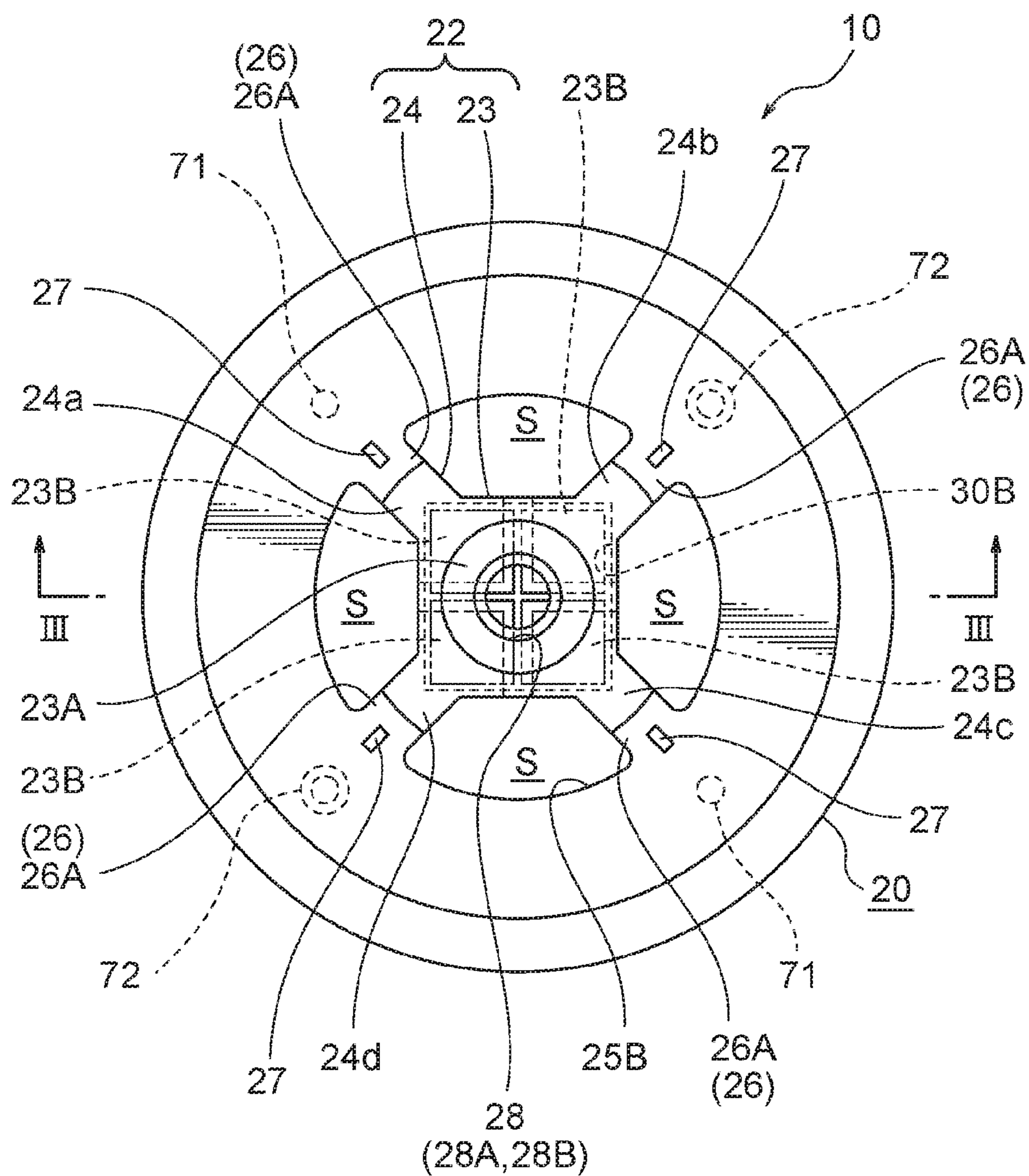


FIG. 3

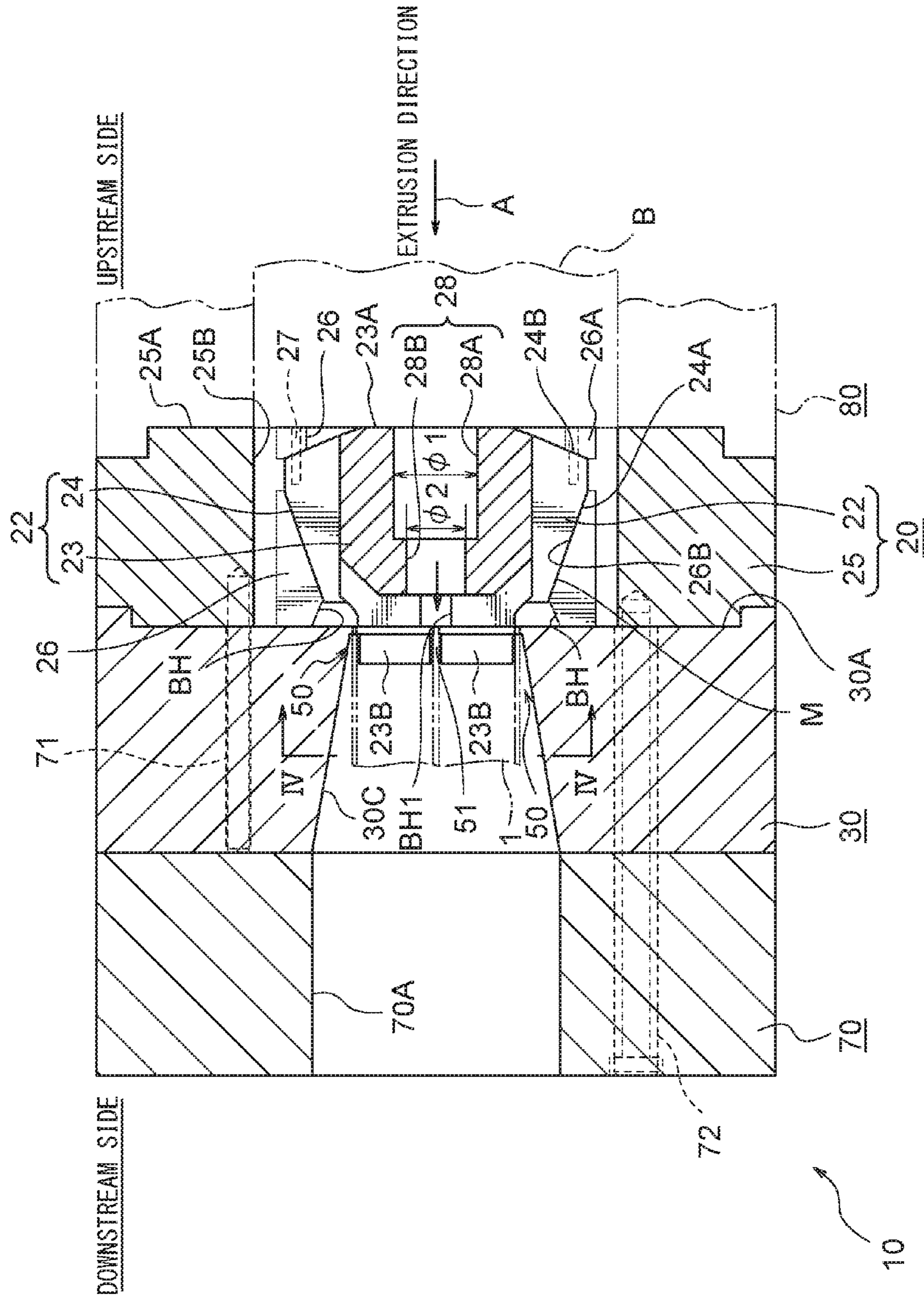


FIG. 4

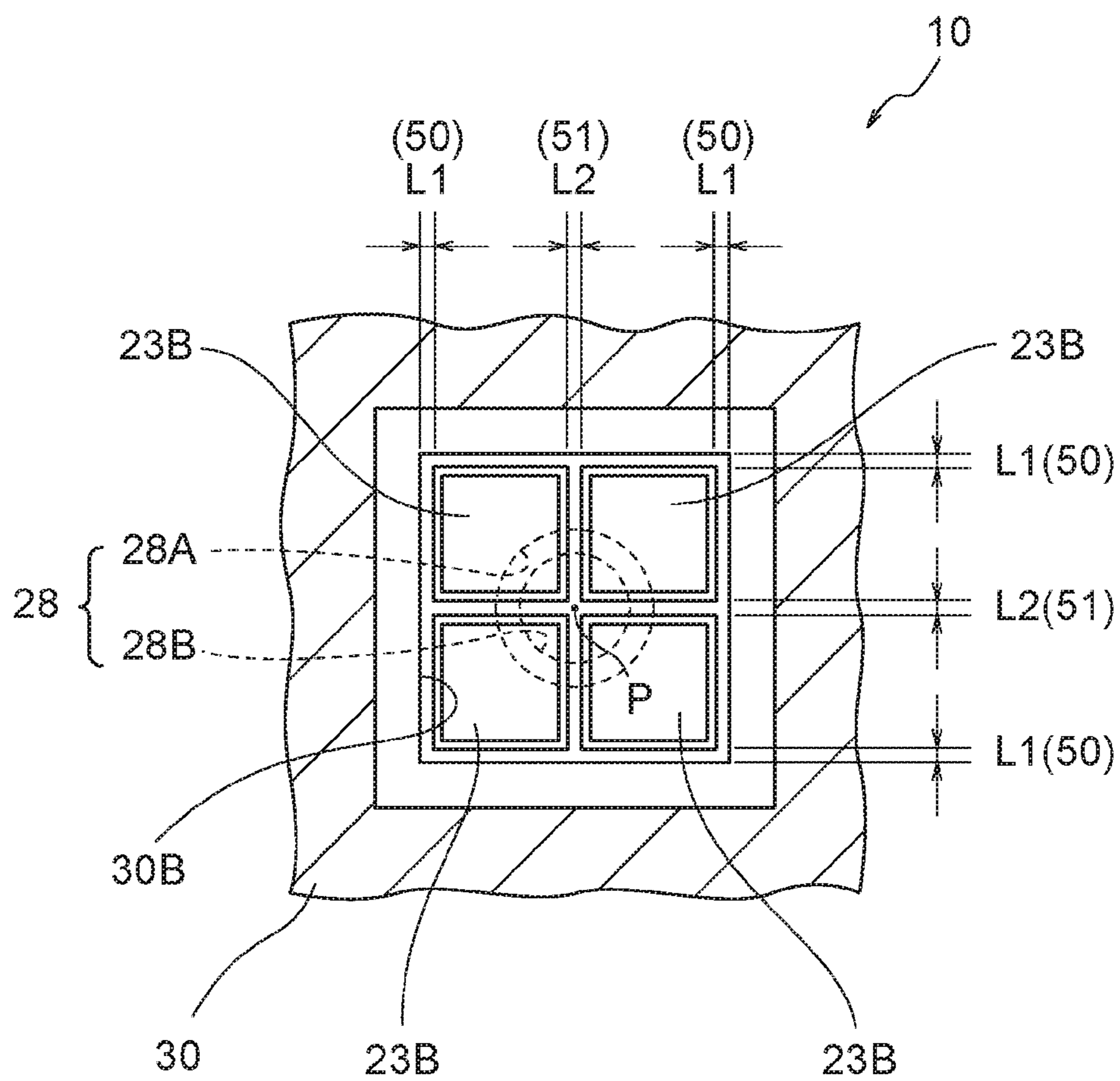


FIG. 5

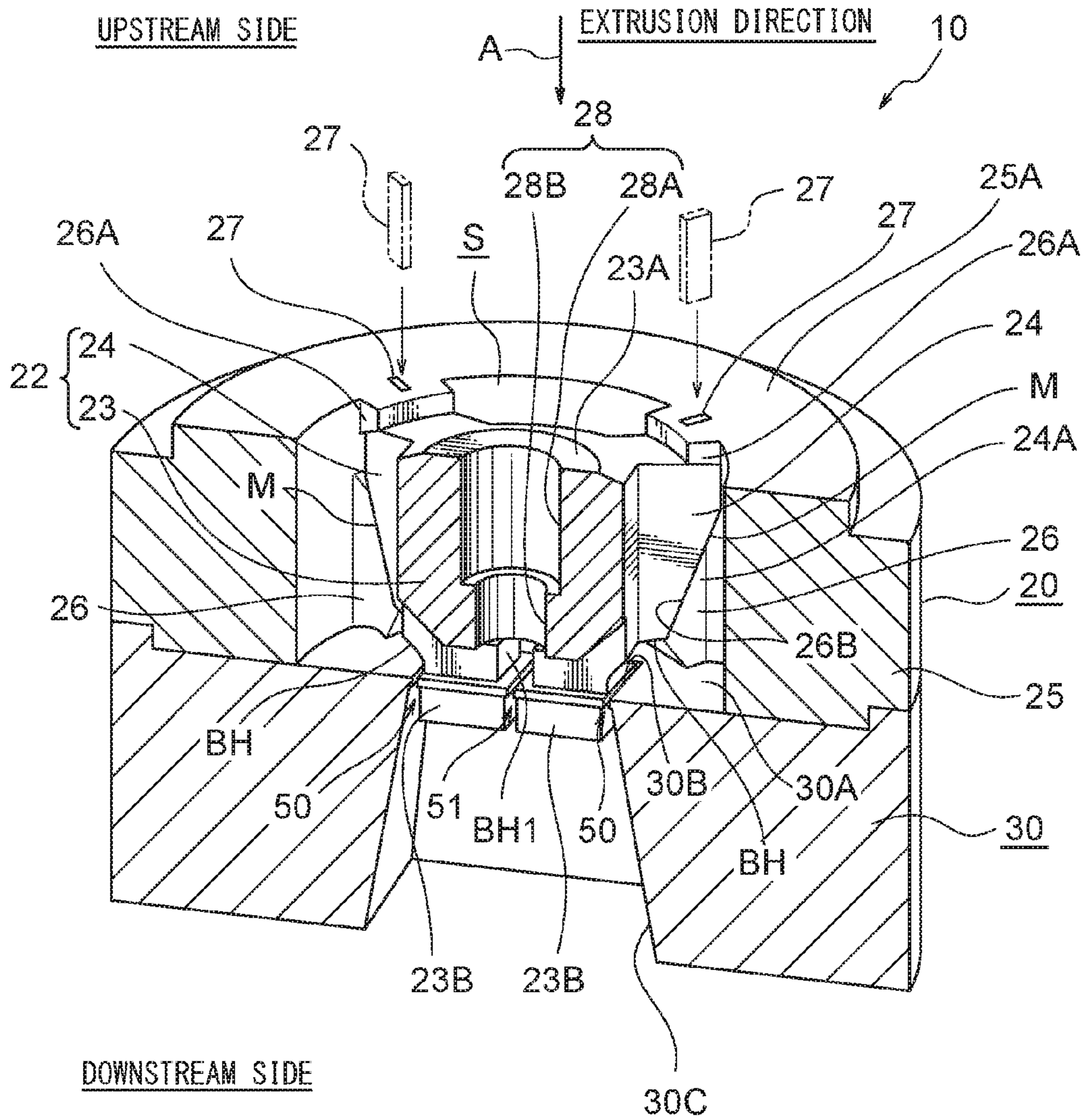


FIG. 6

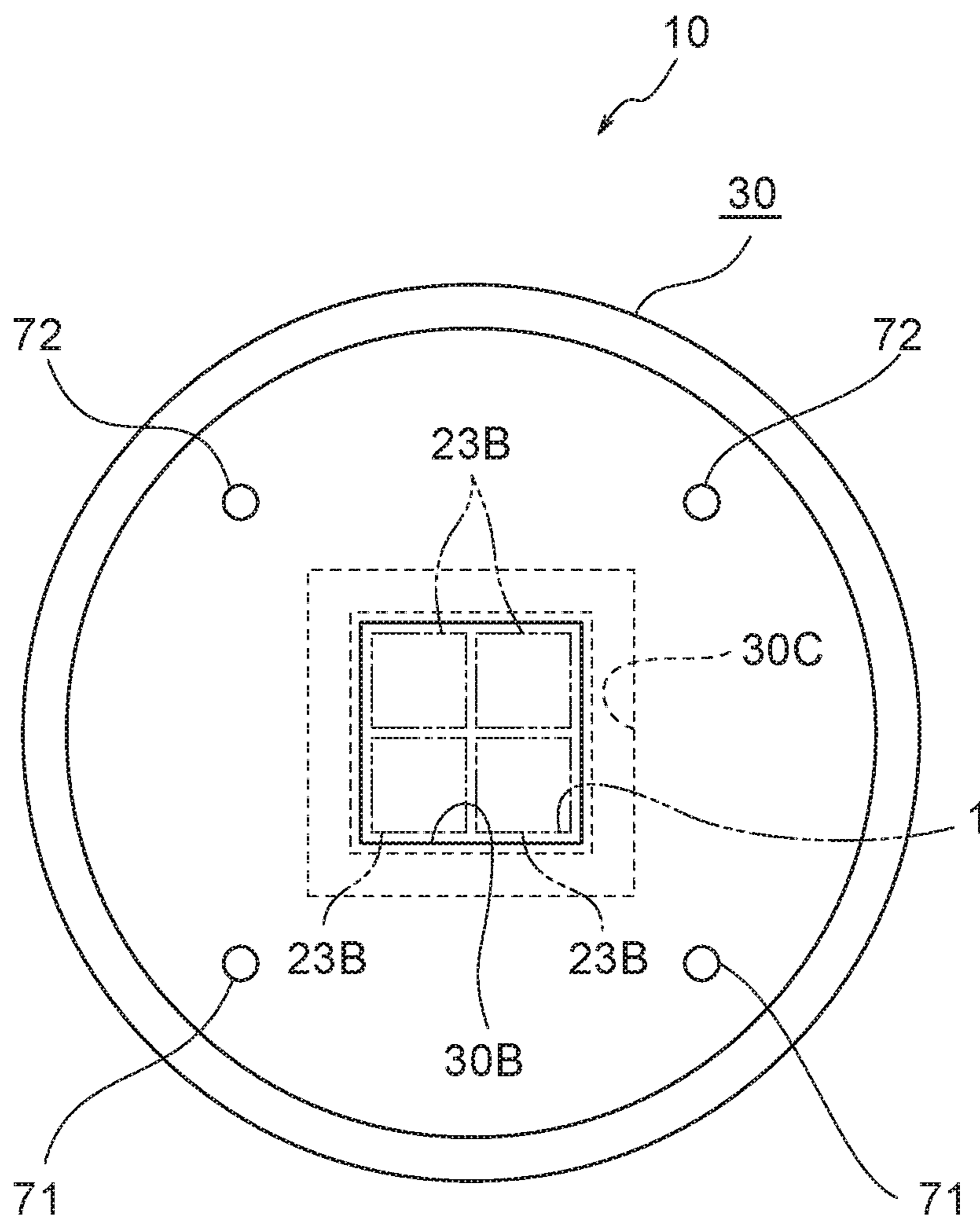


FIG. 7

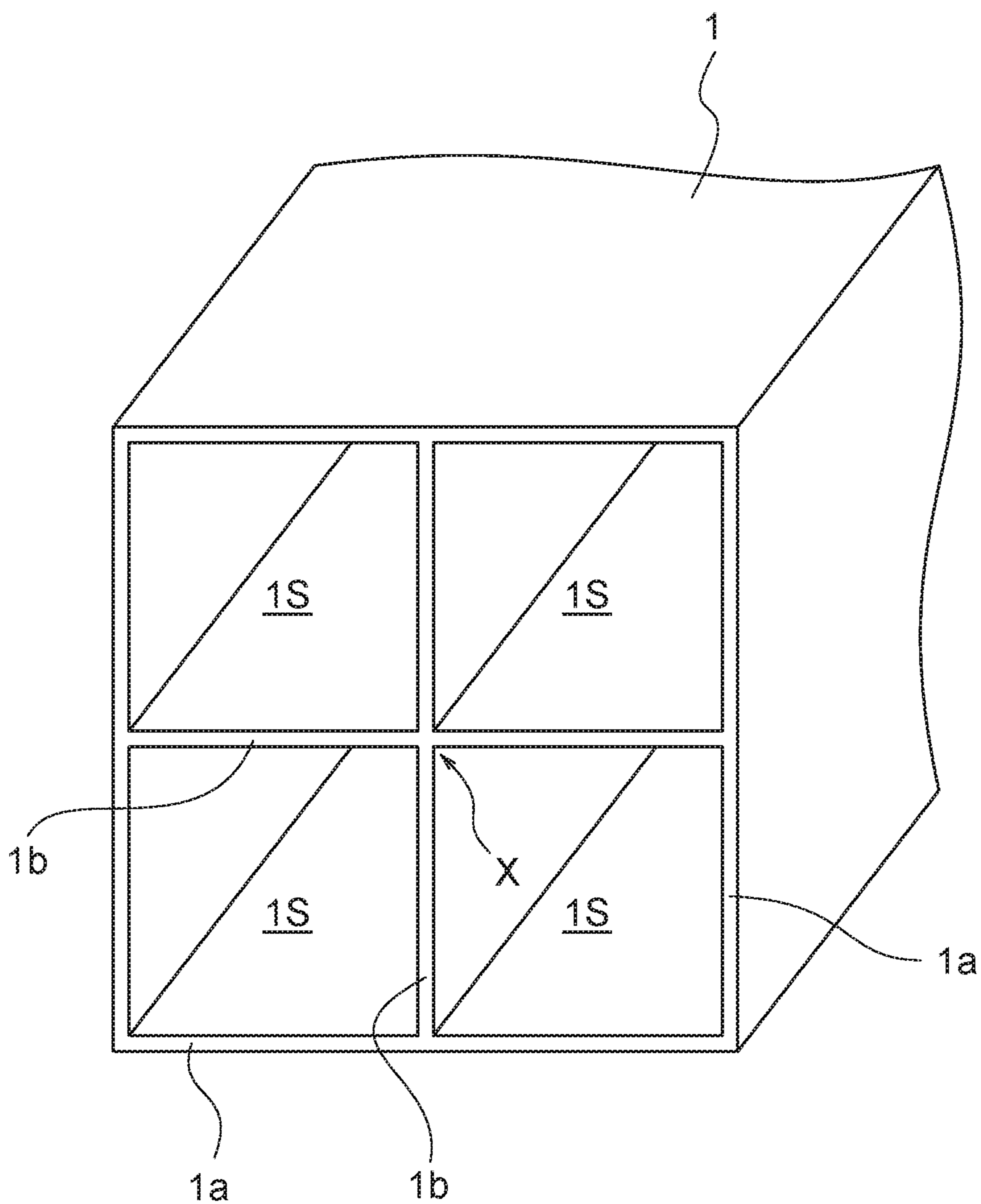


FIG. 8

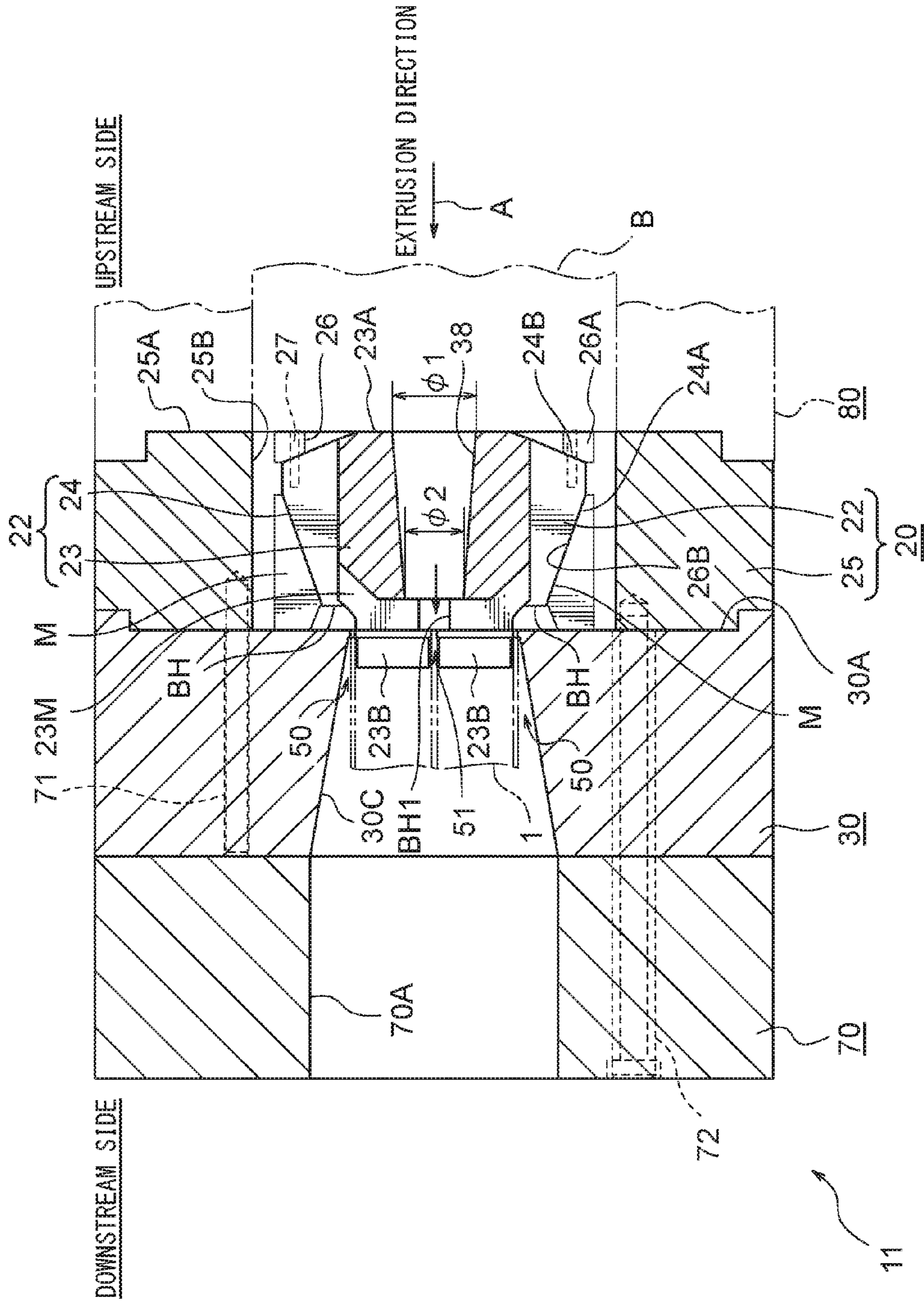


FIG. 9

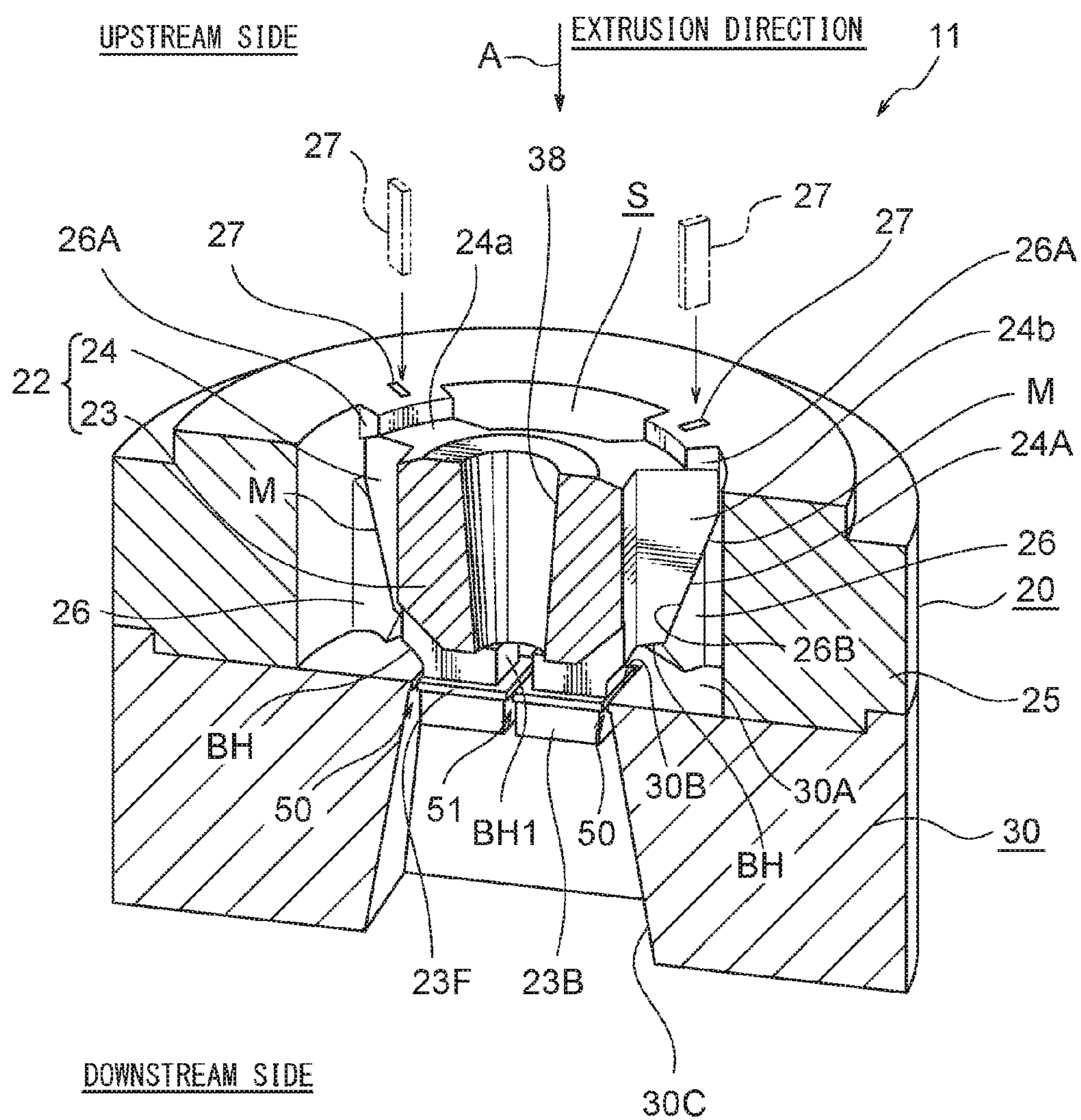


FIG. 10

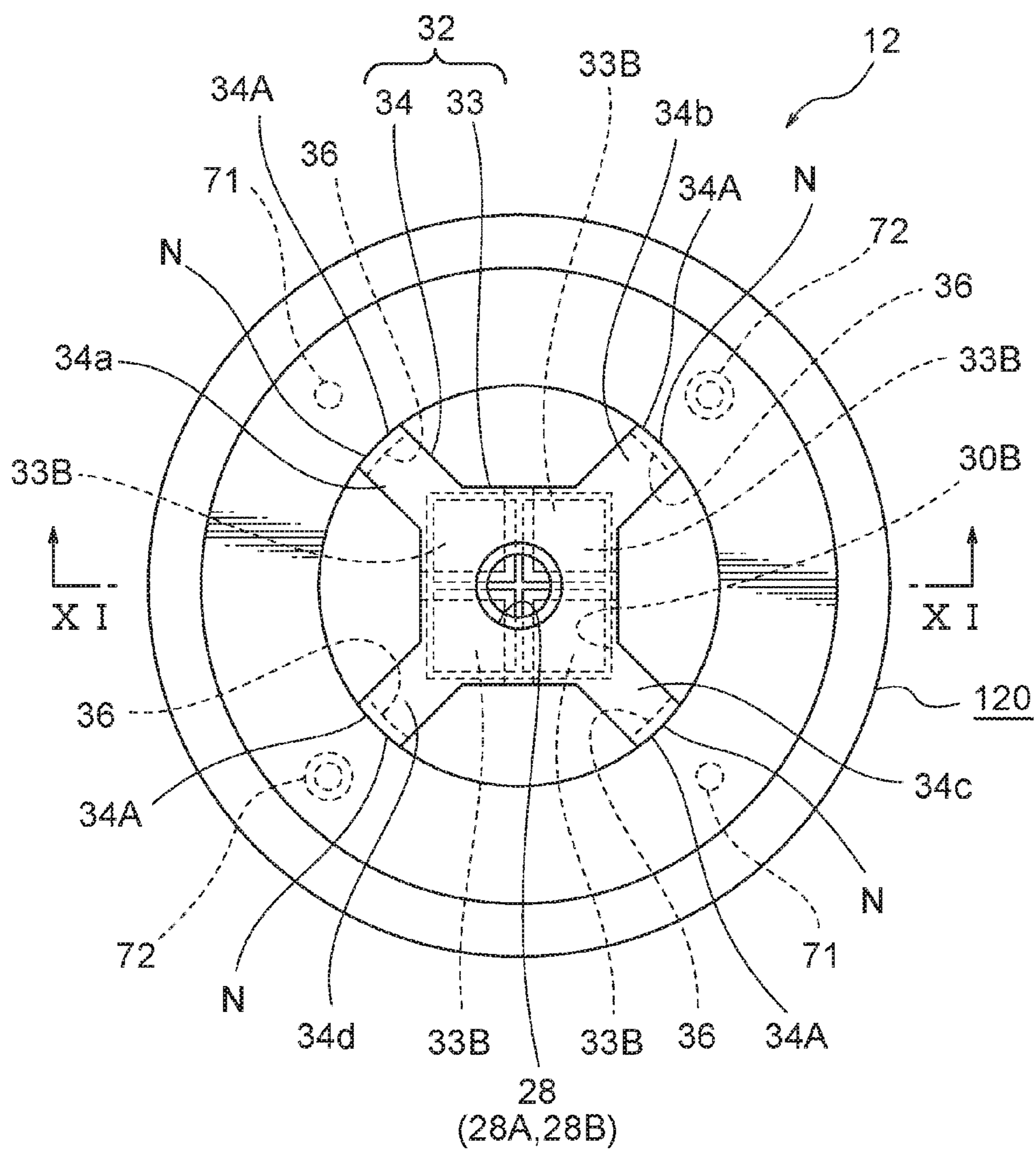


FIG. 12

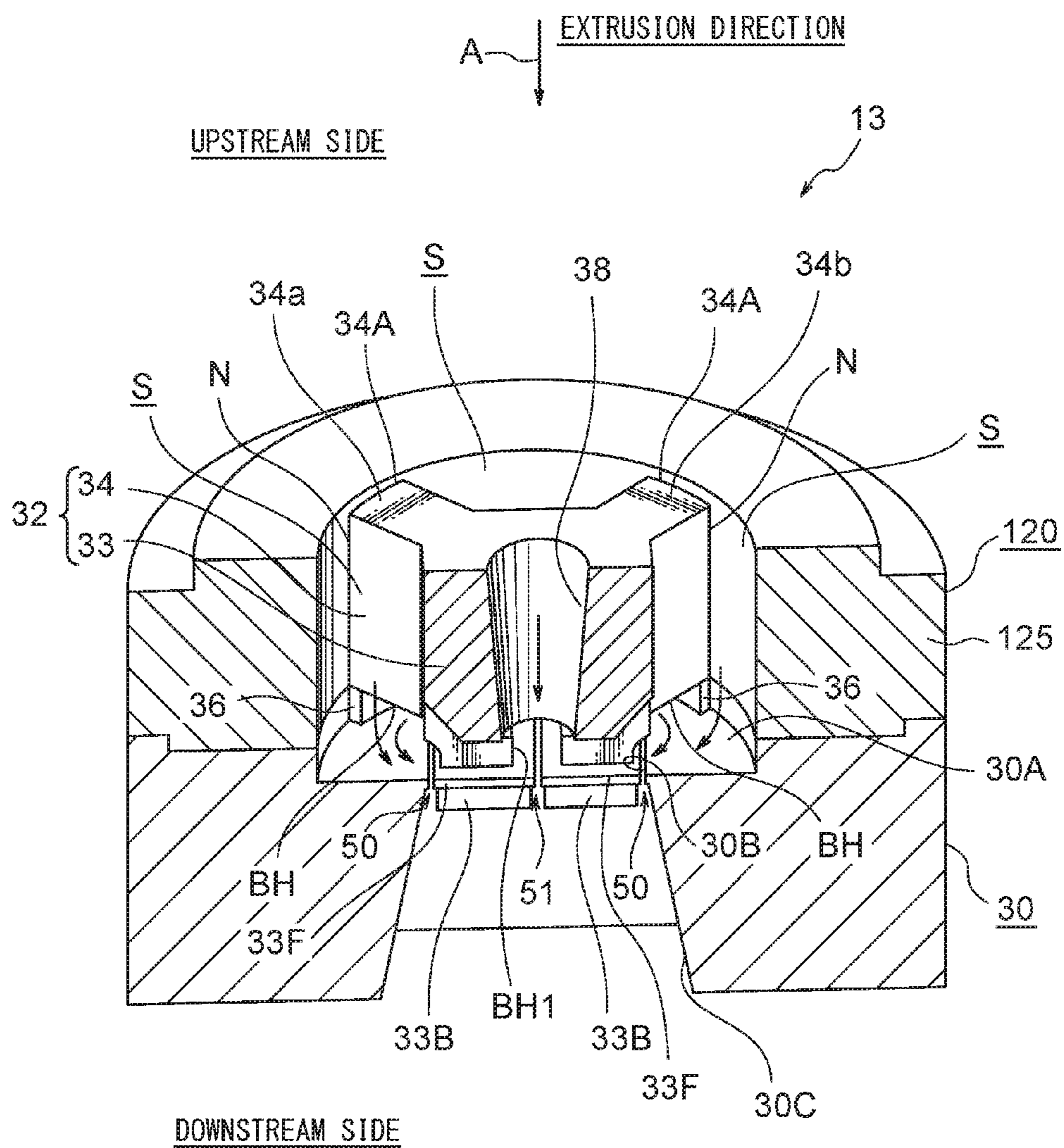


FIG. 14

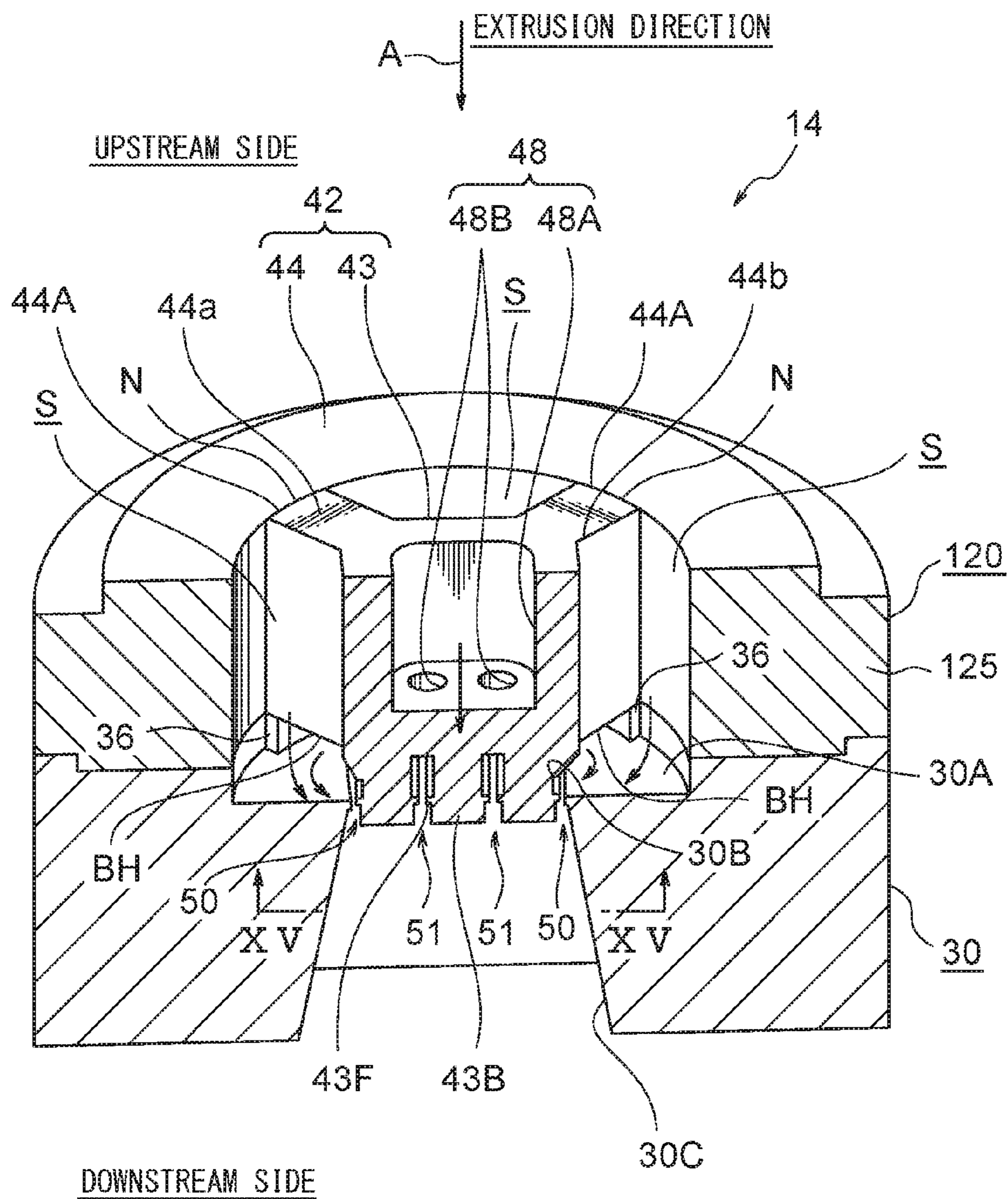


FIG. 15

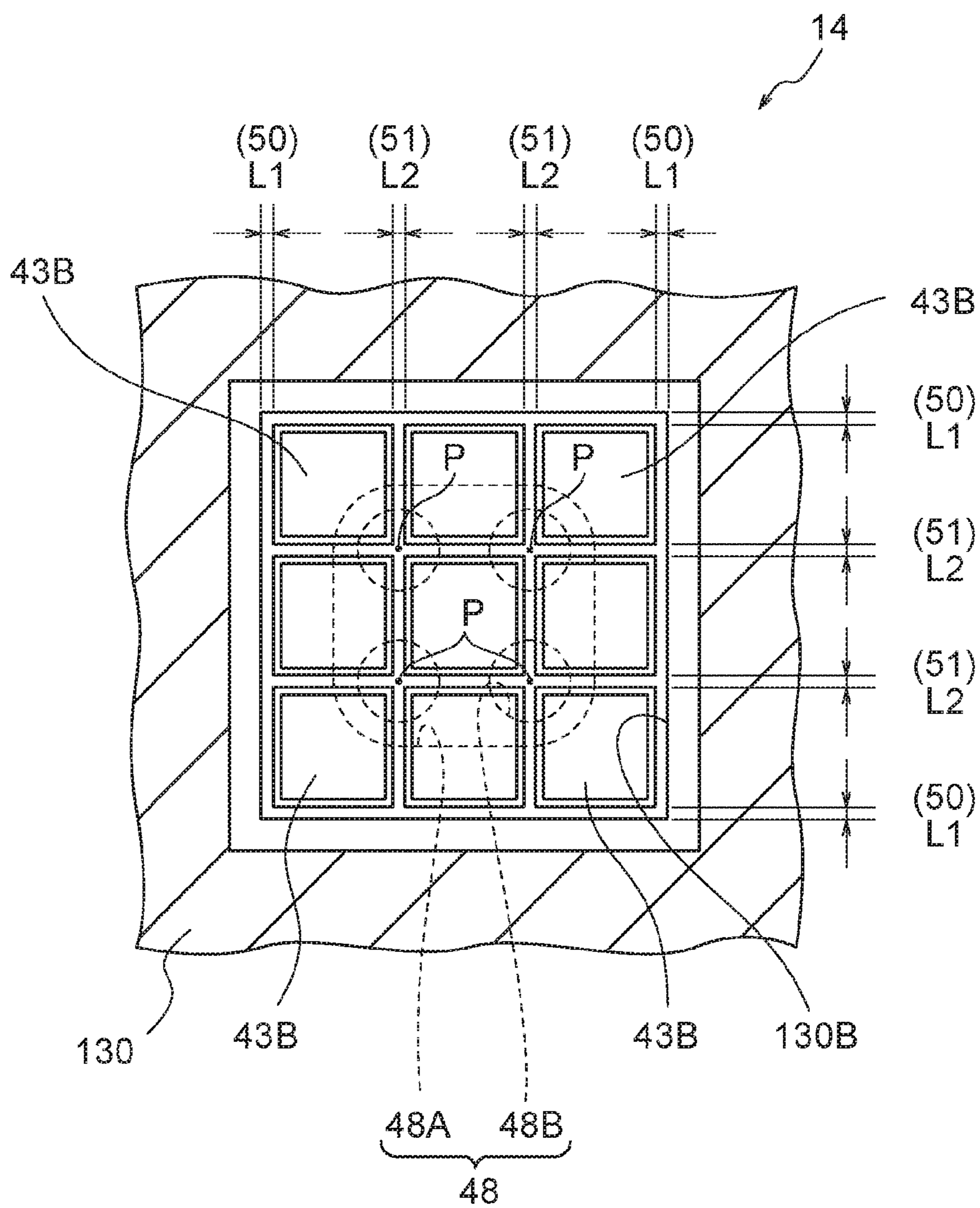


FIG. 16

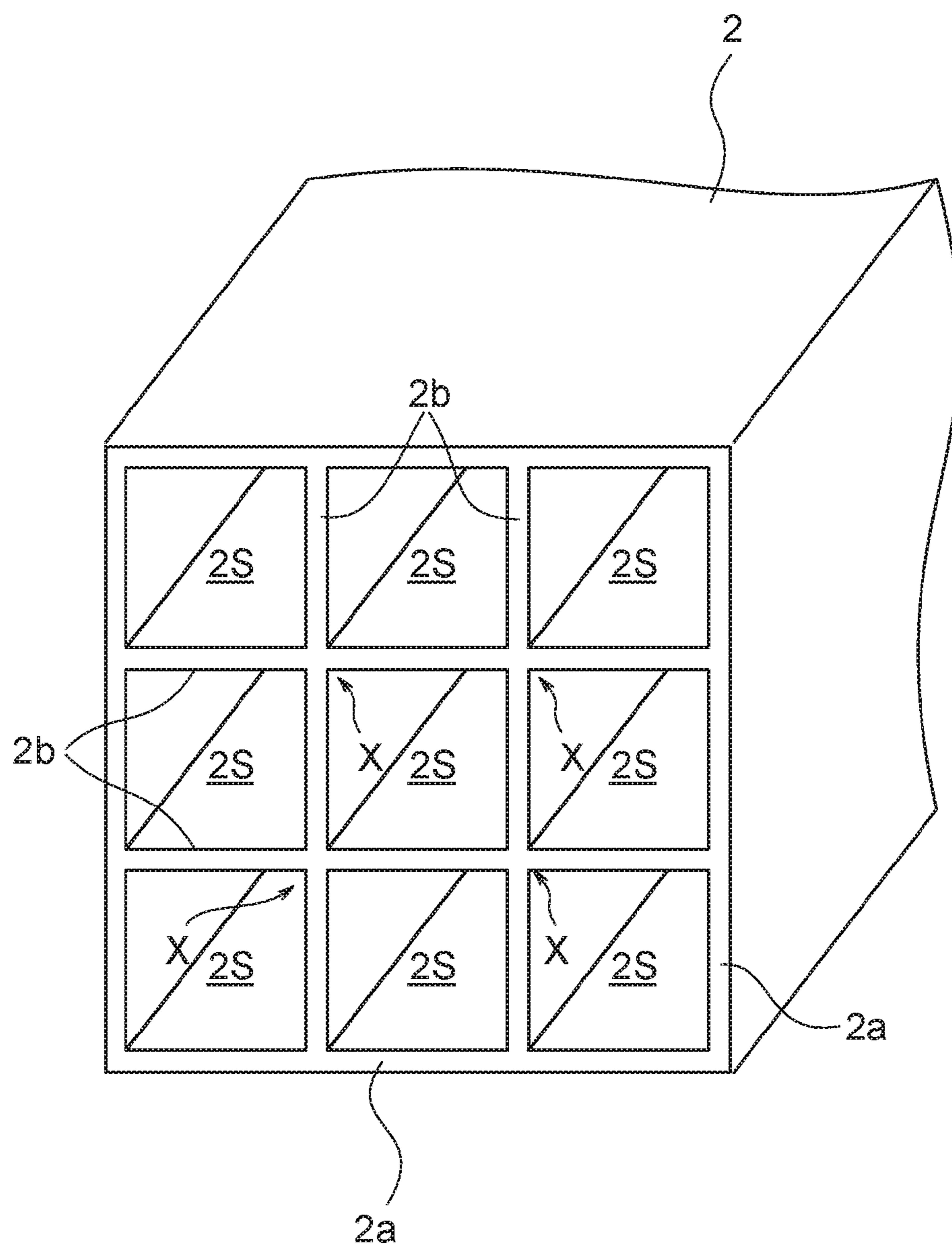


FIG. 17

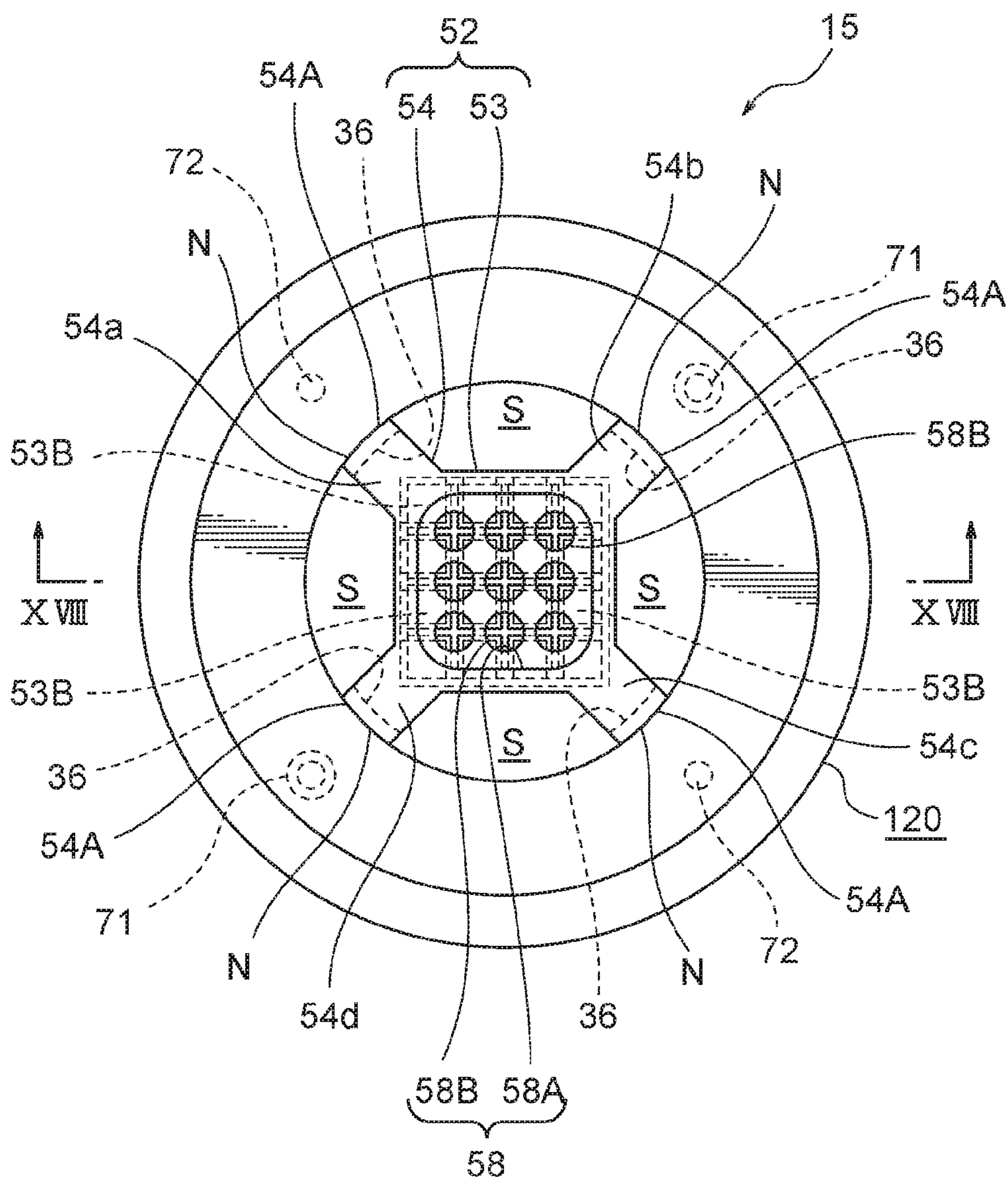


FIG. 18

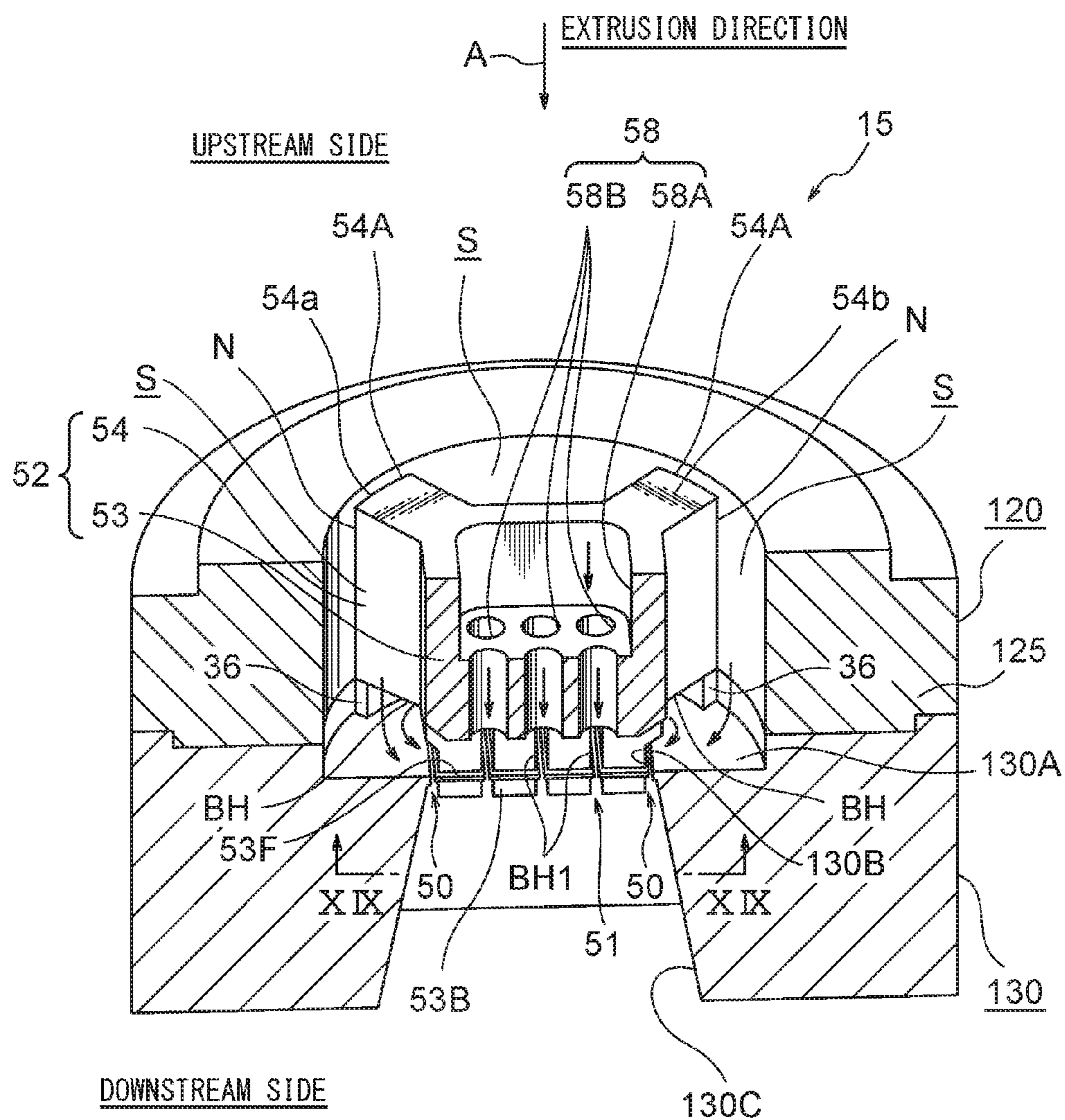


FIG. 19

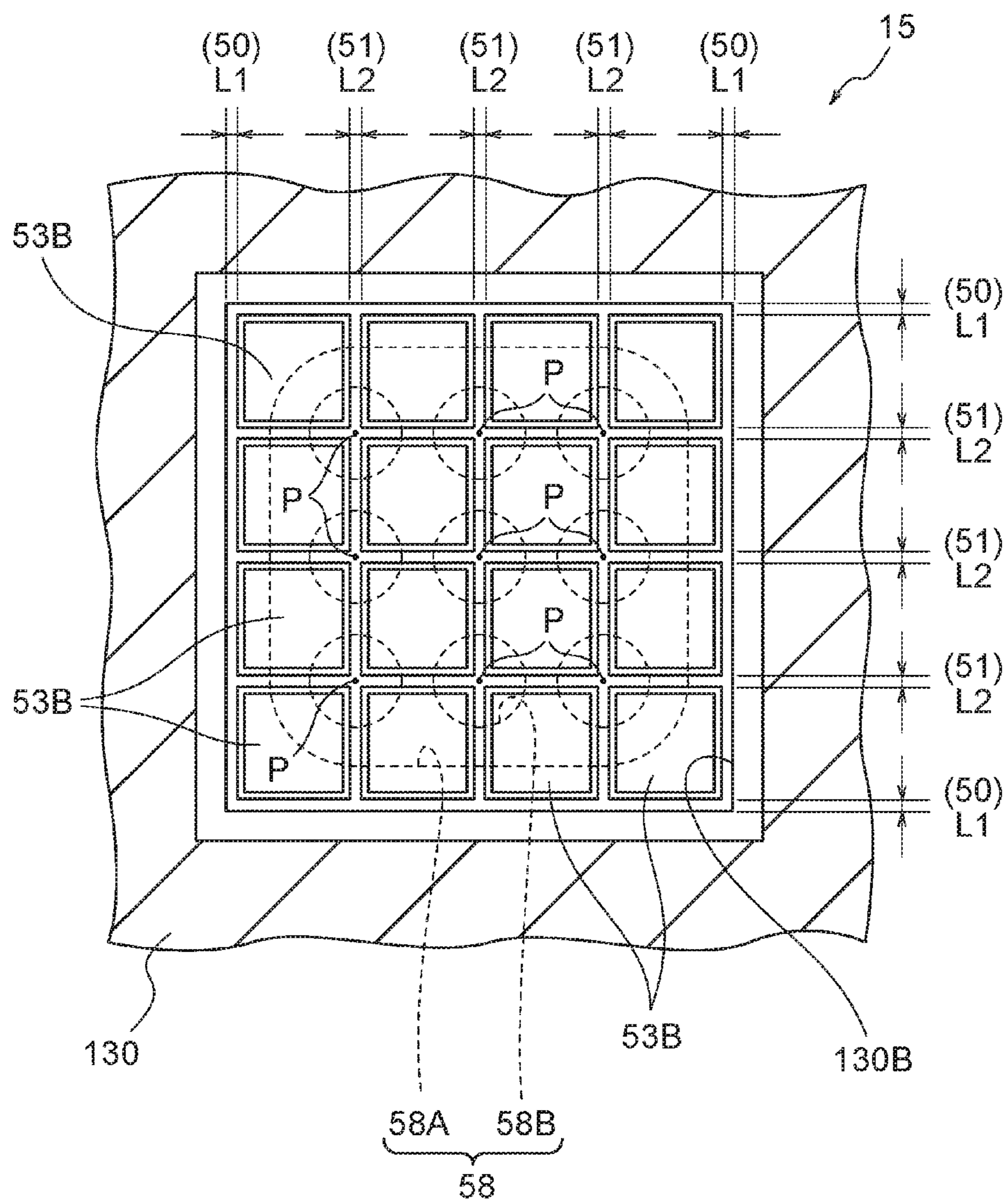


FIG. 20

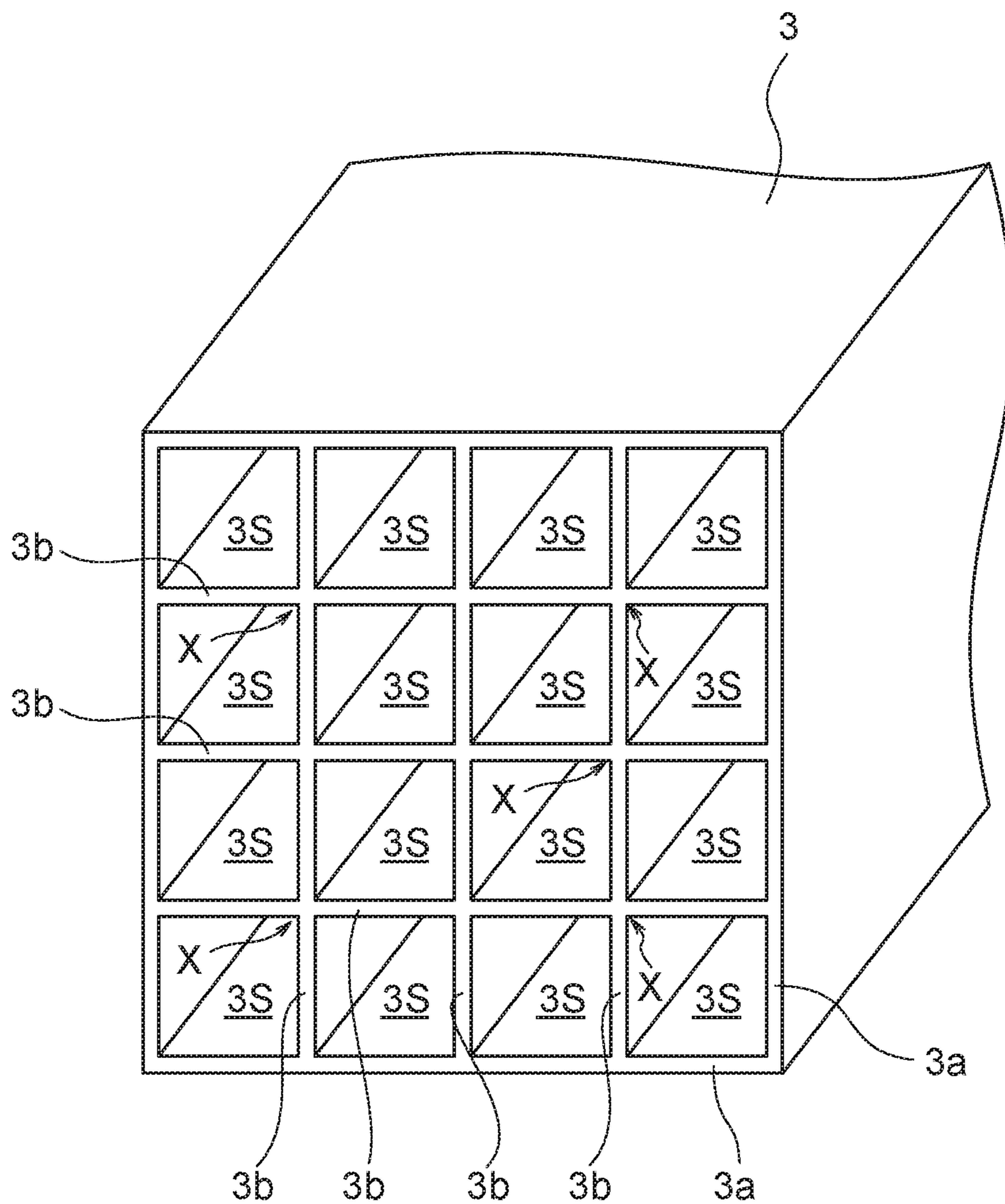


FIG. 21

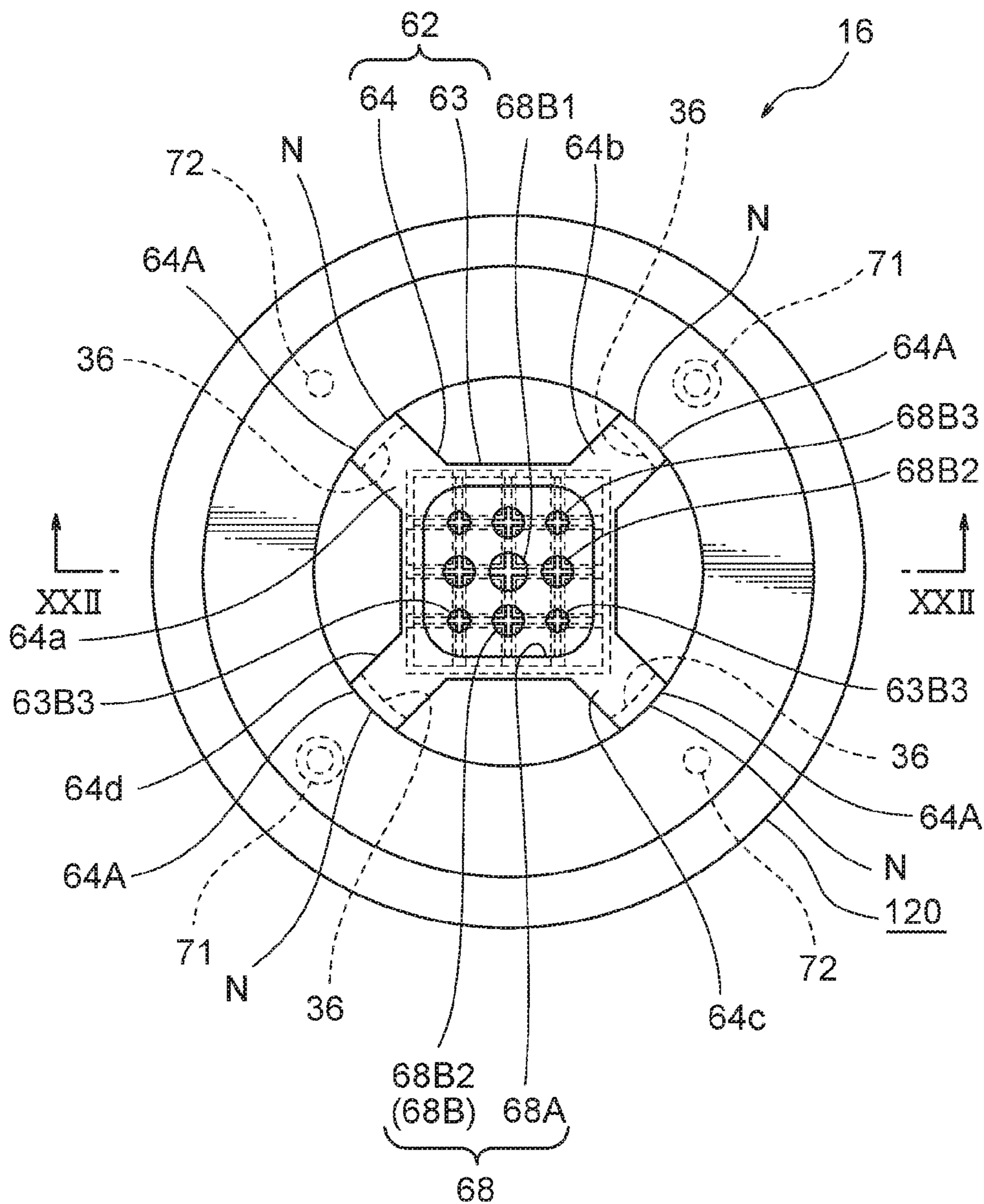


FIG. 22

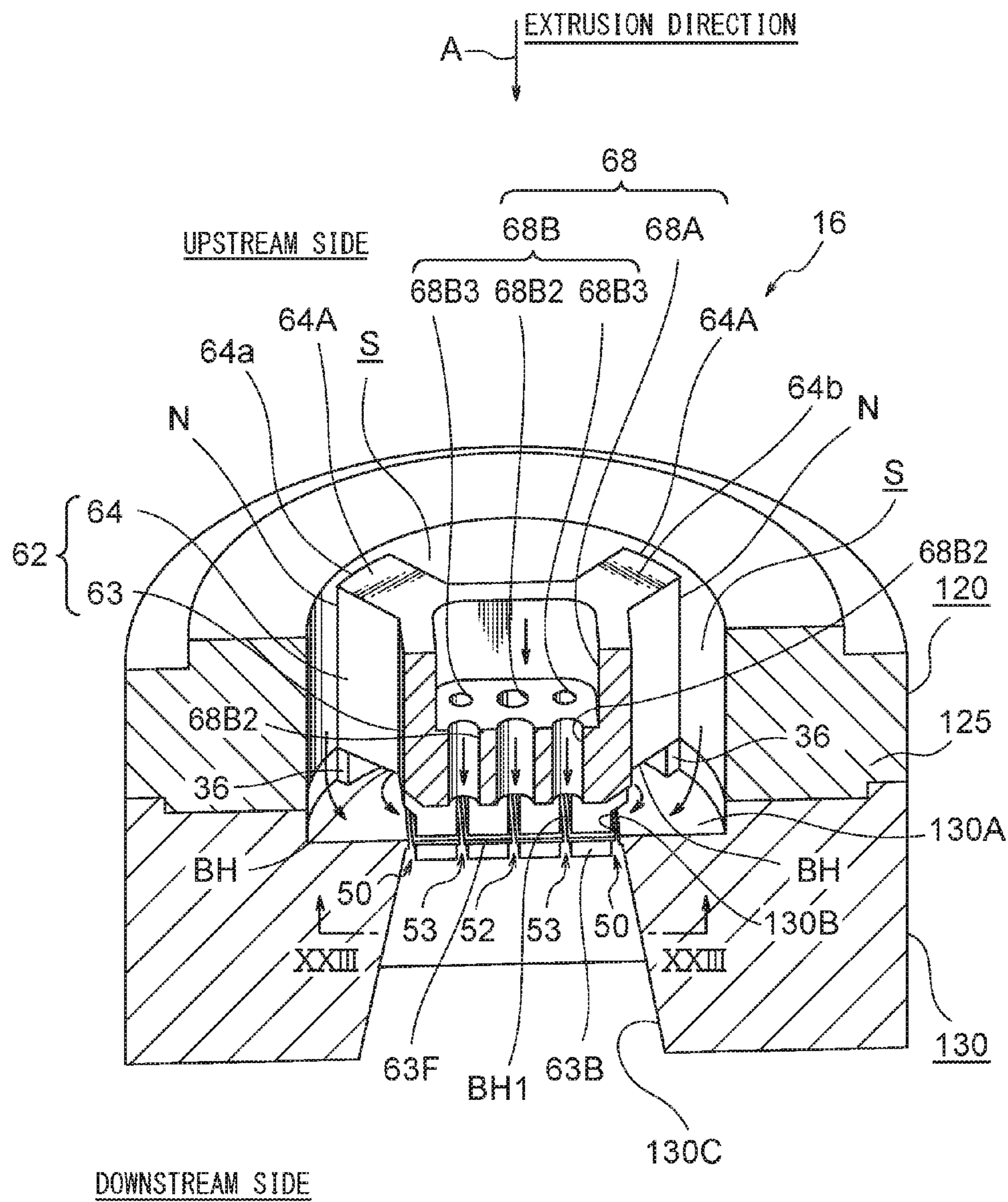


FIG. 23

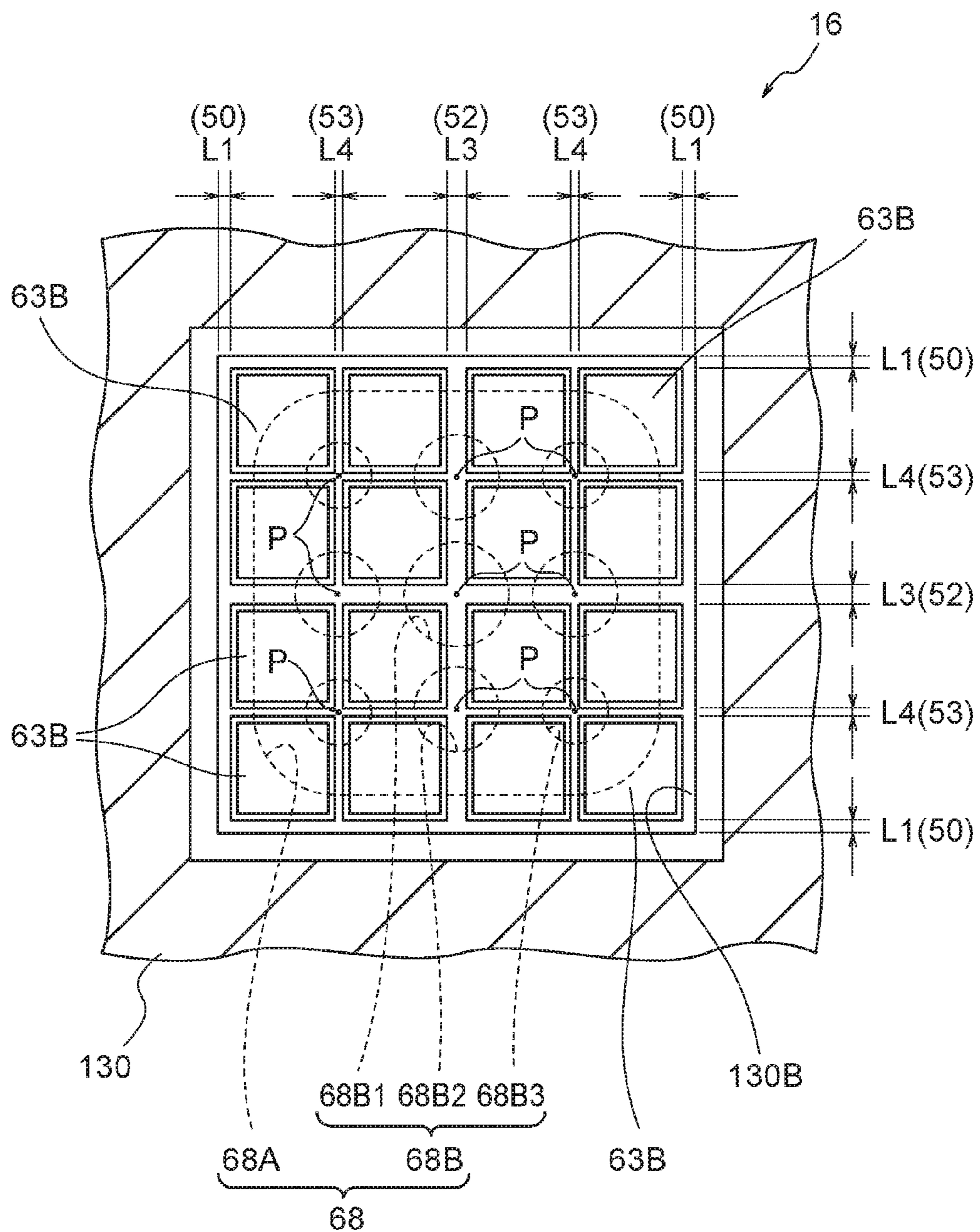


FIG. 24

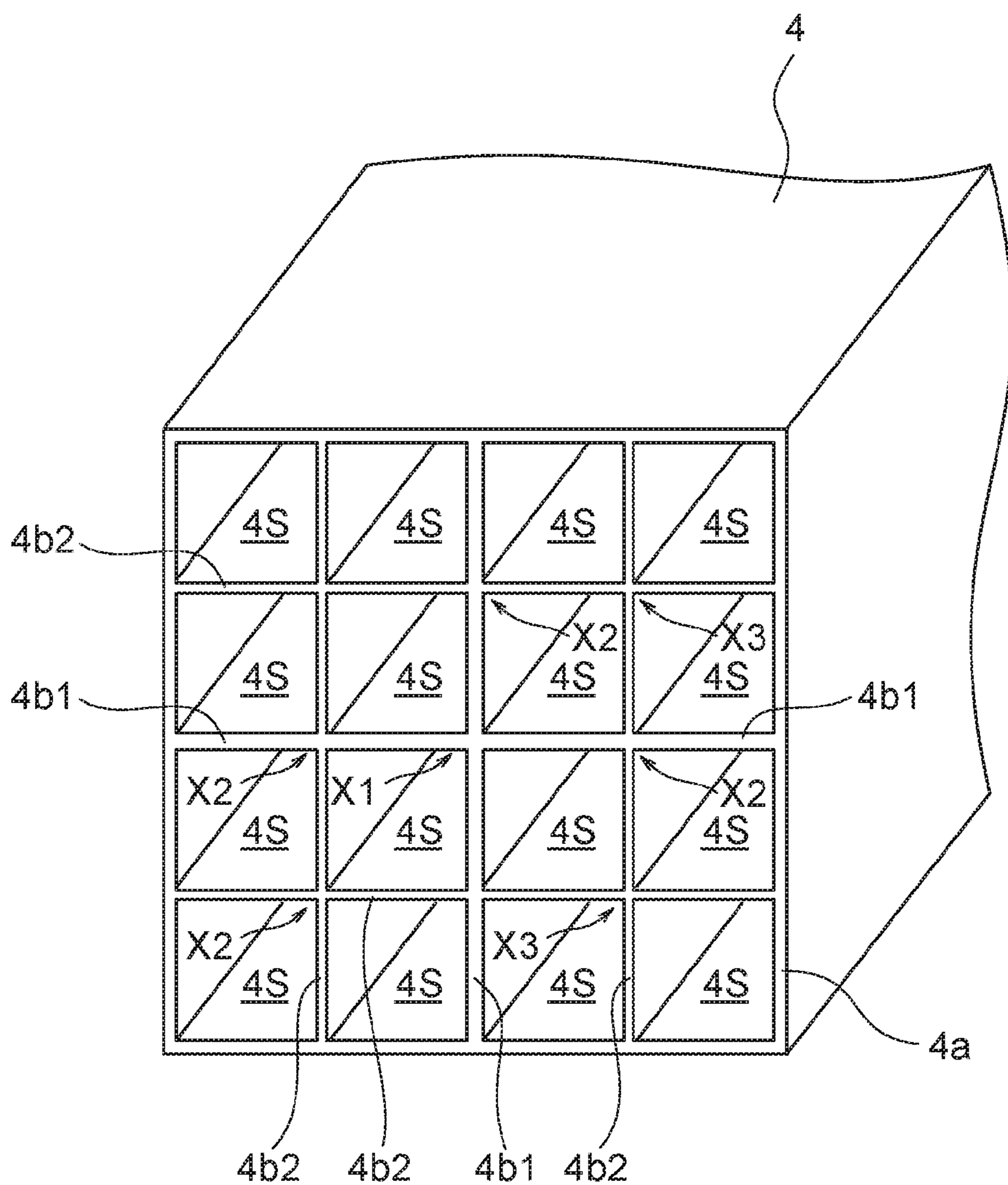


FIG.25A

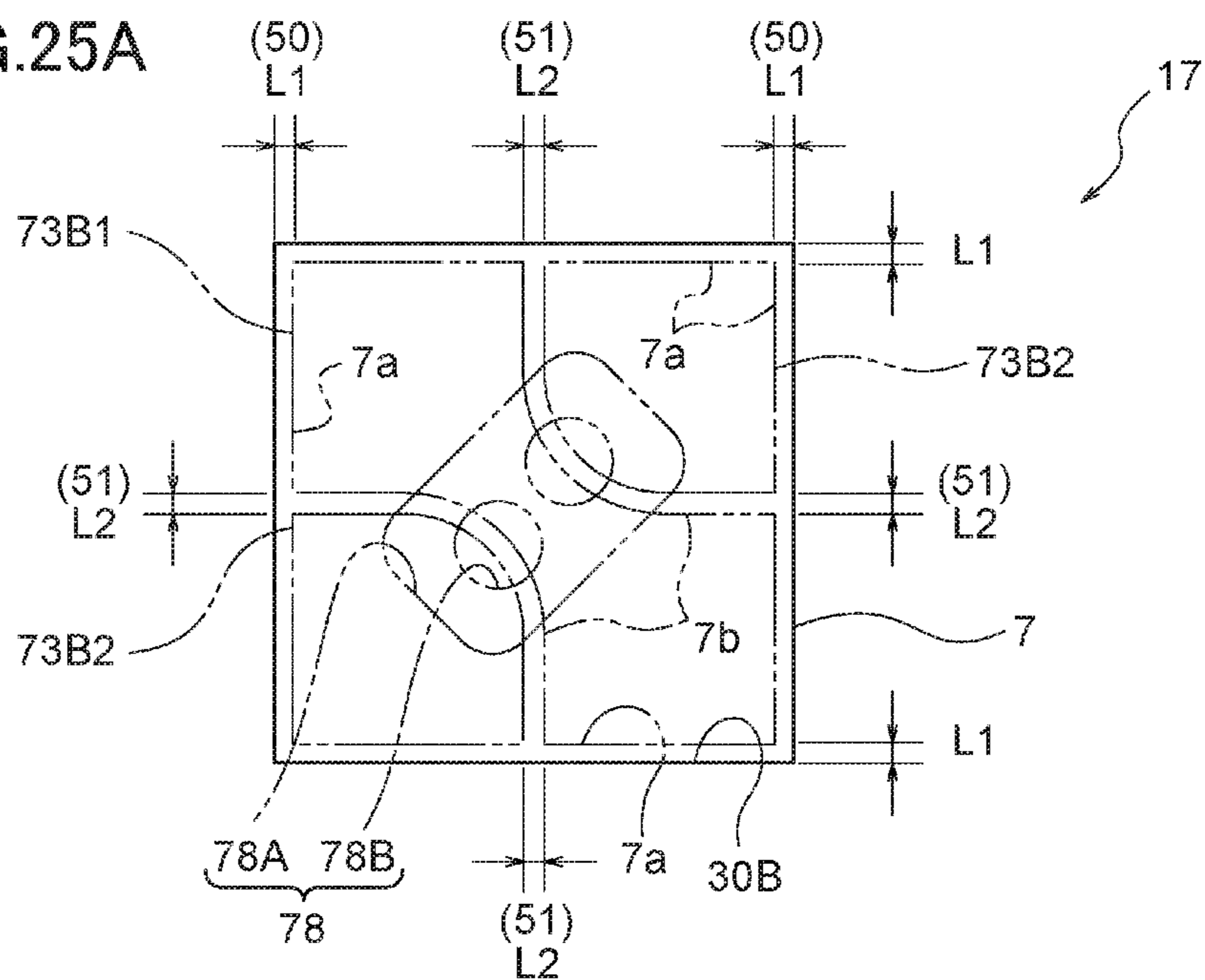


FIG.25B

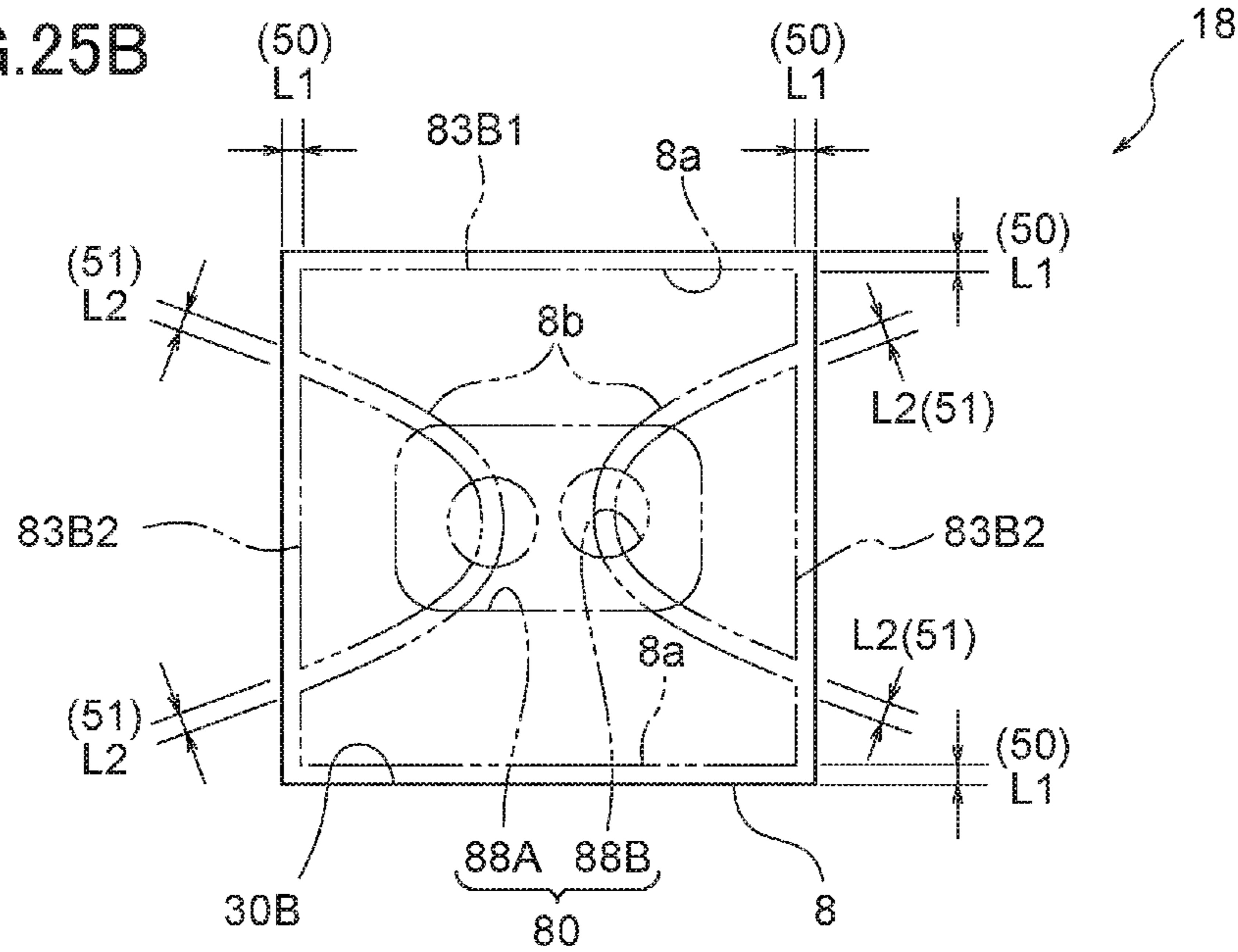


FIG. 26

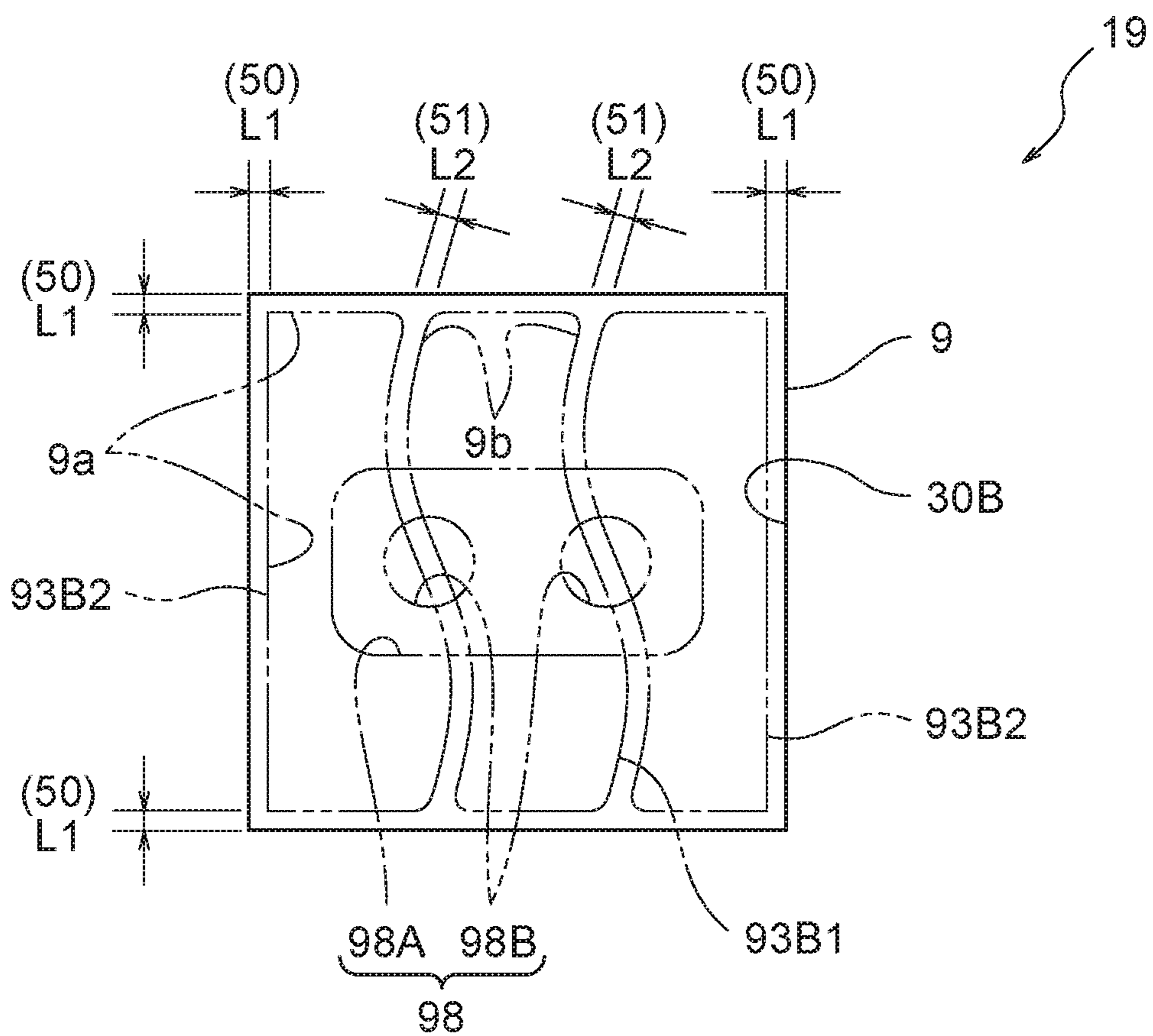


FIG. 27

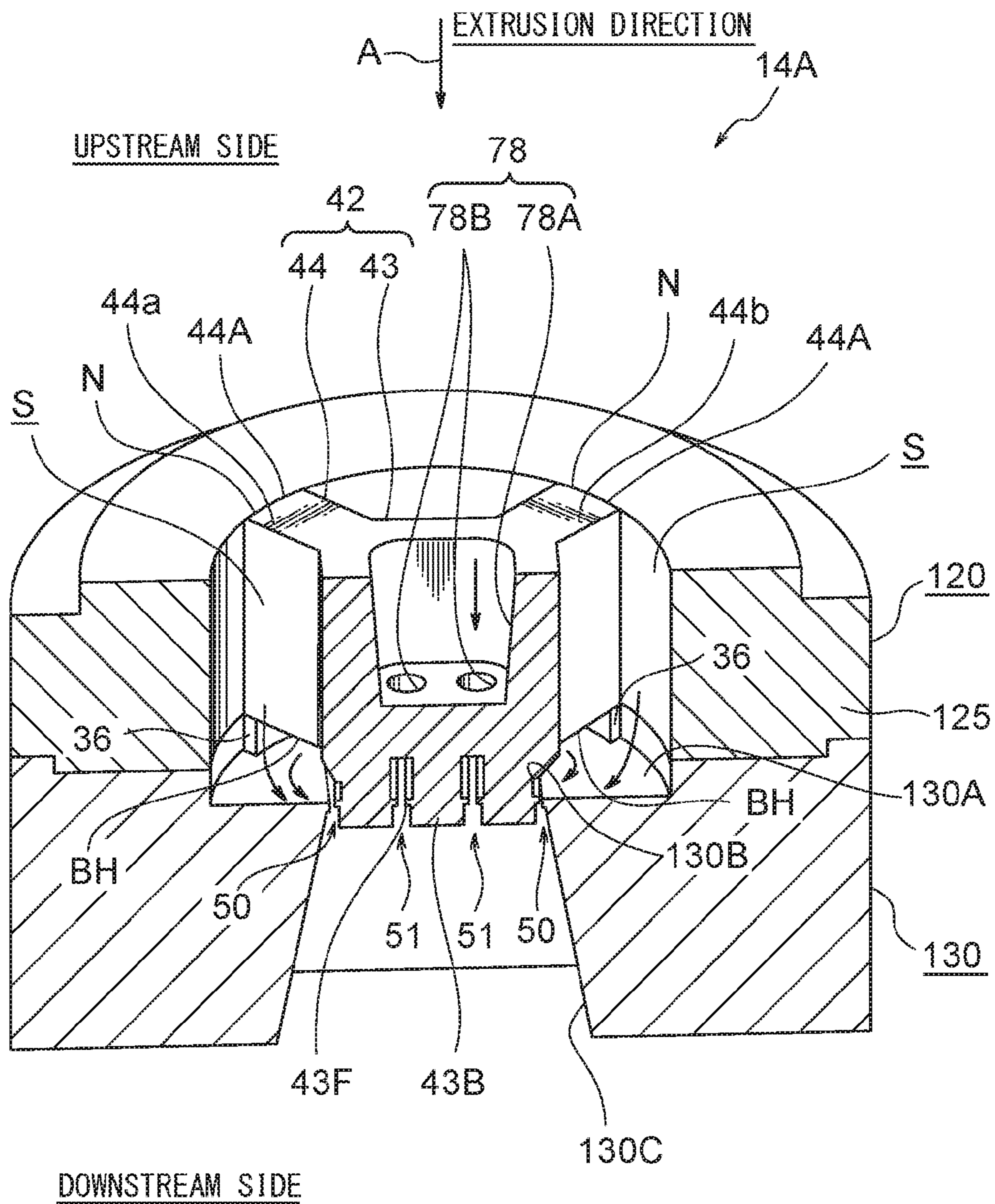


FIG.28A

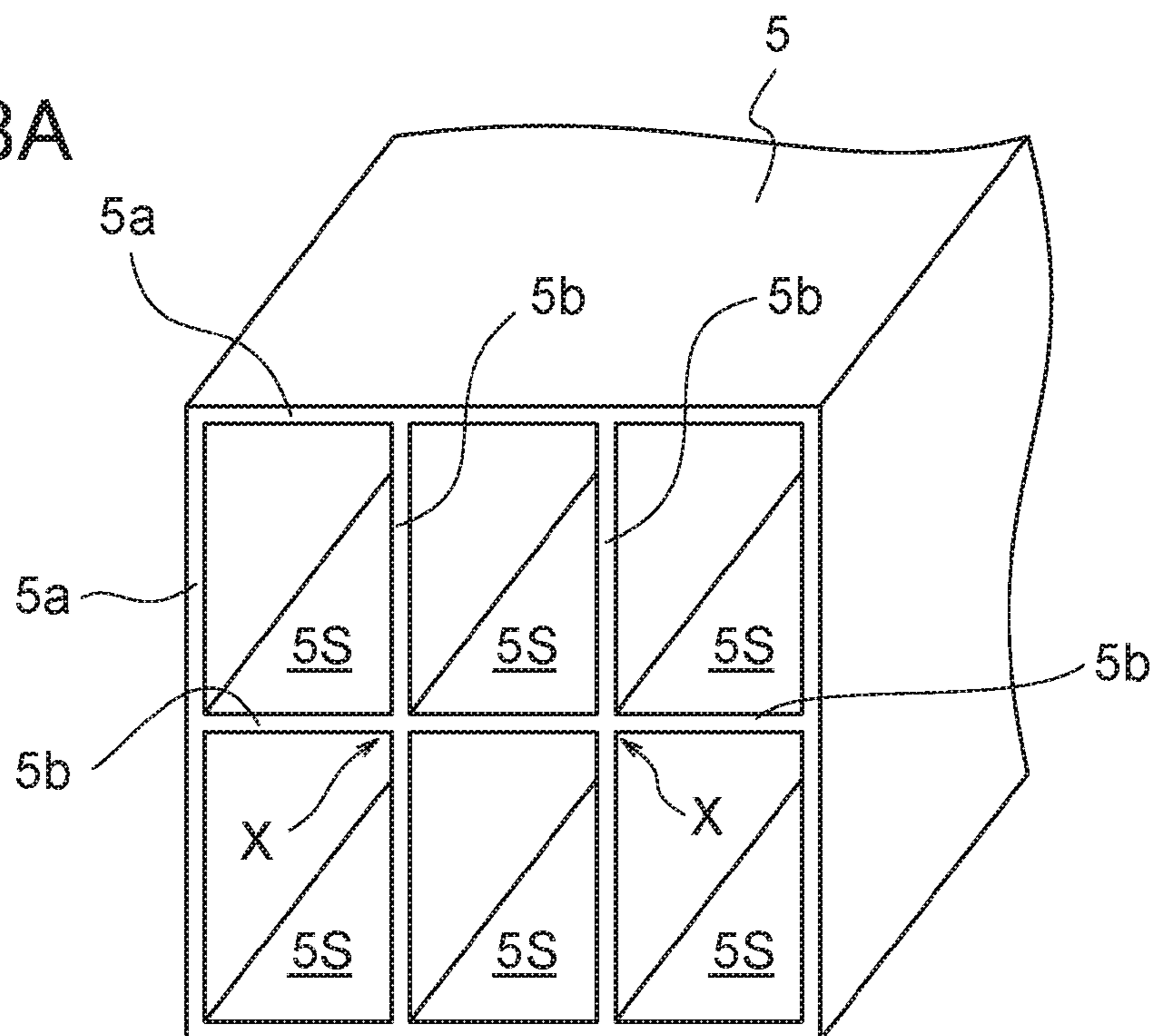
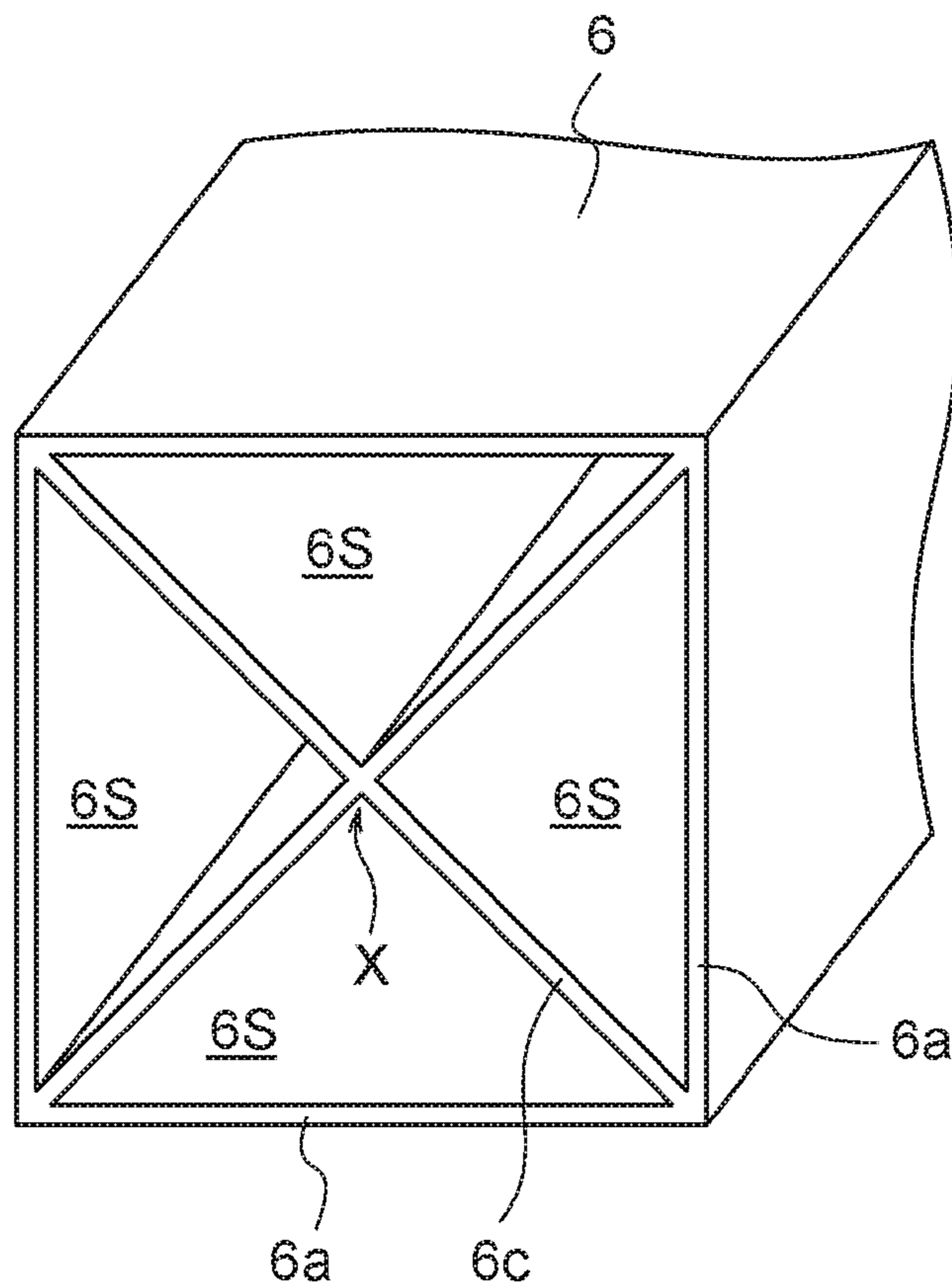


FIG.28B



EXTRUSION DIE FOR FORMING HOLLOW MATERIAL

TECHNICAL FIELD

[0001] The present invention relates to an extrusion die for forming a hollow material and, more specifically, to an extrusion die for forming a hollow material having a partition wall provided in the interior thereof by extruding a high-strength alloy, particularly a high-strength aluminum alloy such as the so-called 7000 series.

BACKGROUND ART

[0002] In general, extrusion processing of an aluminum alloy or the like is broadly employed nowadays since it can provide highly versatile sectional views and is excellent in acquiring hollow materials formed by extrusion.

[0003] That is, products formed by extrusion processing have come to be used broadly as strength members of structural materials, mechanical components, and the like, and demands for extrusion members formed with a high-strength alloy, particularly high-strength aluminum alloys of the so-called 7000 series such as 7075, 7N01, 7003, and the like have been increasing. Further, as hollow materials formed by extrusion, not only the angular columnar shapes but also those with complicated sectional views such as a type in a sectional view with a single lateral partition wall, a type in a sectional view with two lateral partition walls, and the like have recently been produced.

[0004] As an example of conventional extrusion die for molding hollow materials of complicated sectional views, known are a metal-made three-dimensional extrusion material manufacturing method and a manufacturing device thereof (e.g., see Patent Document 1).

[0005] The metal-made three dimensional extrusion material manufacturing method and the manufacturing device thereof are structured to be able to form a three-dimensional extrusion member in which a hollow part and a solid part exist in a mixed manner in the lengthwise direction.

[0006] Further, also known is a hollow material extrusion die for forming a hollow material having a partition wall (e.g., see Patent Document 2).

[0007] This extrusion die is structured to be able to form a hollow material having a laterally-long sectional view with a single partition wall and a hollow material having a sectional view with two partition walls.

[0008] Further, also known are an extrusion processing method and a device for a metal-made extrusion material with different lateral sectional views in the lengthwise direction (e.g., see Patent Document 3). With the extrusion processing method and the device, it is possible to extrusion-mold aluminum-made extrusion materials having different lateral sectional views in the lengthwise direction.

Patent Document 1: Japanese Unexamined Patent Publication Hei 4-305312

Patent Document 2: Japanese Examined Patent Publication Hei 5-9169

Patent Document 3: JP No. 3095916

[0009] Incidentally, in a case of forming a hollow material of a complicated sectional view such as a sectional view with two partition walls by using a high-strength alloy, particularly

7000 series high-strength aluminum as a hollow member molding material, a pair of opposing outer circumferential walls and two parallel partition walls are formed. Those partition walls are in a straight-line form, so that it is considered that billets can flow relatively easily.

[0010] However, recently, not only the hollow materials having the sectional view with two partition walls and the like but also hollow materials having still more complicated sectional views such as a hollow material having a sectional view with a cross-like partition walls, a hollow material having a sectional view with a curve-shaped partition wall, and the like are desired due to the reason for improving the strength of the hollow materials, for example.

[0011] In a case of the hollow material having a sectional view with a cross-like partition wall, the cross-like partition walls forming the sectional view with a cross-like shape intersect with each other at the centers thereof. Thus, the billet formed with an aluminum alloy that is fed from the upstream side and extruded is not easily flown to the direction orthogonal to each other from the intersection. This causes such an issue that the cross-like partition walls having the intersection cannot be formed sufficiently.

[0012] Further, even in a case where there is no intersection and in a case of a hollow material having a complicated curve-shaped partition wall, flow of the billet tends to slow down at the curved part. This causes such an issue that the curve-shaped partition wall cannot be formed sufficiently.

[0013] Further, while the manufacturing method and the manufacturing device of the metallic three-dimensional extrusion material disclosed in Patent Document 1 described above are structured to be able to mold the three-dimensional extrusion material in which the hollow part and the solid part exist in a mixed manner in the lengthwise direction, it is not possible with the device disclosed in Patent Document 1 to mold the hollow material having an intersection constituted with partition walls.

[0014] Further, while the hollow-type material extrusion die having the partition walls disclosed in Patent Document 2 can mold the hollow material having a laterally long sectional view with a partition wall and the hollow material having a sectional view with two partition walls, the intersection is formed with the partition walls as described above. Thus, the extruded billet can flow in one direction but cannot flow easily from the intersection in the direction orthogonal to that direction. Therefore, it is difficult to mold the hollow material having the sectional view with a cross-like form inside therein.

[0015] Further, while the extrusion processing method and the device for the metallic extrusion materials having different lateral sectional views in the lengthwise direction disclosed in Patent Document 3 described above can extrusion-mold aluminum-made extrusion materials having different lateral sectional views in the lengthwise direction, it is not possible with the device disclosed in Patent Document 3 to mold a hollow material having an intersection constituted with partition walls.

[0016] In order to overcome the above-described issues, it is an object of the present invention to provide an extrusion die for forming a hollow material capable of easily forming a hollow material having a partition wall provided inside thereof through extruding a billet formed with a high-strength alloy with a large extrusion processing force, particularly a high-strength aluminum alloy such as the so-called 7000 series.

DISCLOSURE OF THE INVENTION

[0017] In order to achieve the foregoing object, the extrusion die for forming a hollow material according to the present invention is an extrusion die for forming a hollow material, which includes: a male-type member which forms an inner shape of the hollow material while guiding a billet constituted with an aluminum alloy fed from an upstream side toward a downstream side; and a female-type member which holds the male-type member with an outer circumferential part and forms an outer shape of the hollow material, wherein: the male-type member includes a mandrel section for forming the inner shape, and a holder section connected integrally to an outer circumferential part of the mandrel section via a plurality of bridge sections; a billet guide hole for guiding a part of the billet toward the downstream side is provided in a center region of the mandrel section; an upstream-side opening area of the billet guide hole is formed larger than a downstream-side opening area; and a plurality of inner formation pieces are fixedly mounted on a downstream side of the billet guide hole and at positions for forming continuous partition walls inside the hollow material while keeping a billet flow-in gap space forming a merging space of the billet flowing in from each of the bridge sections toward the downstream side.

[0018] The extrusion die for forming a hollow material according to the present invention is structured in the manner described above, so that a part of the billet from the billet guide hole provided in the center region of the mandrel section is mixed with the billet flown-in from the bridge section side and extruded out from the billet flow-in space maintained toward the downstream side. The billet extruded out from the billet guide hole is extruded out toward the position of the partition wall part of the hollow material formed by a plurality of inner formation pieces, so that it can sufficiently reach even into complicated sectional views such as the intersection of the partition walls, the curved part of the curve-shaped partition walls, etc. As a result, it becomes possible to easily form the hollow material having partition walls provided therein through extruding out the billet formed with a high-strength alloy with a large extrusion processing force, particularly a high-strength aluminum alloy such as the so-called 7000 series.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] FIG. 1 is a cross sectional perspective view showing a main part of a first embodiment of an extrusion die for forming a hollow material according to the present invention;

[0020] FIG. 2 is a plan view showing the entire extrusion die for forming the hollow material according to the first embodiment;

[0021] FIG. 3 is a cross sectional view taken along a line III-III of FIG. 2, which is a cross sectional view showing a state where a holder and a bridge outer circumferential face are formed integrally by a bridge section press-fit structure and where a billet guide hole is in a two-stage structure;

[0022] FIG. 4 is a fragmentary sectional arrow view taken along a line IV-IV of FIG. 3;

[0023] FIG. 5 is a sectional perspective view of a male-type member and a female-type member of the first embodiment, which is the entire view of FIG. 1;

[0024] FIG. 6 is an overall plan view showing the surface of the female-type member of the first embodiment;

[0025] FIG. 7 is a perspective view showing a hollow material having a sectional view with a cross-like shape formed by the extrusion die for forming the hollow material according to the first embodiment;

[0026] FIG. 8 is a second embodiment of the extrusion die for forming a hollow material according to the present invention, which is a cross sectional view corresponding to FIG. 3 showing a state where a holder and a bridge outer circumferential face are formed integrally by a bridge section press-fit structure and where a billet guide hole is in a tapered shape;

[0027] FIG. 9 is a sectional perspective view of a male-type member and a female-type member shown in FIG. 8;

[0028] FIG. 10 is an overall plan view showing a third embodiment of the extrusion die for forming a hollow material according to the present invention;

[0029] FIG. 11 is a cross sectional perspective view taken along a line X1-X1 of FIG. 10, which is a cross sectional view showing a state where a holder and a bridge outer circumferential face are formed integrally by a bridge section shrink-fit structure and where a billet guide hole is in a two-stage structure;

[0030] FIG. 12 shows a fourth embodiment of the extrusion die for forming a hollow material according to the present invention, which is a cross sectional perspective view showing a state where a holder and a bridge outer circumferential face are formed integrally by a bridge section shrink-fit structure and where a billet guide hole is in a tapered shape;

[0031] FIG. 13 shows a fifth embodiment of the extrusion die for forming a hollow material according to the present invention, which is an overall plan view showing a state where a holder and a bridge outer circumferential face are formed integrally by a bridge section shrink-fit structure;

[0032] FIG. 14 is a cross sectional perspective view taken along a line XIV-XIV of FIG. 13;

[0033] FIG. 15 is a fragmentary sectional arrow view taken along a line XV-XV of FIG. 14;

[0034] FIG. 16 is a perspective view showing a hollow material having a sectional view with a lattice form which is formed by the extrusion die for forming a hollow material according to the fifth embodiment;

[0035] FIG. 17 is an overall plan view showing a sixth embodiment of the extrusion die for forming a hollow material according to the present invention;

[0036] FIG. 18 is a cross sectional view taken along a line XVIII-XVIII of FIG. 17;

[0037] FIG. 19 is a fragmentary sectional arrow view taken along a line XIX-XIX of FIG. 18;

[0038] FIG. 20 is a perspective view showing a hollow material having a sectional view with a lattice form which is formed by the extrusion die for forming a hollow material according to the sixth embodiment;

[0039] FIG. 21 shows a seventh embodiment of the extrusion die for forming a hollow material according to the present invention, which is an overall plan view showing a state where a holder and a bridge outer circumferential face are formed integrally by a bridge section shrink-fit structure;

[0040] FIG. 22 is a cross sectional perspective view taken along a line XXII-XXII of FIG. 21;

[0041] FIG. 23 is a fragmentary sectional arrow view taken along a line XXIII-XXIII of FIG. 22;

[0042] FIG. 24 is a perspective view showing a hollow material having a sectional view with a lattice form constituted with partition walls of different thicknesses, which is

formed by the extrusion die for forming a hollow material according to the seventh embodiment;

[0043] FIGS. 25A and 25B show schematic views of hollow materials having curve-shaped partition walls formed by utilizing eighth and ninth embodiments of the extrusion die for forming a hollow material according to the present invention, in which FIG. 25A is a view showing a hollow material having curve-shaped partition walls formed by the extrusion die of the eighth embodiment and FIG. 25B is a view showing a hollow material having curve-shaped partition walls formed by the extrusion die of the eighth embodiment;

[0044] FIG. 26 is a schematic view of a hollow material having curve-shaped partition walls formed by utilizing a tenth embodiment of the extrusion die for forming a hollow material according to the present invention, in which two wave-like curve-shaped partition walls are provided;

[0045] FIG. 27 is a cross sectional perspective view showing a modification example of the fifth embodiment (FIG. 14) according to the present invention; and

[0046] FIGS. 28A and 28B show perspective views, in which both FIG. 28A and FIG. 28B show modification examples of a hollow material having partition walls with intersections formed by utilizing the extrusion die for forming a hollow material according to the present invention.

BEST MODES FOR CARRYING OUT THE INVENTION

[0047] Hereinafter, a first embodiment of an extrusion die for forming a hollow material (simply referred to as an extrusion die hereinafter) of the present invention will be described by referring to FIG. 1 to FIG. 6.

[0048] An extrusion die 10 of the first embodiment is for forming a hollow material formed with a high-strength alloy, particularly a high-strength aluminum alloy that is the so-called 7000 series. Further, among hollow materials having complicated sectional views such as curve-shaped partition walls, partition walls forming an intersection, and the like, the extrusion die 10 forms a hollow material 1 having a sectional view with a cross formed with partition walls 1b and 1b provided in a cross-like form having an intersection X inside thereof as shown in FIG. 7.

[0049] As shown in FIG. 1 and FIG. 3, the extrusion die 10 is constituted by including: a male-type member 20 having a mandrel section 23 which forms the inner shape of the hollow material 1 while guiding a billet B formed with an aluminum alloy extruded out from the upstream side toward the downstream side; and a female-type member 30 which holds the male-type member 20 with the outer circumferential part and forms the outer shape of the hollow material 1.

[0050] The male-type member 20 is constituted by including: the mandrel section 23; and a holder section 25 which is integrally connected to the outer circumferential part of the mandrel section 23 via a plurality of bridge sections 24.

[0051] The holder section 25 is formed in a disc shape as a whole with a prescribed thickness. On the end face of the upstream side of the extrusion direction thereof, formed is a billet introduction opening 25B in a disc shape as a whole while being sectioned by each of the bridge sections 24.

[0052] As will be described later in details, a billet guide hole 28 for guiding a part of the billet B toward the downstream side is provided in the center region of the mandrel section 23.

[0053] Further, an upstream-side opening area 28A of the billet guide hole 28 is formed to be larger than the opening area of a downstream-side opening 28B.

[0054] Further, a plurality of (four in this embodiment) inner formation pieces 23B are fixed on the side opposing to the downstream-side opening of the billet guide hole 28 and at positions for forming partition walls having an intersection X inside the hollow material 1 while keeping a billet insertion hole BH1 (a billet flow-in gap space) forming a merging space with the flow-in billet B from each of the bridge sections 24 on the downstream side, i.e., towards the female-type member 30 side. The inner formation pieces 23B are provided to the mandrel section 23 via a connecting section 23M.

[0055] Further, in the female-type member 30, an outer formation die hole 30B for forming outer shapes of a plurality of the hollow materials 1 is provided by opposing to the entire outer circumferential face of the four inner formation pieces 23.

[0056] Hereinafter, each structure will be described in more details.

[0057] First, the entire extrusion die 10 will be described by referring to FIGS. 2 and 3.

[0058] As shown in FIG. 2, the extrusion die 10 is formed in a disc shape as a whole. Further, as shown in FIG. 3, the extrusion die 10 is constituted by including the male-type member 20, the female-type member 30, and a back die 70 for holding the female-type member 30.

[0059] Further, the billet B is housed within a billet extrusion device 80 constituted with a chamber and the like disposed in the upstream side of the male-type member 20, and extruded out by the billet extrusion device 80.

[0060] The male-type member 20, the female-type member 30, and the back die 70 are connected integrally.

[0061] That is, as shown in FIG. 2 and FIG. 3, after the male-type member 20 and the female-type member 30 are placed at the positions by two positioning pins 71, for example, the male-type member 20, the female-type member 30, and the back die 70 are connected and fixed by two connection bolts 72, for example.

[0062] As shown in details in FIGS. 3 and 5, the male-type member 20 is constituted by including a spider 22. The spider 22 is constituted by including: the mandrel section 23 which forms the inner shape of the hollow material 1; the bridge section 24 which supports the mandrel section 23 and is projected substantially in an X-letter shape toward outer side from the periphery of the mandrel section 23; and the holder section 25 which is connected integrally via the bridge section 24.

[0063] As shown in FIG. 2, the bridge section 24 is constituted with four pieces of a first bridge 24a, a second bridge 24b, a third bridge 24c, and a fourth bridge 24d disposed clockwise. Further, the spaces between each of the bridges 24a to 24d form the billet introducing spaces S.

[0064] A top face 23A of the mandrel section 23 is formed in a disc-like flat surface, and the top faces of the bridges 24a to 24d are connected to the top face 23A. The top faces of the bridges 24a to 24d are formed in a downward sloping shape from the top face 23A of the mandrel section 23 toward the internal circumferential face of the holder section 25.

[0065] Further, the top face 23A of the mandrel section 23 is formed as the same height with a top end face 25A of the holder section 25 (see FIGS. 3 and 5) when the spider 22 and the holder section 25 are assembled integrally.

[0066] As shown in FIGS. 1, 3, and 5, tip external circumferential faces 24A of the bridges 24a to 24d are formed to be engaged with bridge receiving faces 26B of a bridge holding section 26 of the holder section 25.

[0067] That is, in the holder section 25, provided by corresponding to each of the bridges 24a to 24d are: bridge presser sections 26A which are formed on the top end of the holder section 25 for pressing the tip upper faces 24B (see FIG. 3) of the bridges 24a to 24d; and the bridge receiving faces 26B which are formed continuously to the bridge presser sections 26A and formed to be substantially equal (preferably a little wider) with respect to the width of the bridge 24a and the like.

[0068] Further, fixing members 27 in a flat square columnar shape, for example, are knocked into the bridge presser sections 26A so that each of the bridges 24a to 24d does not rotate.

[0069] As shown in FIG. 5, the fixing members 27 are knocked from the above into knock-in holes for the fixing members 27 opened over the upper-side parts of the bridge presser sections 26A and the bridges 24a to 24d after precisely positioning each of the bridges 24a to 24d and the bridge presser sections 26A.

[0070] Further, the engaging faces between the tip outer circumferential faces 24A of the bridges 24a to 24d and the bridge receiving faces 26B of the holder section 25 are formed as sloping faces approaching toward the center of the die from the upstream side of the extrusion direction toward the downstream direction. Thus, moment generated at the application point of extrusion by the inner formation pieces 23B to be described later can be decreased, thereby making it possible to increase the strength of each of the bridges 24a to 24d. As a result, breakage of each of the bridges 24a to 24d can be prevented.

[0071] Note that the tip outer circumferential faces 24A of the bridges 24a to 24d and the bridge receiving faces 26B of the holder section 25 are integrated by press fitting by a bridge section press-fit structure M.

[0072] As shown in FIG. 1 in details, the bottom ends of the bridge sections 24a to 24d are located at positions distant from the holder receiving face 30A of the female-type member 30 toward the upper side by a prescribed distance, and formed in a shape connected therefrom to a plurality (four in this embodiment) of the inner formation pieces 23B for forming the inner shape of the hollow materials 1 (see FIG. 7) via the connecting section 23M of the mandrel section 23.

[0073] Further, at each bottom end of each of the bridges 24a to 24d, a tunnel-like billet insertion hole BH is formed with the bottom end of each of the bridges 24a to 24d at the bottom end part of the bridge receiving face 26B of the holder section 25 and the holder receiving face 30A of the female-type member 30. As shown with an arrow, the billet insertion hole BH forms a billet merging space where the billets B introduced from the billet introduction spaces S for introducing each billet B are merged.

[0074] Thereby, the billets B are introduced from the billet introduction space S for introducing each billet B, merged in the billet insertion hole BH, and extruded out to the downstream side.

[0075] As shown in FIGS. 1, 3, and 5, the four inner formation pieces 23B are provided at the downstream-side end of the flow of the billet B of the mandrel section 23.

[0076] Each of those inner formation pieces 23B is formed substantially in a square columnar shape and provided at the end of the mandrel section 23 via the connecting section 23M

as described above (also see FIG. 4). Further, the four inner formation pieces 23B are projected out toward the female-type member 30 side and, as shown in FIGS. 4 and 6 in details, formed to be inserted into the outer formation die hole 30B formed in the female-type member 30.

[0077] The female-type member 30 is formed to oppose to the outer circumferential face of the entire four inner formation pieces 23B and in a size securing a gap L1 of a prescribed size.

[0078] Further, each of the inner formation pieces 23B is designed to be inserted into the outer formation die hole 30B of the female-type member 30, and the gap L1 in the prescribed size set between the outer circumference of each of the inner formation pieces 23B and the outer formation die hole 30B forms a material outer formation hole 50 (see FIGS. 1, 3, and 5). Furthermore, as shown in FIG. 3, the outer formation die hole 30B is formed with a straight-line part in a small size and a clearance hole 30C expanded from the straight-line part toward the outer circumference direction of the female-type member 30.

[0079] Each of such inner formation pieces 23B is designed to form each of the four inside spaces 1S of the hollow material 1 in a sectional view with a cross inside thereof as shown in FIG. 7, and the four inner formation pieces 23B are disposed so that the entire shape thereof forms substantially a square shape as shown in FIG. 4.

[0080] As described above, each of the inner formation pieces 23B is provided at the end on the downstream side of the extrusion direction of the material inner forming section 23 via the connecting section 23M.

[0081] As shown in FIG. 1, on the upstream side of the extrusion direction of each of the inner formation pieces 23B, a band-like flange section 23F projected toward the outer side from the respective outer circumferences is provided by being wrapped around the outer circumference of each of the inner formation pieces 23B.

[0082] As shown in FIGS. 1 and 4, a gap L2 in a prescribed size is formed between the opposing flange sections 23F of the inner formation pieces 23B that are neighboring to each other. Further, with those gaps L2, the material formation inner hole 51 for forming the cross-like partition walls 1b and 1b of the hollow material 1 is constituted.

[0083] Further, the outer circumference of each of the flange sections 23F of the inner formation pieces 23B is disposed to oppose to the outer formation die hole 30B formed in the female-type member 30. Further, the gap L1 in the prescribed size is formed between the both, and the material formation outer hole 50 for forming outer circumferential walls 2a and 2a of the hollow material 1 is formed with those gaps L1.

[0084] As shown in FIGS. 1, 3, and the like, the top faces of the flange sections 23F of the respective inner formation pieces 23B are on the same flat surface as that of the holder receiving face 30A of the female-type member 30. Thus, the billet B is also extruded out along the top end faces of the flange sections 23F via the side face of the connecting section 23M of the mandrel section 23 from the billet insertion hole BH.

[0085] As described above, in the hollow material 1, the single intersection X is formed with the two partition walls 1b and 1b. Thus, the billets B extruded out only from the billet introduction space S for introducing the billet B, the billet insertion hole BH, and the billet insertion hole BH1 may not be sufficient to fill up to the intersection X.

[0086] Thus, as shown in FIGS. 1 to 4, the die 10 of the first embodiment is structured to include the billet guide hole 28 which guides a part of the billet B toward the downstream side provided in the center region of the mandrel section 23.

[0087] The billet guide hole 28 is provided by corresponding to the intersection X of the partition walls 1b and 1b. Further, the upstream side opening area located on the billet B flow-in side of the mandrel section 23 is formed larger than the opening area of the downstream side opening located on the billet B flow-out side.

[0088] Further, on the side opposing to the downstream-side opening of the billet guide hole 28 and also between the opposing surfaces of the connecting section 23M, the billet insertion hole BH1 constituting the billet introduction gap space is provided. The billet insertion hole BH1 is for constituting the billet merging space where the billets B introduced into the billet introduction spaces S for introducing the billets B are merged with each other, and the billets B introduced from the billet guide hole 28 are extruded out via the billet insertion hole BH1.

[0089] That is, as shown in details in FIGS. 1, 3, and 5, the billet guide hole 28 of the first embodiment is constituted with a large opening hole 28A formed with a diameter $\phi 1$ on the upstream side including a step part in the midway of the mandrel section 23 and a small opening hole 28B formed with a diameter $\phi 2$ which introduces a part of the billet B on the lower side of the mandrel section 23, i.e., on the side of the intersection X of the partition walls 1b and 1b.

[0090] Thus, a part of the billet B fed from the upstream side and extruded out is securely introduced into the small opening hole 28B by being guided by the large opening hole 28A.

[0091] Further, since the small opening hole 28B is provided on the lower side of the mandrel section 23, it is possible to secure thickness of the small opening hole 28B to be large in the mandrel section 23. Therefore, the strength of the die for the stress at the time of extrusion can be increased. As a result, cracking of the die can be prevented.

[0092] The region where one corner each of flange sections 23F of the four inner formation pieces 23B gathers, the position of the intersection point P corresponds to the intersection X formed with the partition walls. Further, the position of the small opening hole 28B is set so that the position of the intersection point P and the center of the small opening hole 28B of the billet guide hole 28 to be described later in details become consistent.

[0093] Next, a forming method of the hollow material 1 by the extrusion die 10 in the above-described structure will be described.

[0094] When the billet B is fed and extruded out by the billet extrusion device 80 provided on the upstream side of the extrusion direction of the billet B for the male-type member 20, the billet B is first introduced into the billet introduction space S for introducing the billet B constituted with the gap formed in the mandrel section 23 of the male-type member 20, the bridge section 24, and the holder section 25, and a part thereof is introduced into the larger opening hole 28A of the billet guide hole 28.

[0095] The billet B introduced into the billet introduction space S is introduced into the material formation outer hole 50 from the side faces of the first to fourth bridges 24a to 24d, the side face of the material inner formation section 23, the billet insertion hole BH, the billet insertion hole BH1, and the top

face of the flange section 23F of each of the inner formation pieces 23B, and extruded out from the material formation outer hole 50.

[0096] Meanwhile, a part of the billet B introduced into the large opening hole 28A of the billet guide hole 28 is securely introduced into the small opening hole 28B by being guided by the large opening hole 28A. At that time, the billet B from the billet insertion hole BH1 is also merged and extruded out.

[0097] Then, the extruded and molded hollow material 1 is fed out from a material feed-out hole 70A formed in the back die 70. Thereafter, it is held by a holding mechanism, not shown, and conveyed into a prescribed stockyard or the like.

[0098] Next, the hollow material 1 molded by the above-described extrusion die 10 according to the above-described first embodiment will be described by referring to FIG. 7.

[0099] The hollow material 1 is constituted with the outer circumferential walls 1a, 1a having a square sectional view and the partition walls 1b, 1b in a cross-like form provided inside the outer circumferential walls 1a, 1a. The center part where the partition walls 1b and 1b intersect with each other is the intersection X. Thus, the hollow material 1 is formed in a sectional view with a cross having four spaces 1S inside thereof.

[0100] The hollow material 1 having such sectional view with a cross is molded by continuously extruding out the billet B from the material formation outer hole 50 and the material formation inner hole 51 of the extrusion die 10.

[0101] The extrusion die 10 of the first embodiment is structured in the manner described above, so that following effects can be acquired:

[0102] (1) A part of the billet B fed from the upstream side is extruded out from the billet guide hole 28 provided in the center region of the mandrel section 23 toward the intersection point P where the one corner each of the flange sections 23F of the four inner formation pieces 23B gathers. The position of the intersection point P corresponds to the intersection X formed by the partition walls and, further, the intersection point P and the center of the small opening hole 28B of the billet guide hole 28 are consistent with each other on the same line, so that the billet B fed through the small opening hole 28B is extruded out via the intersection point P. Thus, the intersection X can be molded easily. As a result, it becomes possible to easily mold the hollow material in which complicated-shape partition walls are provided through extruding out a billet formed with a high-strength alloy of a high extrusion processing force, particularly a high-strength aluminum alloy such as the so-called 7000 series.

[0103] (2) The Billet guide hole 28 is in a two-stage structure constituted with the large opening hole 28A formed on the upper side of the mandrel section 23 and the small opening hole 28B formed in the lower side of the mandrel section 23. A part of the billet B extruded out from the upstream side is securely introduced into the small opening hole 28B by being guided by the large opening hole 28A. This makes it possible to secure the sufficient billet for forming the partition walls.

[0104] (3) The engaging face between the tip outer circumferential face 24A of the first to fourth bridges 24a to 24d of the bridge section 24 and the bridge receiving face 26B of the bridge holding section 26 is formed as a sloping surface approaching the center of the die toward the downstream side of the extrusion direction. Therefore, the distance between the base end of the bridge receiving face 26B of the holder section 25 to the application point in the direction orthogonal to the extrusion direction at the inner formation piece 23 from the

base end can be made shorter. Thus, the moment generated at the application point of the inner formation piece **23** can be decreased, so that the strength of the first to fourth bridges **24a** to **24d** can be increased. This makes it possible to prevent breakage of the first to fourth bridges **24a** to **24d**. As a result, it becomes possible to perform high-speed extrusion and to extend the life of the die even when extrusion-molding the billet B formed with a high-strength alloy of a high extrusion processing force, particularly a high-strength aluminum alloy such as the so-called 7000 series.

[0105] (4) Each of the bridges **24a** to **24d** and the bridge receiving face **26B** are formed integrally by the bridge section press-fit structure M, so that the strength of each of the bridges **24a** to **24d** and in its turn the strength of the mandrel section **23** can be secured. Thus, the pressure at the time of extrusion of the billet B can be received by the entire male-type member **20**. As a result, it becomes possible to perform high-speed extrusion and to extend the life of the die even when extrusion-molding the billet B formed with a high-strength alloy of a high extrusion processing force, particularly a high-strength aluminum alloy such as the so-called 7000 series.

[0106] (5) Each of the bridges **24a** to **24d** and the bridge presser section **26A** is fixed by the whirl-stop fixing members **27** knocked into the knock-in holes opened over the spaces therebetween, so that rotation of each of the bridges **24a** to **24d** can be prevented. Thereby, the hollow materials **1** of high precision can be molded.

[0107] Next, a second embodiment of the extrusion die of the present invention will be described by referring to FIG. 8 and FIG. 9.

[0108] The shape of the billet guide hole **28** of the extrusion die **10** according to the first embodiment is in a two-stage structure of the large opening hole **28A** and the small opening hole **28B**, whereas it is formed as a billet guide hole **38** in a tapered shape in an extrusion die **11** of the second embodiment. However, other members, structures, and the like are completely the same as those of the extrusion die **10** of the first embodiment.

[0109] Therefore, the same reference numerals are applied to the same structures and the same members as those of the first embodiment, and only the different points will be described. Note here that the mandrel section **23** is different only in terms of the shapes of the billet guide holes **28** and **38**, so that the reference numeral **23** that is the same as the case of the first embodiment is also applied in the second embodiment for explanation.

[0110] The shape of the billet guide hole **38** of the extrusion die **11** according to the second embodiment is formed in a tapered shape which becomes smaller toward the downstream-side opening side from the upstream-side opening of the mandrel section **23**.

[0111] Note here that the diameter $\phi 1$ of the upstream-side opening of the mandrel section **38** is substantially equivalent to the diameter $\phi 1$ of the large opening hole **28A** of the first embodiment, and the diameter $\phi 2$ of the downstream-side opening of the tapered-shape hole is substantially equivalent to the diameter $\phi 2$ of the small opening hole **28B** of the first embodiment.

[0112] With the billet guide hole **38** of the extrusion die **11** according to the second embodiment, as in the case of the first embodiment, in the region where one corner each of flange sections **23F** of the four inner formation pieces **23B** gathers, the position of the intersection point corresponds to the intersection X formed with the partition walls. Further, the posi-

tion of the billet guide hole **38** is set so that the position of the intersection point and the center of the of the billet guide hole **38** become consistent with each other.

[0113] As in the case of the extrusion die **10** of the first embodiment, it is possible with the extrusion die **11** of the second embodiment described above to mold the hollow material **1** having a sectional view with a cross inside thereof as shown in FIG. 7.

[0114] With the extrusion die **11** of the second embodiment described above, it is possible to acquire substantially the same actions as those of the extrusion die **10** of the first embodiment and substantially the same effects as those described in (1) to (5). In addition, it is possible to achieve the following effect:

[0115] (6) The flow of the billet B can become smooth since the billet guide hole **38** is formed in a tapered shape which becomes smaller from the upstream-side opening of the mandrel section **23** toward the downstream-side opening side.

[0116] Next, a third embodiment of the extrusion die according to the present invention will be described by referring to FIG. 10 and FIG. 11.

[0117] In the extrusion dice **10** and **11** of the first and second embodiments, the lower part of the first to fourth bridges **24a** to **24d** of the bridge section **24** and the lower part of the bridge receiving face **26B** are sloping in the direction approaching the dice center side as going toward the female-type member **30**, and those are engaged by the bridge section press-fit structure M.

[0118] In the meantime, in an extrusion die **12** of the third embodiment, a tip outer circumferential face **34A** of first to fourth bridges **34a** to **34d** of a bridge section **34** for supporting a mandrel section **33** and a part of a holder section **125** for holding each of the bridges **34a** to **34d** are formed as an integrated structure by the bridge section shrink-fit structure N.

[0119] Note here that shrink fitting is a method for acquiring strong bonding by utilizing heat, which is a method with which a member such as a disc with a hole is thermally expanded, a shaft formed slightly larger than the diameter of the hole is fitted therein, and it is cooled thereafter to be fixed. The method is used as bonding of fastening type. Further, the both (the disc and the shaft in the above case) are tightly fixed by shrink fitting.

[0120] A male-type member **120** of the extrusion die **12** according to the third embodiment is substantially the same in terms of the entire shape as those of the extrusion dice **10** and **11** of the first and second embodiments, and the only difference is that there is no bridge presser section **26A** that is formed in the extrusion die **10** and the like.

[0121] A spider **32** of the third embodiment is constituted with: the mandrel section **33** corresponding to the inner shape of the hollow material **1**; and the bridge section **34** which supports the mandrel section **33** and supports the mandrel section **33**.

[0122] The bridge section **34** is constituted with a plurality of, i.e., four bridges of the first bridge **34a**, the second bridge **34b**, the third bridge **34c**, and the fourth bridge **34d** projected substantially in an X-letter shape from the periphery of the mandrel section **33** to the outer side, and the space between each of the bridges **34a** to **34d** forms the billet introduction space S.

[0123] In the center region of the mandrel section **33**, the billet guide hole **28** for guiding a part of the billet B toward the downstream side is provided. The billet guide hole **28** is

formed by corresponding to the intersection X of the partition walls **1b** and **1b**. Further, the billet guide hole **28** is constituted with the large opening hole **28A** and the small opening hole **28B**.

[0124] The billet guide hole **28** is in a similar structure as that of the billet guide hole **28** of the extrusion die **10** according to the first embodiment.

[0125] A supporting member **36** that is a bridge section supporting mechanism for supporting each of the bridges **34a** to **34d** is interposed between the lower end of the outer circumference of each of the bridges **34a** to **34d** and the holder receiving face **30A** of the female-type member **30**. The both ends of the supporting member **36** are fixed over the lower end of each of the bridges **34a** to **34d** and the holder receiving face **30A** of the female-type member **30**.

[0126] Therefore, a gap of the height of the supporting member **36** is to be formed between the lower end of each of the bridges **34a** to **34d** and the holder section receiving face **30A** of the female-type member **30**. This gap forms the tunnel-like billet insertion hole BH where the billets B introduced within the neighboring bridge insertion holes BH are merged with each other. The billet insertion hole BH has the same function as that of the billet insertion hole BH of the first embodiment, which constitutes the billet merging space and the billet flow-in gap space.

[0127] Further, four inner formation pieces **33B** substantially in the same shape as that of the inner formation piece **23B** are provided in the downstream-side end of the flow of the billet B of the mandrel section **33**, and respective flange sections **33F** are provided to those inner formation pieces **33B**.

[0128] Each of the inner formation pieces **33B** is projected toward the female-type member **30** side and inserted into the outer formation die hole **30B** formed in the female-type member **30**.

[0129] Such inner formation pieces **33B** form each of the four inside spaces **1S** of the hollow material **1** having a sectional view with a cross inside thereof as shown in FIG. 7. Further, those inner formation pieces **33B** are formed in a square shape substantially in the same shape as that of the inner formation pieces **23B** of the first and second embodiments and also disposed in a square form.

[0130] With the extrusion die **12** of the third embodiment described above, it is possible to mold the hollow material **1** having the sectional view with a cross inside thereof as shown in FIG. 7.

[0131] With the extrusion die **12** of the third embodiment described above, it is possible to acquire substantially the same actions as those of the extrusion die **10** of the first embodiment and substantially the same effects as those described in (1), (2), and (6). In addition, it is possible to achieve the following effect:

[0132] (7) The tip outer circumferential face **34A** of each of the bridges **34a** to **34d** and a part of the inner circumferential face of the holder section **125** are formed integrally by the bridge section shrink-fit structure N, so that the strength of each of the bridges **34a** to **34d** and in its turn the strength of the mandrel section **33** can be secured. Thus, the pressure at the time of extrusion of the billet B can be received by the entire male-type member **20**. As a result, it becomes possible to perform high-speed extrusion and to extend the life of the die even when extrusion-molding the billet B formed with a

high-strength alloy of a high extrusion processing force, particularly a high-strength aluminum alloy such as the so-called 7000 series.

[0133] (8) At the lower end of each of the bridges **34a** to **34d**, the supporting member **36** is fixed over the lower end of each of those and the holder receiving face **30A** of the female-type member **30**, so that a gap of the height of the supporting member **36** is to be formed between the lower end of each of the bridges **34a** to **34d** and the holder section receiving face **30A** of the female-type member **30**. The supporting member **36** can form the tunnel-like billet insertion hole BH where the billets B introduced into the neighboring bridge insertion spaces S merge with each other and also can support each of the bridges **34a** to **34d**. Therefore, the supporting member **36** can serve two roles, so that it is possible to effectively utilize the member.

[0134] Next, a fourth embodiment of the extrusion die according to the present invention will be described by referring to FIG. 12.

[0135] In an extrusion die **13** of the fourth embodiment, the shape of the billet guide hole **38** is formed different from that of the billet guide hole **28** of the extrusion die **12** of the third embodiment. Further, the shape of the billet guide hole **38** is the same as that of the billet guide hole **38** of the extrusion die **11** of the second embodiment.

[0136] Other members, structures, and the like are completely the same as those of the extrusion die **12** of the third embodiment. Therefore, the same reference numerals are applied to the same structures and the same members as those of the third embodiment, and only the different points will be described.

[0137] The shape of the billet guide hole **38** of the extrusion die **13** according to the fourth embodiment is formed in a tapered shape which becomes smaller toward the downstream-side opening from the upstream-side opening of the mandrel section **33**.

[0138] In the extrusion die **13** of the fourth embodiment, the four inner formation pieces **33B** are disposed in a square form, so that it is possible to mold the hollow material **1** having the sectional view with a cross inside thereof as shown in FIG. 7.

[0139] With the extrusion die **13** of the fourth embodiment described above, it is possible to acquire substantially the same actions as those of the extrusion die **12** of the third embodiment and substantially the same effects as those described in (1), (2), (7), and (8).

[0140] Next, a fifth embodiment of the extrusion die according to the present invention will be described by referring to FIG. 13 to FIG. 16.

[0141] As in the cases of the third and fourth embodiments, in an extrusion die **14** of the fifth embodiment, a tip outer circumferential face **44A** of each of first to fourth bridges **44a** to **44d** and a part of the inner circumferential face of the holder section **125** are fixed integrally by the bridge section shrink-fit structure N. Thus, the strength of each of the bridges **44a** to **44d** and a mandrel section **43** is secured.

[0142] In the extrusion die **14**, the structure of a billet guide hole **48** is designed to be different from those of the billet guide holes **28**, **38** of the extrusion dice **12**, **13** to the third and fourth embodiments. However, other members, structures, and the like are completely the same as those of the extrusion dice **13** and **14** of the third and fourth embodiments.

[0143] Therefore, the same reference numerals are applied to the same structures and the same members as those of the third embodiment, and only the different points will be described.

[0144] The extrusion die **14** of the fifth embodiment is structured to be able to mold a hollow material **2** having a sectional view with a lattice form having four intersections **X** as shown in FIG. **16**.

[0145] The male-type member **120** includes a spider **42** which is constituted with: the mandrel section **43** for molding the inner shape of the hollow material **2**; and a bridge section **44** which supports the mandrel section **43** and is projected substantially in an X-letter form toward the outer side from the periphery of the mandrel section **43**. The spider **42** is integrally connected with the holder section **125** via the bridge section **44**.

[0146] In FIG. **13**, the bridge section **44** is constituted with four bridges disposed clockwise, which are a first bridge **44a**, a second bridge **44b**, a third bridge **44c**, and a fourth bridge **44d**. Further, spaces between each of the bridges **44a** to **44d** form the billet introduction spaces **S** for introducing the billet **B**.

[0147] As shown in FIGS. **13** and **14**, the billet guide hole **48** is in a two-stage structure constituted with a large opening hole **48A** formed on the upstream side of the mandrel section **43** and a small opening hole **48B** formed in the downstream side of the mandrel section **43**, i.e., formed to correspond to the position where the intersection **X** of the partition walls **1b** and **1b** of the hollow material **2** can be formed.

[0148] The large opening hole **48A** is substantially in a square shape on a plan view and is formed in a recessed shape that is recessed by a prescribed size into the lower-part side of the mandrel section **43**. A plurality (four in this embodiment) of the small opening holes **48B** are formed at the large opening hole **48A**. The large opening hole **48A** is provided by opening the holes toward the downstream side of the mandrel section **43** from the bottom face of the large opening hole **48A**.

[0149] In the extrusion die **14** of the fifth embodiment, nine inner formation pieces **43B** are provided to be able to correspond to four intersections **X**. Those inner formation pieces **43B** are formed substantially in the same square shape as that of the inner formation pieces **23B** of the extrusion die **10** of the first embodiment, and are provided in the lower part of the mandrel **43** via a connecting section that is in the same structure as that of the connecting section **23**.

[0150] Further, those inner formation pieces **43B** are disposed to form a square shape as a whole as shown in FIG. **15**. Furthermore, the material formation inner hole **51** is formed by the gaps **L2** between each of the inner formation pieces **43B**. Further, the nine inner formation pieces **43B** are inserted into an outer formation die hole **130B** of the female-type member **130**.

[0151] In the extrusion die **14** of the fifth embodiment, the mandrel **43** is substantially in the same size as that of the mandrel sections **33** and **33** of the extrusion die **13** of the fourth embodiment, and the nine inner formation pieces **43B** are provided in the mandrel section **43**. Thus, the size of each of the inner formation pieces **43B** is formed to be smaller than the size of each of the four inner formation pieces **33B** of the extrusion die **13** of the fourth embodiment. The mandrel **43** may be formed larger in a case where each of the inner formation pieces **43B** is to be formed larger.

[0152] Further, the four regions where one corner each of flange sections **43F** of the nine inner formation pieces **43B** gathers, the positions of each of the intersection points **P** correspond to the intersections **X** formed with the partition walls. Further, the positions of the small opening holes **48B** are set so that the positions of the four intersection points **P** and the centers of each of the small opening holes **48B** of the four billet guide holes **48** become consistent with each other.

[0153] Next, the hollow material **2** molded by the extrusion die **14** of the above-described fifth embodiment will be described by referring to FIG. **16**.

[0154] The hollow material **2** is formed substantially in a square sectional shape and constituted with two pairs of outer circumferential walls **2a**, **2a** disposed to oppose to each other and two each of partition walls **2b**, **2b** provided laterally and vertically inside thereof. The sectional view thereof is a lattice form having nine spaces **2S** inside thereof. Further, there are four intersections **X** where the partition walls **2b** and **2b** intersect.

[0155] Note that the thickness of the partition walls **2b** and **2b** is the same.

[0156] With the extrusion die **14** of the fifth embodiment described above, it is possible to acquire substantially the same actions as those of the extrusion dice of the third and fourth embodiments and substantially the same effects as those described in (1), (2), (7), and (8). In addition, it is possible to achieve the following effect:

[0157] (9) A part of the billet **B** fed from the upstream side is extruded out from the large opening hole **48A** of the billet guide hole **48** provided in the center region of the mandrel section **43** via the small opening hole **48B** toward the four intersection points **P** where the one corner each of the flange sections **43F** of the nine inner formation pieces **43B** gathers. The positions of each of the intersection points **P** correspond to the four intersections **X** formed by the partition walls and, further, each of the intersection points **P** and the centers of the small opening holes **48B** of each of the billet guide holes **48** are consistent with each other on the same line, so that the billet **B** fed through each of the small opening holes **48B** is extruded out via each of the intersection points **P**. Thus, the four intersections **X** can be molded easily.

[0158] Next, a sixth embodiment of the extrusion die according to the present invention will be described by referring to FIGS. **17** to **20**.

[0159] In the extrusion die **14** of the fifth embodiment, there are the four small opening holes **48B** provided in the bottom face of the large opening hole **48A**. However, in an extrusion die **15** of the sixth embodiment, nine small opening holes **58B** are provided in the bottom face of a large opening hole **58A**.

[0160] As described above, the extrusion die **15** of the sixth embodiment is different from the extrusion die **14** of the fifth embodiment only in terms of the shapes of the billet guide holes **48B** and **58B**. Other members, structures, and the like are completely the same as those of the extrusion die **14** of the fifth embodiment. Therefore, the same reference numerals are applied to the same structures and the same members as those of the fifth embodiment, and only the different points will be described.

[0161] The extrusion die **15** of the sixth embodiment is structured to be able to form a hollow material **3** having a sectional view with a lattice form as shown in FIG. **20**. Further, in the hollow material **3**, nine intersections **X** are provided.

[0162] The male-type member **120** of the extrusion die **15** includes a spider **52** which is constituted with: a mandrel section **53** for molding the inner shape of the hollow material **2**; and a bridge section **54** which supports the mandrel section **53** and is projected substantially in an X-letter form toward the outer side from the periphery of the mandrel section **53**. The spider **52** is integrally connected with the holder section **125** via the bridge section **54**.

[0163] Further, a tip outer circumferential face **54A** of each of first to fourth bridges **54a** to **54d** and a part of the inner circumferential face of the holder section **125** are fixed integrally by the bridge section shrink-fit structure N. Thus, the strength of each of the bridges **54a** to **54d** and the mandrel section **53** is secured.

[0164] In FIG. 17, the bridge section **54** is constituted with four bridges disposed clockwise, which are the first bridge **54a**, the second bridge **54b**, the third bridge **54c**, and the fourth bridge **54d**. Further, spaces between each of the bridges **54a** to **54d** form the billet introduction spaces S for introducing the billet B.

[0165] As shown in FIGS. 18 and 19, the billet guide hole **58** is constituted with a large opening hole **58A** formed on the upstream side of the mandrel section **53** and a small opening hole **58B** formed in the downstream side of the mandrel section **53**, i.e., formed to correspond to the positions where the intersections X of the partition walls **1b** and **1b**.

[0166] The large opening hole **58A** is substantially in the same shape as that of the large opening hole **48A** of the extrusion die **14** of the fifth embodiment. That is, the large opening hole **58A** is formed substantially in a square shape on a plan view and is formed in a recessed shape that is recessed by a prescribed size into the lower-part side of the mandrel section **53**. The small opening holes **58B** are formed in the bottom face of the large opening hole **58a**. Nine small opening holes **58B** are provided by opening the holes toward the downstream side of the mandrel section **53** from the bottom face of the large opening hole **58A**.

[0167] Further, those small opening holes **58B** are designed to correspond to the nine intersections X for forming the hollow material **3** having the sectional view with a lattice, and sixteen inner formation pieces **53B** are provided in the lower part of the mandrel **53** to be able to form the intersections X. In the nine regions where one corner each of flange sections **53F** of the sixteen inner formation pieces **53B** gathers, the positions of each of the intersection points P correspond to the intersections X. Further, the positions of the small opening holes **58B** are set so that the positions of the nine intersection points P and the centers of each of the small opening holes **58B** of the nine billet guide holes **58** become consistent with each other.

[0168] There are the nine small opening holes **58B** provided in the bottom face of the large opening hole **58A**, so that the plan shape of the large opening hole **58A** is formed larger than that of the large opening hole **48A** of the fifth embodiment. Further, the size of each of the inner formation pieces **53B** is substantially the same as the size of each of the inner formation pieces **43B** of the extrusion die **14** of the fifth embodiment, so that the size of the mandrel **53** of the extrusion die **15** is formed larger than the size of the mandrel **43** of the extrusion die **14** of the fifth embodiment.

[0169] Therefore, the size of the outer formation die hole **130B** of the female type **130** for housing the sixteen inner

formation pieces **53B** is formed larger than the size of the outer formation die hole **30B** of the extrusion die **14** of the fifth embodiment.

[0170] Further, each of the sixteen inner formation pieces **53B** is in the same square shape and disposed to form a square shape as a whole as shown in FIG. 19. Furthermore, the material formation inner hole **51** is formed by the gaps L2 between each of the inner formation pieces **53B**. Further, the sixteen inner formation pieces **53B** disposed in a square shape are inserted into the outer formation die hole **130B** of the female-type member **130**.

[0171] Next, the hollow material **3** molded by the extrusion die **16** of the above-described sixth embodiment will be described by referring to FIG. 20.

[0172] The hollow material **3** is formed substantially in a square sectional shape and constituted with two pairs of outer circumferential walls **3a**, **3a** disposed to oppose to each other and three each of partition walls **3b**, **3b** provided laterally and vertically inside thereof. The sectional view thereof is a lattice form having sixteen spaces **3S** inside thereof. Further, there are nine intersections X where the partition walls **3b** and **3b** intersect.

[0173] The three each of the partition walls **3b** and **3b** provided laterally and vertically are formed in the same thickness.

[0174] With the extrusion die **15** of the sixth embodiment described above, it is also possible to acquire substantially the same actions as those of the extrusion die **14** of the fifth embodiment and substantially the same effects as those described in (1), (2), (7), and (8). In addition, it is possible to achieve the following effect:

[0175] (10) A part of the billet B fed from the upstream side is extruded out from the large opening hole **58A** of the billet guide hole **58** provided in the center region of the mandrel section **53** via the small opening holes **58B** toward the nine intersection points P where the one corner each of the flange sections **53F** of the sixteen inner formation pieces **53B** gathers. The positions of each of the intersection points P correspond to the nine intersections X formed by the partition walls and, further, each of the intersection points P and the centers of the small opening holes **58B** of each of the billet guide holes **58** are consistent with each other on the same line, so that the billet B fed through each of the small opening holes **58B** is extruded out via each of the intersection points R. Thus, the hollow material **3** with the lattice-form sectional view having the nine intersections X can be molded easily.

[0176] Next, a seventh embodiment of the extrusion die according to the present invention will be described by referring to FIGS. 21 to 24.

[0177] In an extrusion die **16** of the seventh embodiment, the structure of a billet guide hole **68** is formed different from that of the billet guide hole **58** of the extrusion die **15** of the sixth embodiment. However, other members, structures, and the like are completely the same as those of the extrusion die **15** of the sixth embodiment. Therefore, the same reference numerals are applied to the same structures and the same members as those of the sixth embodiment, and only the different points will be described.

[0178] The male-type member **120** of the extrusion die **16** includes a spider **62** which is constituted with: a mandrel section **63** for molding the inner shape of the hollow material **3**; and a bridge section **64** which supports the mandrel section **63** and is projected substantially in an X-letter form toward

the outer side from the periphery of the mandrel section **63**. The spider **62** is integrally connected with the holder section **125** via the bridge section **64**.

[0179] Further, a tip outer circumferential face **64A** of each of bridges **64a** to **64d** and a part of the inner circumferential face of the holder section **125** are fixed integrally by the bridge section shrink-fit structure N. Thus, the strength of each of the bridges **64a** to **64d** and the mandrel section **63** is secured.

[0180] In FIG. 21, the bridge section **64** is constituted with four bridges disposed clockwise, which are the first bridge **64a**, the second bridge **64b**, the third bridge **64c**, and the fourth bridge **64d**. Further, spaces between each of the bridges **64a** to **64d** form the billet introduction spaces S.

[0181] The extrusion die **16** of the seventh embodiment is structured to be able to form a hollow material **4** having a sectional view with a lattice form as shown in FIG. 24. Further, in the hollow material **4**, there are nine intersections X that are formed by partition walls of different thicknesses. The billet guide hole **68** is structured to be able to correspond to those intersections X.

[0182] That is, the billet guide hole **68** is constituted with a large opening hole **68A** provided on the upper side of the mandrel section **63** and nine small opening holes **68B** formed in the lower side of the mandrel section **63** by corresponding to each of the nine intersections X. The large opening hole **68A** is substantially in the same shape as that of the large opening hole **58A** of the billet guide hole **58** of the extrusion die **15** of the sixth embodiment.

[0183] Further, the small opening holes **68B** are formed by opening the holes from the bottom face of the large opening hole **68A** toward the intersection X side, i.e., toward the female-type member **130** side.

[0184] The small opening holes **68B** are constituted with three kinds having different opening areas as shown in FIGS. 21 and 23.

[0185] That is, among three each of the small opening holes **68B** disposed laterally and vertically in an equivalent manner, a single first small opening hole **68B1** of a largest opening area is disposed in the center, and second small opening holes **68B2** of a second largest opening area are provided on cross-like lines with respect to the first small opening hole **68B1** on both sides thereof.

[0186] Further, on lines in parallel to the cross-like lines of the second small opening holes **68B2**, one each of third small opening holes **68B3** of a smaller opening area than that of the second small opening hole **68B2** is provided on the outer side of the second small opening holes **68B2**. That is, the third small opening holes **68B3** are disposed in the four corners of the bottom face of the large opening hole **68A**.

[0187] Further, those small opening holes **68B** are designed to be able to correspond to the nine intersections X for forming the hollow material **4** having the sectional view with a lattice form, and sixteen inner formation pieces **63B** are provided in the lower part of the mandrel **63** to be able to form the intersections X.

[0188] In the nine regions where one corner each of flange sections **63F** of the sixteen inner formation pieces **63B** gathers, the positions of each of the intersection points P correspond to the intersections X1, X2, and X3, respectively. Further, the positions of each of the small opening holes **68B1**, **68B2**, and **68B3** are set so that the positions of the nine intersection points P and the centers of each of the small

opening holes **68B1**, **68B2**, and **68B3** of the nine billet guide holes **68** become consistent with each other.

[0189] Further, the size of each of the inner formation pieces **63B** is substantially the same as the size of each of the inner formation pieces **53B** of the extrusion die **15** of the sixth embodiment.

[0190] Each of the sixteen inner formation pieces **63B** is in the same square shape, and disposed in an equivalent manner to form a square shape as a whole as shown in FIG. 23.

[0191] Note here that each of the inner formation pieces **63B** is disposed with different spaces provided with each other. That is, four each of the sixteen inner formation pieces **63B** are disposed by sandwiching a cross-like gap L3, and the four each of the inner formation pieces **63B** are disposed by sandwiching a cross-like gap L4.

[0192] Among the sixteen inner formation pieces **63B**, the side faces of the outermost twelve inner formation pieces **63B** oppose to the outer formation die **130B** formed in the female-type member **130** with the gap L1 provided therebetween.

[0193] Note here that the gap space of the gap L4 is designed to be a larger width gap space than the gap space of the gap L3, while the gap L1 is set to be the gap space that is between the gap L4 and the gap L3. Further, the material formation inner hole **52** is formed by the gap L3, the material formation inner hole **53** is formed by the gap L4, and the material formation outer hole **50** is formed by the gap L1.

[0194] Furthermore, those sixteen inner formation pieces **63B** are to be inserted into the outer formation die hole **130B** of the female-type member **130**.

[0195] Next, the hollow material **4** molded by the extrusion die **16** of the above-described seventh embodiment will be described by referring to FIG. 24.

[0196] The hollow material **4** is formed in a lattice-form sectional shape, and constituted with outer circumferential wall **4a**, **4a** in a square columnar sectional shape, cross-like first partition walls **4b1**, **4b1** continuing from the outer circumferential walls **4a**, **4a**, and cross-like second partition walls **4b2**, **4b2** provided in the center part in the length direction of the first partition walls **4b1**, **4b1**.

[0197] Further, the first partition walls **4b1**, **4b1** are formed to be thicker compared to the second partition walls **4b2**, **4b2**.

[0198] Furthermore, the part where the first partition walls **4b1** and **4b1** intersect with each other is the intersection X in the greatest thickness, and the part where the first partition wall **4b1** and the second partition wall **4b2** intersect with each other is the intersection X2 that is in the second greatest thickness. Further, the part where the second partition walls **4b2** and **4b2** intersect with each other is the intersection X3 that is in the smallest thickness.

[0199] As shown in FIGS. 21 and 23, the first small opening hole **68B1** corresponds to the thickest intersection X1, the second small opening hole **68B2** corresponds to the second thickest intersection X2, and the third small opening hole **68B3** corresponds to the thinnest intersection X3.

[0200] As a result, it becomes possible to form intersections of arbitrary thicknesses through changing the diameters of each of the small opening holes **68B1**, **68B2**, and **68B3**.

[0201] With the extrusion die **16** of the seventh embodiment described above, it is also possible to acquire substantially the same actions as those of the extrusion die **15** of the sixth embodiment and substantially the same effects as those described in (1), (2), (6), (7), and (9). In addition, it is possible to achieve the following effect:

[0202] (10) The large opening hole 68A to the small opening holes 68B of the billet guide hole 68 are constituted with three kinds of the holes with different diameters, i.e., the first small opening hole 68B1, the second small opening hole 68B2, and the third small opening hole 68B3. Each of those corresponds to the intersections of different thicknesses, i.e., the intersection X1 where the first partition walls 4b1 and 4b1 intersect, the intersection X2 where the first partition wall 4b1 and the second partition wall 4b2 intersect, and the third intersection X3 where the second partition walls 4b2 and 4b2 intersect. Therefore, the hollow material 4 in a lattice-form sectional shape having the partition walls of different thicknesses can be molded easily.

[0203] Next, eighth to tenth embodiments of the extrusion die of the present invention will be described by referring to FIGS. 25 and 26.

[0204] In the first to seventh embodiments, the hollow materials 1 to 6 molded by each of the extrusion dice 10 to 16 have complicated sectional shapes with the intersections X formed by the partition walls 1b and the like. However, the hollow materials are not limited to such cases. With extrusion dice 17 to 19 of the eighth to tenth embodiments of the present invention, it is possible to mold hollow materials 7, 8, and 9 having curve-shaped partition walls 7b, 8b, and 9b inside thereof as shown in FIGS. 25A, 25B and FIG. 26, through changing the shapes of the inner formation pieces, respectively.

[0205] That is, as shown in FIG. 25A, the hollow material 7 molded by the extrusion die 17 of the eighth embodiment is constituted with: outer circumferential walls 7a, 7a in a square sectional shape; and curve-shaped partition walls 7b, 7b provided inside those outer circumferential walls 7a, 7a. Those partition walls 7b, 7b are formed to connect the center parts in the length direction of the orthogonal outer circumferential walls 7a, 7a with curve-shaped lines.

[0206] The partition walls 7b and 7b are constituted with a single inner formation piece 73B1 and two inner formation pieces 73B2 disposed by sandwiching the inner formation piece 73B1. Those inner formation piece 73B1 and the inner formation pieces 73B2 are designed to be inserted into the outer formation die hole 30B formed in the female-type member 30.

[0207] Note here that the material formation outer hole 51 of the gap L1 is formed between each of the inner formation piece 73B1, the inner formation piece 73B2, and the outer formation die hole 30B. Further, the thickness of the partition walls 7b and 7b is set to be the gap L2, and the material formation inner hole 51 is formed by the gap L2.

[0208] At the part where the curved sections of the partition walls 7b and 7b come closest to each other, the small openings 78B and 78B of the billet guide hole 78 are disposed opposing to each other. The large opening hole 78A of the billet guide hole 78 is connected to those small openings 78B and 78B.

[0209] Note that the billet guide hole 78 is provided in the center part of the mandrel, not shown. Further, the entire structure of the extrusion die 17 is substantially the same as the entire structure of the extrusion die 10 and the like of the first embodiment.

[0210] With the structure described above, the billet is fed from the upstream side, a part thereof is introduced into the large opening hole 78A of the billet guide 78, and extruded out from the gap between the inner formation piece 73B1 and the inner formation pieces 73B2 via the small openings 78B, 78B. At that time, the billet introduced into the small openings

78B, 78B is extruded out from the material formation inner hole 51. Therefore, the curved-shape partition walls 7b and 7b can be formed easily.

[0211] Next, the extrusion die 18 of the ninth embodiment will be described.

[0212] As shown in FIG. 25B, the hollow material 8 molded by the extrusion die 18 is constituted with: outer circumferential walls 8a, 8a in a square sectional shape; and curve-shaped partition walls 8b, 8b provided inside those outer circumferential walls 8a, 8a. Each of those partition walls 8b and 8b is formed in a curved shape projected toward the center part of the sectional shape of the hollow material 8 from the opposing outer circumferential walls 8a and 8a.

[0213] The partition walls 8b and 8b are constituted with a single inner formation piece 83B1 and two inner formation pieces 83B2 disposed by sandwiching the inner formation piece 83B1. Those inner formation piece 83B1 and the inner formation pieces 83B2 are designed to be inserted into the outer formation die hole 30B formed in the female-type member 30.

[0214] Note here that the material formation outer hole 50 of the gap L1 is formed between each of the inner formation piece 83B1, the inner formation piece 83B2, and the outer formation die hole 30B. Further, the thickness of the partition walls 8b and 8b is set to be the gap L2, and the material formation inner hole 51 is formed by the gap L2.

[0215] Further, at the part where the curved sections of the partition walls 8b and 8b come closest to each other, the small openings 88B and 88B of the billet guide hole 88 are disposed opposing to each other. The large opening hole 88A of the billet guide hole 88 is connected to those small openings 88B and 88B.

[0216] Note that the billet guide hole 88 is provided in the center part of the mandrel, not shown. Further, the entire structure of the extrusion die 18 is substantially the same as the entire structure of the extrusion die 10 and the like of the first embodiment.

[0217] With the structure described above, the billet is fed from the upstream side, a part thereof is introduced into the large opening hole 88A of the billet guide 88, and extruded out from the gaps between the inner formation piece 83B1 and the inner formation pieces 83B2 via the small openings 88B, 88B.

[0218] At that time, the billet introduced into the small openings 88B, 88B is extruded out from the material formation inner hole 51. Therefore, the curve-shaped partition walls 8b and 8b can be formed easily.

[0219] Next, the extrusion die 19 of the tenth embodiment will be described.

[0220] As shown in FIG. 26, the hollow material 9 molded by the extrusion die 19 is constituted with: outer circumferential walls 9a, 9a in a square sectional shape; and wave-shaped partition walls 9b, 9b provided inside those outer circumferential walls 9a, 9a. Each of those partition walls 9b and 9b is formed in a wave-like shape connecting between the opposing outer circumferential walls 9a and 9a.

[0221] The partition walls 9b and 9b are constituted with a single inner formation piece 93B1 and two inner formation pieces 93B2 disposed by sandwiching the inner formation piece 93B1. Those inner formation piece 93B1 and the inner formation pieces 93B2 are designed to be inserted into the outer formation die hole 30B formed in the female-type member 30.

[0222] Note here that the material formation outer hole **50** of the gap **L1** is formed between each of the inner formation piece **93B1**, the inner formation piece **93B2**, and the outer formation die hole **30B**. Further, the thickness of the partition walls **9b** and **9b** is set to be the gap **L2**, and the material formation inner hole **51** is formed by the gap **L2**.

[0223] Further, at substantially the center parts in the respective length directions of the partition walls **9b** and **9b**, the small openings **98B** and **98B** of the billet guide hole **98** are disposed opposing to each other. The large opening hole **98A** of the billet guide hole **98** is connected to those small openings **98B** and **98B**.

[0224] Note that the billet guide hole **98** is provided in the center part of the mandrel, not shown. Further, the entire structure of the extrusion die **19** is substantially the same as the entire structure of the extrusion die **10** and the like of the first embodiment.

[0225] With the structure described above, the billet is fed from the upstream side, a part thereof is introduced into the large opening hole **98A** of the billet guide **98**, and extruded out from the gaps between the inner formation piece **93B 1** and the inner formation pieces **93B2** via the small openings **98B**, **98B**.

[0226] At that time, the billet introduced into the small openings **98B**, **98B** is extruded out from the material formation inner hole **51**. Therefore, the curve-shaped partition walls **9b** and **9b** can be formed easily.

[0227] While the present invention has been described above by referring to the embodiments, the present invention is not limited only to the embodiments. Various changes and modifications occurred to those skilled in the art can be applied to the structures and details of the present invention. Further, the present invention also includes mutual and proper combinations of a part of or a whole of each of the embodiments.

[0228] For example, in the fifth embodiment, the large opening hole **48A** of the billet guide hole **48** of the extrusion die **14** is formed substantially in a square shape on a plan shape and in a dented recessed shape toward the downstream side. However, as shown in FIG. **27**, the large opening hole **78A** in the extrusion die **14A** of a modification example is formed as a tapered-shape hole that becomes narrower from the top face of the mandrel section **43** toward the bottom face of the large opening hole **78A**.

[0229] Further, the large opening holes **58A** and **68A** of the billet guide holes **58** and **68** of the sixth and seventh embodiments may also be formed as a tapered-shape hole that becomes narrower from the top face of the mandrel sections **53** and **63** toward the bottom face of the large opening holes **58A** and **68A** as in the above case.

[0230] Further, while the billet guide hole **28** is formed as a two-stage structure of the large opening hole **28A** and the small opening hole **28B** and the bottom face of the large opening hole **28A** is formed as a flat face in the first and third embodiments, the structure thereof is not limited to such case. The bottom face of the large opening hole **28A** may be formed as a bottom face constituted with an angular part with a sloping face of 45° , for example. With this, flow of the billet **B** can become still smoother.

[0231] Further, while each of the extrusion dice **10** to **13** of the first to fourth embodiments can mold the hollow material **1** having a sectional shape with a cross inside thereof and each of the extrusion dice **14** to **16** of the fifth to seventh embodiments can mold the hollow materials **2** to **4** having a sectional

shape with a lattice form inside thereof, the structures are not limited only to such cases. For example, as shown in FIG. **28A**, it is possible to employ a structure capable of molding the hollow material **5** in which two intersections **X** are formed laterally with two vertically disposed outer circumferential walls **5a**, **5a** and a single laterally disposed partition walls **5b**, **5b** through changing the shapes of a plurality of inner formation pieces.

[0232] Further, as shown in FIG. **28B**, it is also possible to employ a structure capable of forming the hollow material **6** having an external shape in which partition walls **6c**, **6c** are provided in an X-letter form at the four corners of the external circumferential walls **6a**, **6a** formed in a square columnar shape through changing the shapes of a plurality of inner formation pieces.

INDUSTRIAL APPLICABILITY

[0233] The extrusion die of the present invention is utilized when molding hollow materials having partition walls inside thereof by using a high-strength alloy, particularly a high-strength aluminum alloy such as the so-called 7000 series.

REFERENCE NUMERALS

- [0234] **1** Hollow material having sectional shape with cross inside (hollow material formed by first to fourth embodiment)
- [0235] **2** Hollow material having sectional shape with lattice inside (hollow material formed by fifth embodiment)
- [0236] **3** Hollow material having sectional shape with lattice inside (hollow material formed by sixth embodiment)
- [0237] **4** Hollow material having sectional shape with lattice inside (hollow material formed by seventh embodiment)
- [0238] **10** Extrusion die for forming hollow material (first embodiment)
- [0239] **11** Extrusion die for forming hollow material (second embodiment)
- [0240] **12** Extrusion die for forming hollow material (third embodiment)
- [0241] **13** Extrusion die for forming hollow material (fourth embodiment)
- [0242] **14** Extrusion die for forming hollow material (fifth embodiment)
- [0243] **15** Extrusion die for forming hollow material (sixth embodiment)
- [0244] **16** Extrusion die for forming hollow material (seventh embodiment)
- [0245] **20** Male-type member
- [0246] **22** Spider
- [0247] **23** Mandrel section
- [0248] **23B** Inner formation piece
- [0249] **24** Bridge section
- [0250] **24a to 24d** First to fourth bridges
- [0251] **24A** Bridge tip outer circumferential face
- [0252] **25** Holder section
- [0253] **26** Bridge holding section
- [0254] **26B** Bridge receiving face as bridge abutting/engaging face
- [0255] **30** Female-type member
- [0256] **30B** Outer formation die hole
- [0257] **50** Material formation outer hole

- [0258] 51 Material formation inner hole
 [0259] BH Billet insertion hole (billet merging space)
 [0260] BH1 Billet insertion hole (billet merging space)
 [0261] S Billet introducing part
 [0262] M Bridge section press-fit structure
 [0263] N Bridge section shrink-fit structure

1. An extrusion die for forming a hollow material, comprising: a male-type member which forms an inner shape of the hollow material while guiding a billet constituted with an aluminum alloy fed from an upstream side toward a downstream side; and a female-type member which holds the male-type member with an outer circumferential part and forms an outer shape of the hollow material, wherein:

the male-type member comprises a mandrel section for forming the inner shape, and a holder section connected integrally to an outer circumferential part of the mandrel section via a plurality of bridge sections;

a billet guide hole for guiding a part of the billet toward the downstream side is provided in a center region of the mandrel section;

an upstream-side opening area of the billet guide hole is formed larger than a downstream-side opening area; and a plurality of inner formation pieces are fixedly mounted on a downstream side of the billet guide hole and at positions for forming continuous partition walls inside the hollow material while keeping a billet flow-in gap space forming a merging space of the billet flowing in from each of the bridge sections toward the downstream side.

2. The extrusion die for forming the hollow material as claimed in claim 1, wherein

the billet guide hole is formed as a stepped hole constituted with an upstream-side large opening hole and a down-

stream-side small opening hole formed in the bottom part of the large opening hole.

3. The extrusion die for forming the hollow material as claimed in claim 2, wherein

an inner wall face of the upstream-side large opening hole is formed in a tapered shape in which an opening side has a larger opening area than a bottom part of the large opening hole.

4. The extrusion die for forming the hollow material as claimed in claim 1, wherein

the billet guide hole is formed in a tapered shape narrowed from the upstream-side opening toward the downstream-side opening.

5. The extrusion die for forming the hollow material as claimed in claim 2, wherein a plurality of the downstream-side small opening holes are provided.

6. (canceled)

7. The extrusion die for forming the hollow material as claimed in claim 3, wherein a plurality of the downstream-side small opening holes are provided.

8. The extrusion die for forming the hollow material as claimed in claim 5, wherein the small opening holes of the billet guide hole are disposed by opposing to intersection points of gaps for forming a plurality of partition walls set by the plurality of inner formation pieces.

9. The extrusion die for forming the hollow material as claimed in claim 7, wherein the small opening holes of the billet guide hole are disposed by opposing to intersection points of gaps for forming a plurality of partition walls set by the plurality of inner formation pieces.

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