



(22) Date de dépôt/Filing Date: 1998/07/24

(41) Mise à la disp. pub./Open to Public Insp.: 1999/01/24

(45) Date de délivrance/Issue Date: 2008/09/23

(30) Priorités/Priorities: 1997/07/24 (US60/053,593);
1998/07/22 (US09/120,616)

(51) Cl.Int./Int.Cl. *B22D 41/00* (2006.01),
B22D 45/00 (2006.01)

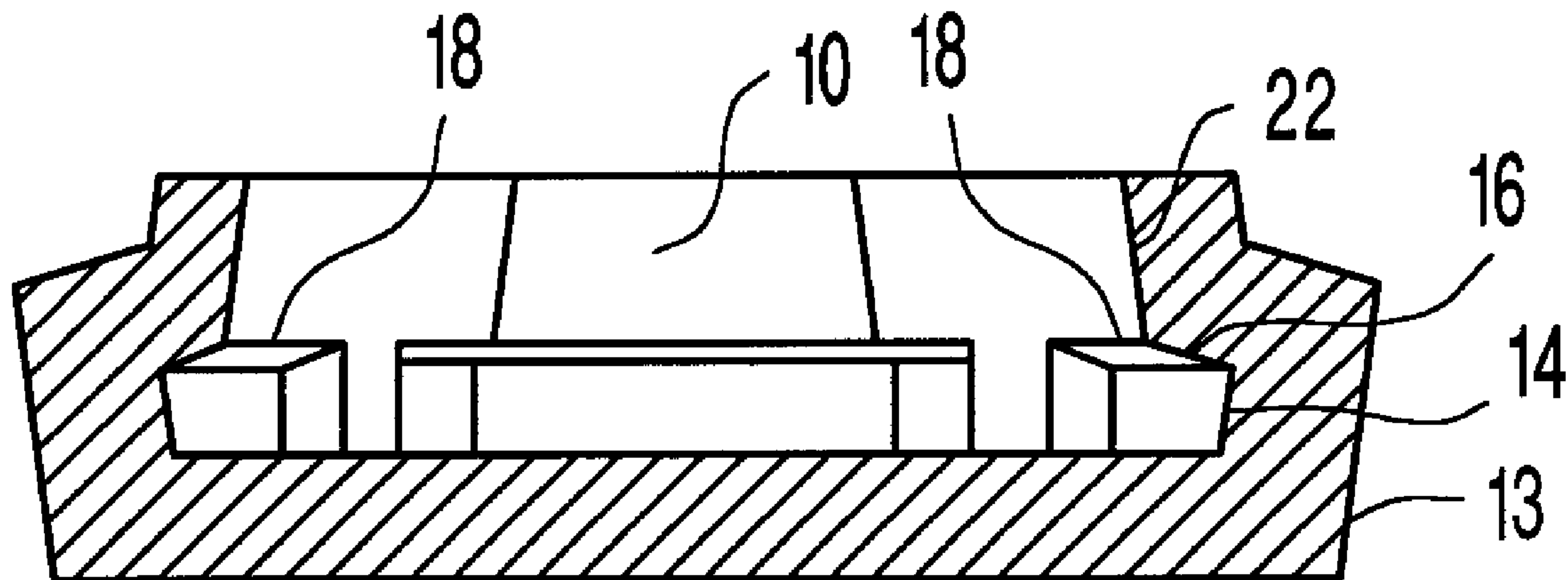
(72) Inventeurs/Inventors:
HEASLIP, LAWRENCE J., CA;
DORRICOTT, JAMES D., CA

(73) Propriétaire/Owner:
PSC TECHNOLOGIES, INC., US

(74) Agent: MCCARTHY TETRAULT LLP

(54) Titre : CHAMBRE DE RECEPTION A SURFACE D'IMPACT

(54) Title: IMPACT PAD



(57) Abrégé/Abstract:

A chamber for receiving a downward flow of liquid metal includes a generally horizontal base having a generally planar impact surface. A first faceted sidewall having a plurality of facets formed therein, generally extends upwardly from and encompasses the planar surface to define an interior space. The interior space has an upper opening for receiving the downward flow of liquid metal. A second wall extends inwardly and upwardly from the first faceted wall toward the upper opening. A plurality of buttresses are spaced along the first faceted wall. Each of the buttresses extends between the impact surface and the second faceted wall. The buttresses form a plurality of discrete pockets including at least one facet. The pockets are defined by the buttresses, the impact surface, the first faceted wall and the second wall. The buttresses laterally deflect and divide the radial outward flow into a plurality of discrete flow patterns associated with the plurality of pockets.



IMPACT PADABSTRACT OF THE DISCLOSURE

5 A chamber for receiving a downward flow of liquid metal includes a generally horizontal base having a generally planar impact surface. A first faceted sidewall having a plurality of facets formed therein, generally extends upwardly from and encompasses the planar surface to define an interior space. The interior space has an upper opening for receiving the downward
10 flow of liquid metal. A second wall extends inwardly and upwardly from the first faceted wall toward the upper opening. A plurality of buttresses are spaced along the first faceted wall. Each of the buttresses extends between the impact surface and the second faceted wall.
15 The buttresses form a plurality of discrete pockets including at least one facet. The pockets are defined by the buttresses, the impact surface, the first faceted wall and the second wall. The buttresses laterally deflect and divide the radial outward flow into a
20 plurality of discrete flow patterns associated with the plurality of pockets.

IMPACT PAD

5

BACKGROUND OF THE INVENTION

Field of the Invention

10 The present invention relates to a tundish impact pad and more particularly to a tundish impact pad that stabilizes the flow of liquid metal exiting the pad.

Description of the Related Art

15 Liquid metal, and in particular liquid steel, is often poured from one vessel to another vessel. For example, liquid metal may be poured from a furnace into a ladle, and or from a ladle into a tundish, and or from a tundish into a mold. When liquid metal is poured into the tundish from the ladle, it is normally poured into the tundish through an outlet in the ladle bottom. The stream from the ladle is metered by a valve and the
20 outlet stream may be enclosed in a ceramic tube, called a ladle shroud, which is connected to the valve.

25 A typical tundish has a simple design consisting of either a trough or box shaped vessel having a generally horizontal or flat bottom with vertically arranged walls. In these designs, the stream pouring from the ladle, i.e. incoming ladle stream or flow, enters the tundish, impacts the tundish bottom, and spreads in all directions. A flat impact pad is commonly

- 2 -

used on the tundish bottom in the impact area pad to reduce erosion of the tundish refractory lining.

After the incoming flow is spread, a portion of the incoming flow rises up the vertical walls of the tundish, travels back along the surface of the liquid steel toward the ladle stream inlet location, and is re-entrained within the incoming flow of the ladle stream or flow. Another portion of the flow does not directly impact the tundish vertical walls and is dispersed throughout the tundish volume.

The aforementioned flow patterns result in many problems. The problems encountered with the above described flow pattern include:

1. Non-separation of slag and inclusion particles. The turbulence introduced by the incoming ladle stream or flow and the pattern of liquid metal flow generated within the tundish does not allow the separation by flotation of buoyant slag and inclusion particles entrained within the liquid metal and can actually cause slag to be re-entrained.

2. Smooth flow disturbance. Turbulence within the tundish caused by the dissipation of the kinetic energy of the ladle stream is propagated above adjacent tundish nozzles and this energy disturbs the smooth flow which is required to properly fill the molds.

3. Thermal inhomogeneity. Short-circuit flow and different liquid metal residence time behavior associated with each tundish to mold stream results in thermal inhomogeneity of the liquid metal contained in the tundish. Tundish exit streams therefore experience different temperatures, with colder metal exiting the tundish furthest from the ladle stream and hotter metal exiting the tundish closest to the ladle stream.

- 3 -

Tundish impact pads having complex geometries have been proposed to alleviate the above problems, but without success. Examples of these pads are disclosed in U.S. Patent No. 5,169,591 (the "'591 patent") and U.S. Patent No. 5,358,551 (the "'551 patent"). Both of these patents describe impact pads which contain the inlet flow from the ladle. This is not unique since flow from a ladle has been contained within many different impact pad designs for many years. Moreover, the existence of a continuous wall around a pad with upward release of the flow has been practiced in many designs prior to the existence of the aforementioned patents.

The '551 and '591 patents teach a reversal of the flow generated by the incoming ladle stream. One of the many problems with these pad designs is that they do not address the very real issue of what happens to the flow when the incoming stream is not directed at the exact geometric center of the pad. This is the normal state of affairs in a tundish as the ladle stream moves in practice as the ladle valve compensates for the changing head pressure in the ladle. A non-central location of the incoming ladle stream causes an amplification of the reversed flow and can result in excessive splash or ultimately, liquid metal being ejected from the tundish.

Another problem with these pad designs is that the flow is directed from the pad in an inward and upward manner. This inward and upward flow accelerates the flow and causes it to "rebound" off the surface of the liquid metal in the tundish, causing short-circuit flow to the closer tundish exit strands.

Thus, none of the prior art pads effectively eliminate the aforementioned problems and furthermore,

- 4 -

can exacerbate problems associated with slag emulsification, flow stagnation regions, thermal inhomogeneity, short-circuit flow, liquid residence distribution, and in particular, initial splash when the ladle is first opened.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide an impact pad that stabilizes the flow of liquid metal exiting the pad.

10 Another object is to provide such an impact pad to control the radially dispersed outward flow which is formed by the impact of the downward ladle stream on the base of the pad.

15 A further object is to provide such an impact pad to control the radially dispersed outward flow by multiple faceting and discrete pocketing of the pad's sidewall.

20 It is also an object to provide such an impact pad to control the radially dispersed outward flow by laterally deflecting and dividing the radial flow into multiple discrete, stable and consistent flow patterns or segments associated with each of the sidewall pockets.

It is another object to provide such an impact pad that is insensitive to the ladle pouring stream.

25 It is a further object to provide such an impact pad to eliminate problems associated with slag emulsification, flow stagnation regions, thermal inhomogeneity, short-circuit flow, liquid residence distribution, and in particular, initial splash when the ladle is first opened.

30 It is still a further object to provide such an impact pad that is easy to use and manufacture.

- 5 -

It has been found that the above and other objects of the present invention are attained in a chamber for receiving a downward flow of liquid metal. The chamber includes a generally horizontal base having a generally planar impact surface. A first faceted sidewall having a plurality of facets formed therein, generally extends upwardly from and encompasses the planar surface to define an interior space. The interior space has an upper opening for receiving the downward flow of liquid metal. A second wall extends inwardly and upwardly from the first faceted wall toward the upper opening.

A plurality of buttresses or flow dividers are spaced along the first faceted wall. Each of the buttresses extend between the impact surface and the second faceted wall. The buttresses form a plurality of discrete pockets including at least one facet. The pockets are defined by the buttresses, the impact surface, the first faceted wall and the second wall. The buttresses laterally deflect and divide the radial outward flow into a plurality of discrete flow patterns associated with the plurality of pockets.

In a preferred embodiment, the buttresses laterally deflect the flow patterns towards the facets and the discrete flow patterns are directed out of the interior space in an upwardly and outwardly direction away from the downward flow of liquid metal.

Preferably, the pad includes a third wall defining the upper opening of the interior space. The third wall extends generally upwardly from the second wall.

- 6 -

In a preferred embodiment, the first faceted wall is outwardly and upwardly angled at an angle greater than about 90° from the planar impact surface.

5 Preferably, the second wall extends from the first faceted wall at an angle of about 45 to 135° , and more preferably, at an angle of about 90° .

10 In a preferred embodiment, the third wall extends from the second wall at an angle of about 45 to 150° . Preferably, the third wall extends from the second wall at an angle of about 125° .

Other features and advantages of the present invention will become apparent from the following description of the invention which refers to the accompanying drawings.

15 **BRIEF DESCRIPTION OF THE DRAWING(S)**

For the purpose of illustrating the invention, there is shown in the drawings an embodiment which is presently preferred; it being understood, however, that the invention is not limited to the precise arrangements and instrumentalities shown.

20 Fig. 1 is a top plan view of an impact pad of the present invention.

Fig. 1a is a side sectional view of the impact pad of Fig. 1.

25 Fig. 2 is a top plan view of a first alternative embodiment of the impact pad of the present invention.

Fig. 2a is a side sectional view of the impact pad of Fig. 2.

30 Fig. 3 is a top plan view of a second alternative embodiment of the impact pad of the present invention.

- 7 -

Fig. 3a is a side-sectional view of the impact pad of Fig. 3.

Fig. 3b is another side-sectional view of the impact pad of Fig. 3.

5 Fig. 4 is a schematic representation of the flow of liquid metal in the interior region of the impact pad of the present invention.

10 Fig. 5 is a schematic representation of the flow of liquid metal into and out of the impact pad of Fig. 4 taken along line A-A of Fig. 4.

Fig. 6 is a top plan view of a third alternative embodiment of the impact pad of the present invention.

15 Fig. 6a is a cross-sectional view of the impact pad of Fig. 6 taken along line A-A.

Fig. 6b is a cross-sectional view of the impact pad of Fig. 6 taken along line B-B.

Fig. 7 is a top plan view of the third alternative embodiment of Fig. 6 having an oval shape.

20 Fig. 7a is a cross-sectional view of the impact pad of Fig. 7 taken along lines A-A.

Fig. 7b is a cross-sectional view of the impact pad of Fig. 7 taken along line B-B.

25 Fig. 7c is a cross-sectional view of the impact pad of Fig. 7 taken along line C-C.

Fig. 8 is a top plan view of the third alternative embodiment of Fig. 6 having a five-sided shape.

30 Fig. 8a is a cross-sectional view of the impact pad of Fig. 8 taken along line A-A.

Fig. 8b is a cross-sectional view of the impact pad of Fig. 8 taken along line B-B.

- 8 -

Fig. 9 is a fourth alternative embodiment of the impact pad of the present invention.

Fig. 9a is a cross-sectional view of the impact pad of Fig. 9 taken along line A-A.

5 Fig. 9b is a cross-sectional view of the impact pad of Fig. 9 taken along line B-B.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

The impact pad of the present invention is a tundish impact pad that receives a stream of liquid metal falling from a ladle into a tundish. The pad radially spreads, then laterally deflects (or reflects) and divides the radial outward flow which is formed by the impact of the downward ladle stream on the base of the pad. The radial outward flow is deflected and divided into multiple discrete, stable and consistent flow patterns or segments. Subsequently, the flow is redirected upwardly and outwardly out of the chamber to the remainder of the tundish volume in a manner which promotes a more homogeneous temperature distribution, promotes an upwardly flow for the flotation of inclusions and entrained slag, and eliminates splash when the tundish level is below the height of the chamber.

Referring now to the drawings wherein like numerals indicate like elements, there is shown in Fig. 1 an impact pad 8 of the present invention. The impact pad 8 is different and unique in its design. As a result, the design produces a different and unique effect upon the fluid flow of the liquid metal.

The impact pad 8 includes an inner chamber 10 for receiving a downward flow of liquid metal. The chamber 10 includes a generally horizontal or planar

- 9 -

bottom wall 12 where the flow is spread radially. The bottom wall 12 may be flat or contoured or textured, i.e., it may include a landscape of various shapes and/or reliefs. For example, the bottom wall 12 may include one or more ripples or humps formed therein. The bottom wall 12 is fully surmounted and surrounded by an outer endless multi-faceted sidewall 13 including facets 15 and an inner multi-faceted sidewall 14 including facets 15a. Due to the buttresses or flow dividers 18 discussed below, and the discrete pocketing formed by the buttresses, the inner sidewall 14 does not include a continuous or endless wall or annulus. Stated otherwise, the inner sidewall 14 is not continuous.

The inner sidewall 14 should have a plurality of facets 15a. Located at the intersection of facets 15a are corners or apices 17. Preferably, there should be at least 4-10 facets and more preferably eight (8) facets. It should be appreciated by those skilled in the art that the outer sidewall 13 need not be faceted.

The first faceted wall 14 is outwardly and upwardly angled at an angle greater than about 90° from the horizontal, i.e. bottom wall, and preferably at an angle between about 90° and 120° .

A second faceted internal wall 16 meets the top of the first faceted wall 14 at an angle between those walls of about 90° , but at least in the range between about 45° - 135° . The second faceted wall 14 extends upwardly and inwardly towards the chamber 10.

At approximately the midpoint of four (4) facets 15a of the first faceted wall 14, and adjoining all of the bottom wall 12, the first faceted wall 14, and the second faceted wall 16, are four (4) flow deflectors or flow dividers or buttresses 18 that project into the

- 10 -

chamber 10 from all of the walls 12, 14 and 16. It should be appreciated by those skilled in the art that the buttresses 18 can be any size or shape just so long as the buttresses laterally deflect and/or divide the radially outward flow into a plurality of discrete, consistent flow patterns.

The impact pad 8 should include a plurality of buttresses 18. Preferably, the impact pad 8 should include about 4-10 buttresses, and more preferably about eight (8) buttresses located at approximately the midpoint of all eight (8) facets of the first faceted wall 14. See Fig. 4.

The buttresses 18 divide the chamber 10 into four (4) discrete pockets 20. Each of the pockets 20 should include at least one apex 17. Preferably, there should be enough buttresses to divide the chamber 10 into a plurality of discrete pockets 20, preferably about 4-10 pockets 10. For example, in a preferred embodiment, the impact pad should have eight (8) buttresses dividing the chamber into eight (8) discrete pockets, Fig. 4.

The pockets 20 are where the radial flow is laterally divided, stabilized and more consistently directed into the apices 17. In practice, in each of the pockets 20, the radial flow first is divided and deflected laterally into the apices 17 by buttresses 18 and facets 15a. The flow is then directed upwardly toward the second faceted wall 16. The flow is then directed out of the impact pad 8 in an upwardly and outwardly direction away from the center of the chamber 10.

A third faceted wall 22 meets the top of the second faceted wall 16 at an angle between those walls typically about 125° , but could range from about 110°

- 11 -

150°. The angle of the third faceted wall 22 defines the final upper release space for the second upwardly and outwardly flow caused by the second faceted wall 16. It should be appreciated by those skilled in the art that the second and third faceted walls 16, 22 need not be faceted.

Referring now to Figs. 2, 2a, in an alternative embodiment the second faceted wall 16 may include outlet ports 24. The outlet ports 24 release the first upwardly flow caused by the first faceted wall 14 from the pad in an upwardly and outwardly direction. In Fig. 2a the buttresses are not shown for clarity.

Referring now to Figs. 3, 3a, 3b, these figures show an alternative embodiment of the present invention suitable for tundish designs where, for example, the ladle pouring position causes the downward stream to impact the tundish near the tundish sidewall. In that case, the segment 19 of the outer wall 13 would rest against the inner wall of the tundish, now shown.

Referring now to Figs. 4 and 5, these figures show a schematic representation of the flow behavior when looking down on the preferred embodiment 8-faceted (or octagonal) impact pad 8. The pad 8 includes eight facets 41a-h, and eight (8) sidewall pocket regions 26, 28, 30, 32, 34, 36, 38 and 40 formed by eight (8) buttresses 25. Each of the pocket regions includes at least one apex 45. In Fig. 5, the buttresses 25 are not shown for clarity.

It should be realized by those skilled in the art that the impact pad of the present invention need not take on any particular shape or geometry. The impact pad 8 of the present need not take on any particular shape or geometry just so long as the buttresses 18 divide the chamber into the number of pockets, and include the

- 12 -

number of facets, described above. In fact, it is contemplated that the impact pad of the present invention can take on a variety of shapes and geometries to accommodate the shape and geometry of any given vessel, e.g., tundish, and to accommodate various ladle pouring positions, e.g., off-center pouring positions as discussed above with respect to Fig. 3.

The impact pad 8 laterally deflects and divides the radially outward flow by the multiple faceting 41a-h and discrete pocketing 26, 28, 30, 32, 34, 36, 38 and 40 of the inner sidewall 41. This has the effect of dividing the radial outward flow into multiple discrete, consistent flow patterns 43 (eight (8) in the case of Fig. 4) each associated with a sidewall pocket 26-40.

Dividing the flow into eight (8) discrete flow patterns 43 each associated with a respective pocketed region 26, 28, 30, 32, 34, 36, 38 and 40 has a stabilizing influence on the flow behavior. The 3-dimensional flow patterns which are formed within the pad are illustrated with arrows in Fig. 4. The central region labeled P_{down} is the region where the dynamic pressure of the incoming stream 49 is greatest and downwardly directed. The eight (8) regions 42 which are adjacent to the apices of the pad 45 are the regions where the upward dynamic pressure or force is greatest.

After the incoming stream 49 impacts the base of the pad in the central region labeled P_{down} , the flow spreads radially outward until it contacts the buttresses 25 which laterally deflect and divide the radial outward flow into the eight (8) discrete flow patterns 43 associated with the pockets 26, 28, 30, 32, 34, 36, 38 and 40. Once the flow is divided within each of the pockets 26, 28, 30, 32, 34, 36, 38 and 40, the separate

- 13 -

or divided flows 43 are directed or deflected by buttresses 25 and facets 41a-h toward the respective apices 45. The flow is then directed upwardly and outwardly toward the second faceted wall 47. The second faceted wall 47 then diverts the separate flows 43 toward the regions 42 adjacent apices 45 where the upward dynamic pressure or force is greatest.

The separate flows 43 then exit the pad at the regions 42 in an upwardly and outwardly direction away from the incoming flow 49 as shown in Fig. 5. The outgoing flow at regions 42 and the incoming flow 49 at region P_{down} do not overlap, (i.e. they do not strike each other, interfere or cancel their respective oppositely directed forces) nor do they slow each other down. If the second faceted wall 47 includes outlet ports 24, at least part of the upwardly and outwardly flow from the first faceted wall 41 would also be directed out of the pad in a upwardly and outwardly direction through the outlet ports 24.

Referring to Figs. 6, 6a, and 6b, a third alternative embodiment 100 of the impact pad of the present invention is shown having an octagon shape. The impact pad 100, however, can take on a variety of other shapes as exemplified by Figs. 7 and 8.

Impact pad 100 includes a flat base 110 which is surrounded by an outer sidewall 112 which encloses an interior space 114. Outer sidewall 112 includes an upper lip 116 defining an upper opening 118 for receiving the molten metal. Upper lip 116 includes an inner wall surface 120 that extends upwardly and outwardly.

Outer sidewall 112 includes an inner wall surface 122 having a first surface 124 which extends upwardly and outwardly from base 110, and a second

- 14 -

surface 125 which meets first surface 124 and extends upwardly and inwardly therefrom.

Inner wall surface 122 includes a plurality of spaced apart buttresses 126a-d. Buttresses 126a-d merge with base 110 and first and second surfaces 124 and 125, and project into the interior of the pad. Buttresses 126a-d divide the interior of the pad into four discrete pockets 128ab, 128bc, 128cd, and 128ad. Specifically, buttresses 126a and 126b define pocket 128ab, buttresses 126b and 126c define pocket 128bc, buttresses 126c and 126d define pocket 128cd, and buttresses 126d and 126a define pocket 128ad.

Buttresses 126a-d also interrupt and divide first and second surfaces 124 and 125. For example, buttresses 126a-d divide second surface 125 into four separate segments 125ab, 125bc, 125cd, and 125ad each having a beginning and an end. Specifically, buttresses 126a and 126b define segment 125ab, buttresses 126b and 126c define segment 125bc, buttresses 126c and 126d define segment 125cd, and buttresses 126d and 126a define segment 125ad. Thus, second surface 125 does not extend continuously about the impact pad, i.e., it is not endless. In other words, the second wall surface 125 is not continuous because buttresses 126a-d divide second surface 125 into four segments 125ab, 125bc, 125cd and 125ad each having a discrete beginning and end. In addition, at buttresses 126a-d, there are no second wall surfaces 125. The innermost surface of the buttresses 126 extend upwardly and outwardly from the base 110.

The flow of molten metal out of the impact pad 100 is upwardly and outwardly. Because the segments of the second surface 125 are not continuous, i.e., 125ab, 125bc, 125cd, and 125ad, they do not function to redirect

- 15 -

or reverse the outgoing stream of molten metal upwardly and inwardly toward the incoming stream all around the incoming stream. Nor do these segments of the second surface 125 create two opposed vertical streams or counter current flows in and above the pad, which interact with each other to such a degree that they significantly slow each other down, as may be found in other impact pads.

Instead, the purpose of inner wall surfaces 122, including segments 125ab, 125bc, 125cd, and 125ad, along with buttresses 126a-d is to interfere with any such upwardly and inwardly flow. These elements instead laterally reflect and radially divide the flow within pockets 128ab, 128bc, 128cd and 128ad. Thus, the flow of molten metal out of the impact pad of Figs. 6, 6a and 6b is upwardly and outwardly away from the incoming stream of molten metal.

Referring to Figs. 9, 9a, and 9b a fourth alternative embodiment 200 of the present invention is shown having an octagon shape. The impact pad 200, however, can take on a variety of other shapes, such as the shapes of Figs. 7 and 8.

Impact pad 200 includes a base 246 having a raised impact surface 248. An outer wall 210 extends from the base 246 in an upwardly and outwardly direction as shown in Figs. 9a and 9b. Outer wall 210 and base 246 define an interior space 212. Outer wall 210 includes an upper lip 214 defining an upper opening 216 to receive the molten metal. Upper lip 214 includes a first wall surface 218 extending upwardly and outwardly, and a second wall surface 220 also extending upwardly and outwardly.

- 16 -

Outer wall surface 210 includes an inner wall surface 222 having a first wall surface 224 extending inwardly and downwardly and a second wall surface 225 extending upwardly and outwardly.

5 Inner wall surface 222 includes a plurality of spaced apart buttresses 226a-d extending between first surface 224, second surface 225 and base 246 and projecting into the interior of the impact pad. Buttresses 226a-d divide the interior of the pad into
10 four discrete pockets 232ab, 232bc, 232cd and 232ad. In particular, buttresses 226a and 226b define pocket 232ab, buttresses 226b and 226c define pocket 232bc, buttresses 226c and 226d define pocket 232cd, and buttresses 226d and 226a define pocket 232ad.

15 Buttresses 226a-d also interrupt and divide inner wall surface 222 and first and second portions 224 and 225. For example, buttresses 226a-d divide first surface 224 into four separate segments 224ab, 224bc, 224cd and 224ad each having a beginning and an end. In
20 particular, buttresses 226a and 226b define segment 224ab, buttresses 226b and 226c define segment 224bc, buttresses 226c and 226d define segment 224cd, and buttresses 226d and 226a define segment 224ad. Thus, first surface 224 does not extend continuously around the
25 impact pad, i.e., it is not endless. In fact, at buttresses 226a-d, there are no surfaces extending inwardly and upwardly. The innermost surface 228 of buttresses 26a-d extend vertically upwardly from the raised impact surface 248.

30 Raised impact surface 248 does not fully extend to second surface 225 of inner wall surface 222. This creates a recessed channel 230 defined by outer edge 232 of raised impact surface 248 and second surface 225 of

- 17 -

inner surface 222. Thus, there are actually four separate channels extending between buttresses 226a and 226b, 226b and 226c, 226c and 226d, and 226d and 226a.

5 Significant in the structure of impact pad 200 is the lack of any upwardly and inwardly surface reversing or directing either an incoming or outgoing stream of molten metal. All surfaces of upper lip 214 and inner wall surface 222 are directed upwardly and outwardly, except for first portion 224 which is directed
10 downwardly and inwardly towards raised impact surface 248. The flow of molten metal out of impact pad 200 is directed upwardly and outwardly guided by upwardly and outwardly extending wall surfaces 218 and 220.

A downwardly directed stream of molten metal
15 into impact pad 200 is not redirected or reversed upwardly and inwardly toward the incoming stream. Nor is there an upward and inward portion, let alone an endless or continuous upward and inward portion, to redirect or reverse the incoming stream back into itself in an
20 upwardly and inwardly direction, as may be found in other impact pads. Nor does impact pad 200 create two opposed vertical streams or counter current flows in and above the pad, which interact with each other to such a degree that they significantly slow each other down.

25 To the contrary, the flow of molten metal is redirected inwardly and downwardly in the vicinity of inner wall surface 222 by first wall surfaces 224. And the flow is redirected upwardly and outwardly out of impact pad 200 which is away from the incoming stream.
30 The purpose of inner wall surface 222, including segments 224ab, 224bc, 224cd and 224ad, buttresses 226a-d and channels 230 is to create turbulence which "brakes" or

- 18 -

slows down the upwardly and outwardly flow of molten metal out of the impact pad.

By utilizing lateral deflection of the flow from the ladle, instead of, for example, flow reversal as taught by prior impact pads, the impact pad of the present invention provides many benefits. These benefits are:

1. Flow stabilization. Dividing and laterally deflecting the radial flow within the discrete pockets produces a much more stable flow exiting the pad. In addition, flow stabilization as a result of the buttresses, and controlling the area of the outlet holes provides sufficient velocity and controlled flow redirection so that the fluid residence time behavior within the tundish is complimented. A relationship between the total casting rate in lbs/min., the volume in the chamber (cubic inches), and the outlet hole(s) area (square inches) can be determined on the basis of the desired turbulence energy factor.

2. Insensitivity to the ladle pouring position. Dividing and laterally deflecting the flow within the discrete pockets eliminates the initial splash associated with the first ladle opening because the flow within the impact chamber pad is not sensitive to the ladle pouring position. In prior art pads, a non-central location of the incoming ladle stream amplifies the reversed flow and can result in excessive splash or ultimately, liquid metal being ejected from the tundish. In the case of the impact pad of the present invention, the lateral deflection and flow pattern division stabilizes the flow so that even under non-central ladle pouring conditions, high velocity jetting and resulting turbulence are alleviated.

- 19 -

3. No short-circuit flow. In prior art pads, the flow is directed from the pad in an upward and inward direction which accelerates the flow and causes it to "rebound" off the surface of the liquid metal in the tundish, causing short-circuit flow to the closest exit strands in the tundish. In the impact pad of the present invention, the chamber releases the flow in an upward and outward manner which alleviates this type of short-circuit flow.

4. Cleanliness. The upward and outward flow from the impact pad of the present invention provides continual opportunity for the floatation of slag and non-metallic inclusions, resulting in liquid metal cleanliness improvements, particularly when the tundish is being filled or refilled. Moreover, the impact pad prevents the radial outward flow from being re-entrained with the incoming ladle stream.

In summary, the impact pad of the present invention stabilizes the flow of liquid metal exiting the pad. It controls the radially dispersed outward flow which is formed by the impact of the downward ladle stream on the base of the pad.

The impact pad controls the radially dispersed outward flow by the multiple faceting and discrete pocketing of the pad's sidewall. The sidewall pockets radially disperse the outward flow by laterally deflecting and dividing the radial flow into multiple discrete, stable and consistent flow patterns or segments associated with each of the sidewall pockets.

The impact pad of the present invention is insensitive to the ladle pouring stream. It eliminates problems associated with slag emulsification, flow stagnation regions, thermal inhomogeneity, short-circuit

- 20 -

flow, liquid residence distribution, and in particular, initial splash when the ladle is first opened. And the impact pad is easy to use and manufacture.

5 Although the present invention has been described in relation to particular embodiments thereof, many other variations and modifications and other uses will become apparent to those skilled in the art.

WHAT IS CLAIMED IS:

1. An impact pad for receiving a downward flow of liquid metal comprising:
 - a base having an impact surface;
 - 5 a first faceted sidewall having a plurality of facets formed therein, the sidewall extending upwardly from and encompassing the impact surface to define an interior space having an upper opening for receiving the downward flow of liquid metal;
 - a second wall extending inwardly and upwardly from the first faceted wall toward the upper opening;
 - 10 a third wall extending upwardly and outwardly from the second wall to define an upper lip of the impact pad; and
 - a plurality of buttresses spaced along the first faceted wall, each buttress extending between the impact surface and the second wall, and having a surface facing an interior of the impact pad and coextensive with the third wall, the buttresses forming a plurality
 - 15 of discrete pockets including at least one facet, the pockets being defined by the buttresses, the impact surface, the first faceted wall and the second wall.
2. The impact pad of claim 1, wherein the interior surface of each buttress and the coextensive third wall extend upwardly and outwardly from the base.
- 20
3. The impact pad of claim 1, wherein each discrete pocket has a second wall being non-continuous and with a beginning and an end as defined by the spaced apart buttresses.

4. An impact pad for receiving a downward flow of liquid metal comprising:
a base surface;
a first faceted sidewall having a plurality of facets formed therein, the sidewall extending
upwardly and outwardly from the base and encompassing the base surface to define an
interior space having an upper opening for receiving the downward flow of liquid metal;
a second wall extending inwardly and upwardly from the first faceted wall to the upper
opening; and
a plurality of buttresses spaced along the first faceted wall, each buttress extending
between the base surface and the second wall, the buttresses forming a plurality of
discrete pockets including at least one facet, the pockets being defined by the buttresses,
the base surface, the first faceted wall and the second wall.
5. The impact pad of claim 4, further comprising a lip defined by at least one wall extending
upwardly and outwardly from the second wall.
6. The impact pad of claim 4, wherein the base surface has a raised portion spaced from the
first faceted wall and thereby defining a depression in each of the pockets.
7. The impact pad of claim 4, wherein the upper opening has at least one surface extending
upwardly and outwardly.

8. The impact pad of claim 7, wherein the upper opening has a second surface connected to the at least one surface and extending upwardly and outwardly.

9. The impact pad of claim 4, wherein each buttress has a surface facing the interior space of the impact pad, and such surface extends upwardly from the base surface.

10. The impact pad of claim 4, wherein each first faceted wall of each discrete pocket is non-continuous with a beginning and an end as demarcated by the buttresses defining each discrete pocket.

11. The impact pad of claim 4, wherein each second wall is non-continuous with a beginning and an end as demarcated by the buttresses defining each discrete pocket.

12. An impact pad for receiving a downward flow of liquid metal, comprising:
- a base surface;
- a first wall having a plurality of facets formed therein encompassing the base surface to define an interior space having an upper lip for receiving the downward flow of liquid metal;
- a second wall connected to an upper end of the first wall;
- a plurality of spaced-apart buttresses, each buttress extending between the base surface and the second wall; and
- a plurality of discrete pockets defined by the buttresses, the base surface, the first wall, and the second wall;
- none of the first wall, second wall and plurality of buttresses extends upwardly and inwardly with respect to the base surface.
13. The impact pad of claim 12, wherein the surface of the first wall extends upwardly and outwardly from the base surface.
14. The impact pad of claim 12, wherein the second wall extends inwardly and downwardly relative to the base surface.
15. The impact pad of claim 12, wherein the surface of the second wall of each discrete pocket has a beginning and an end which are defined by the buttresses.

1/8

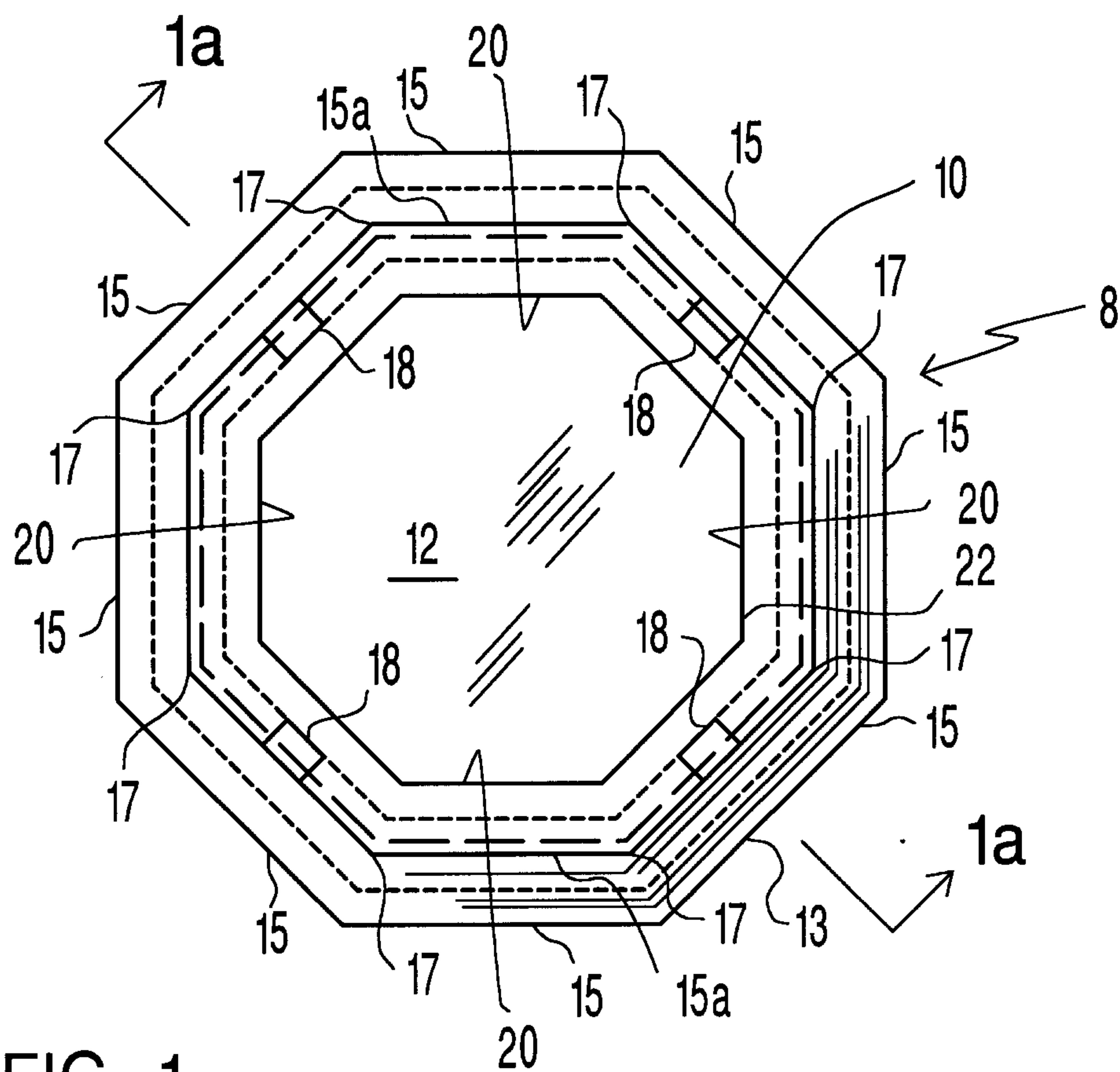
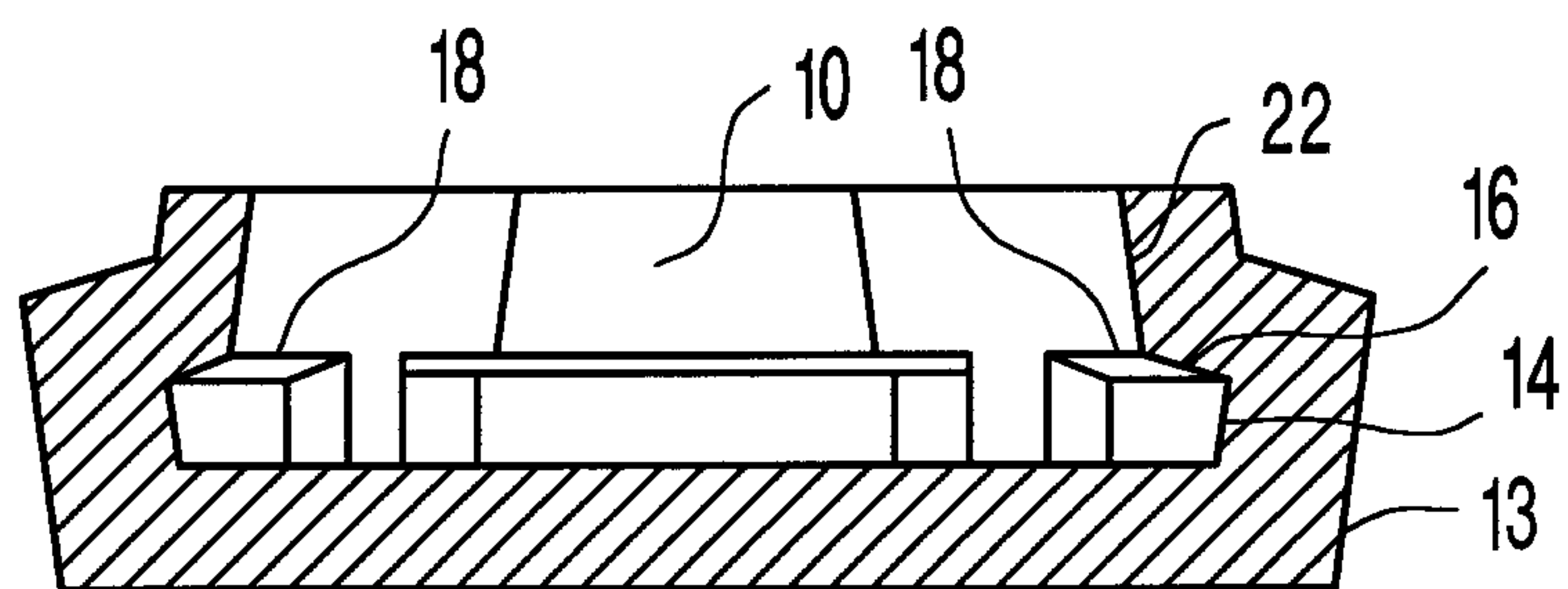
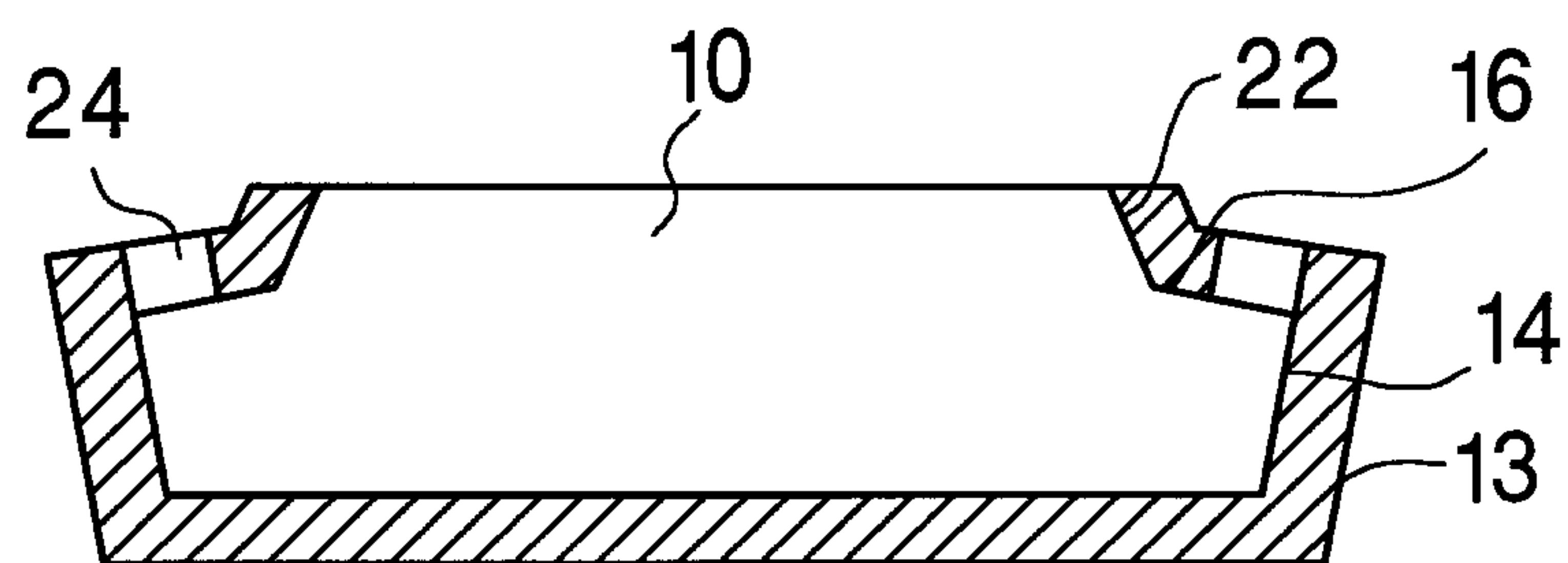
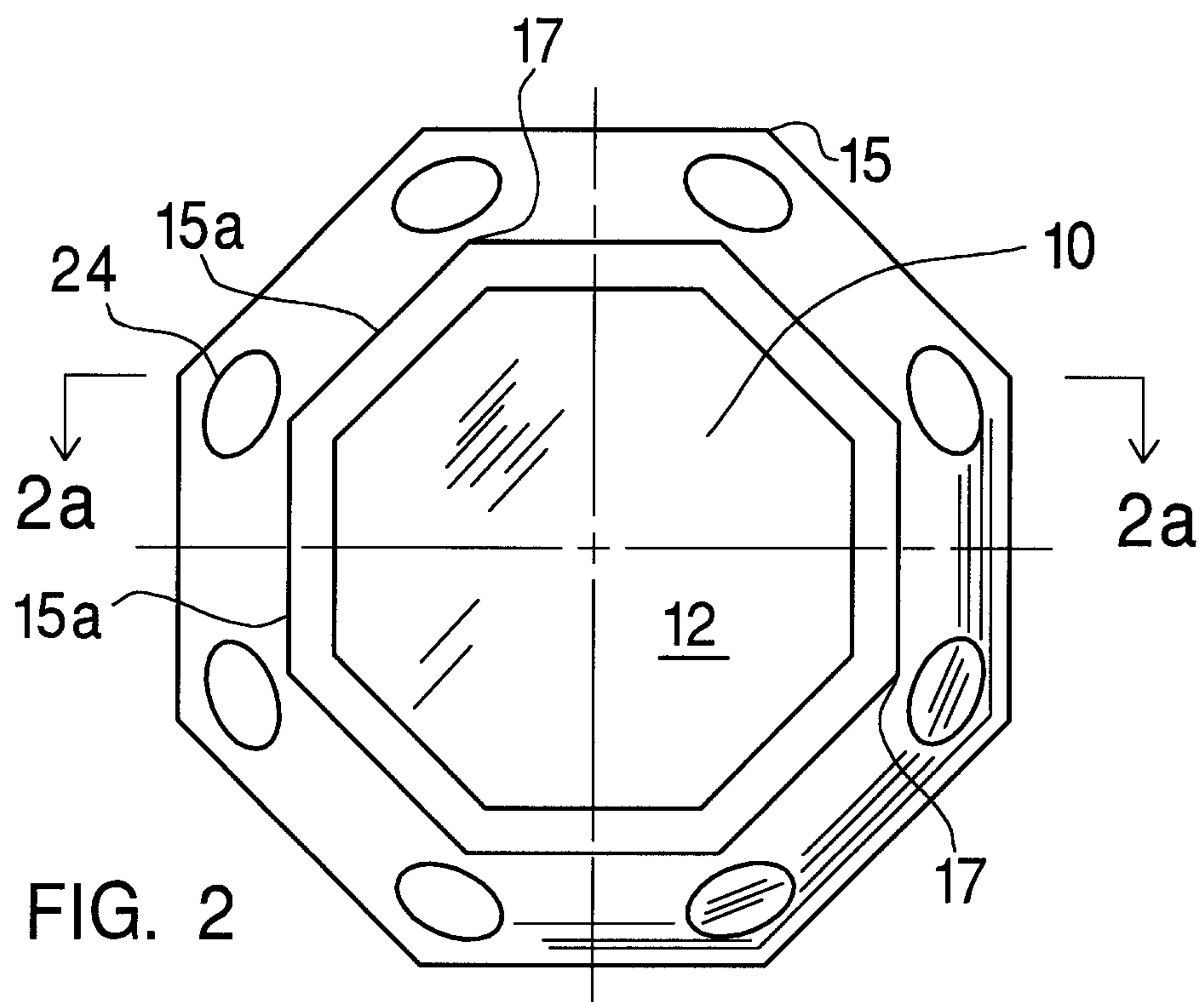


FIG. 1

FIG. 1a



2/8



(BUTRESSES NOT SHOWN IN
BACKGROUND FOR CLARITY)

FIG. 2a

3/8

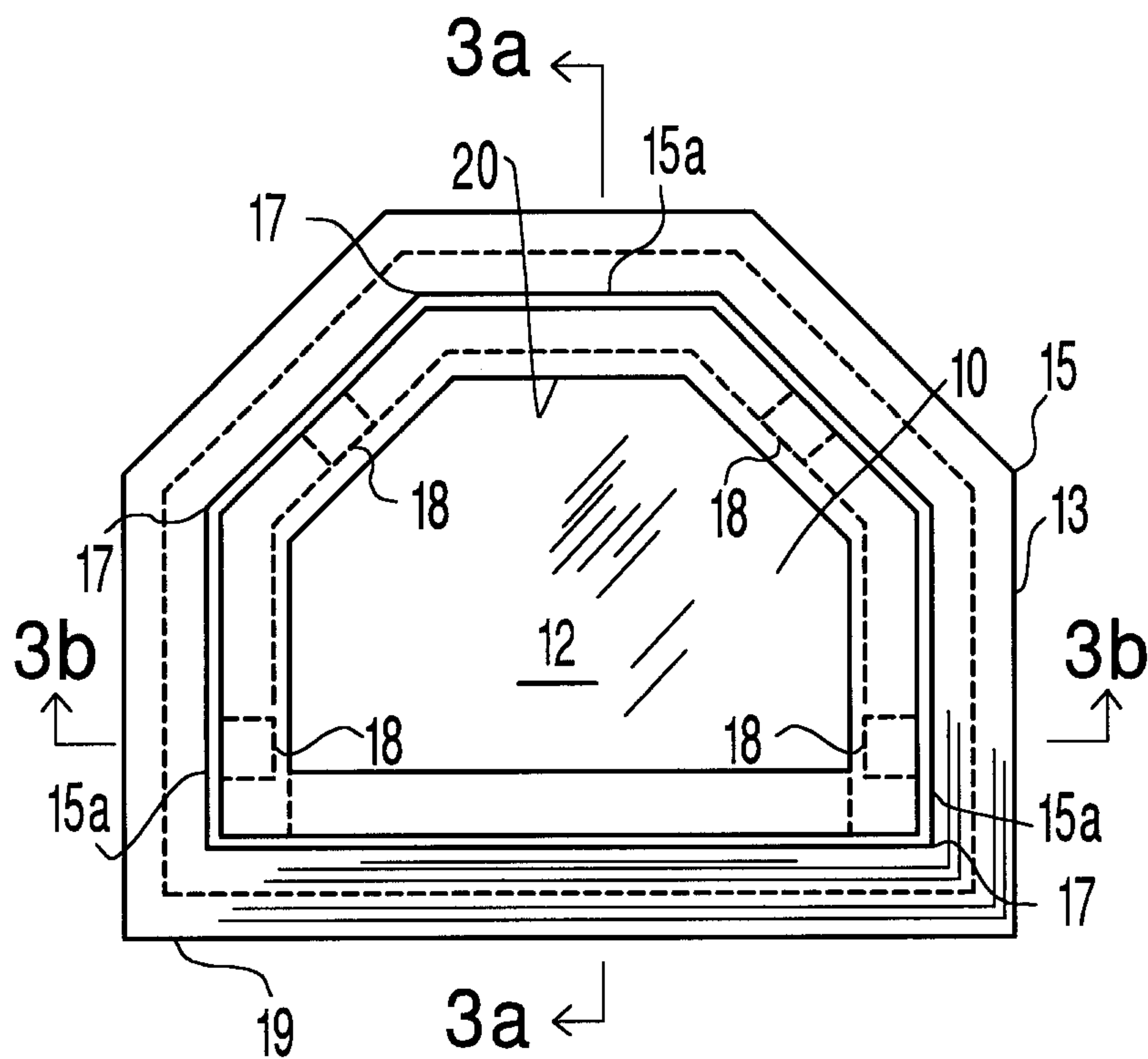


FIG. 3

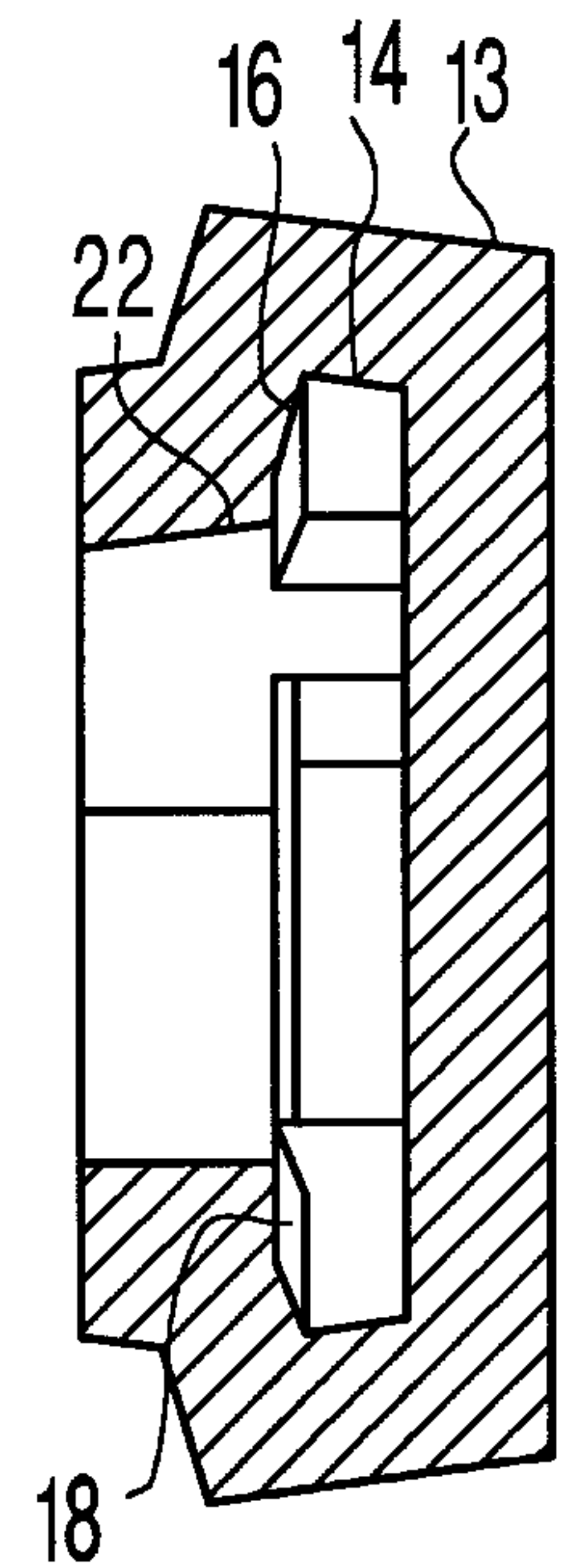


FIG. 3a

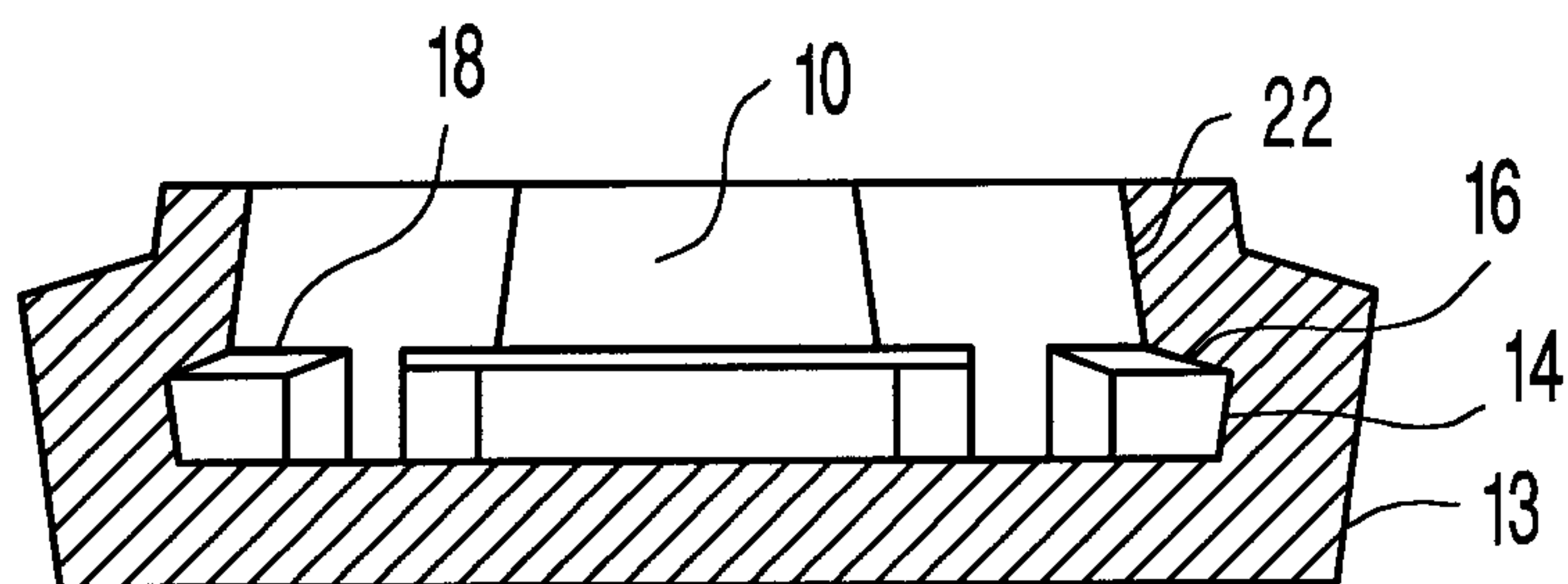


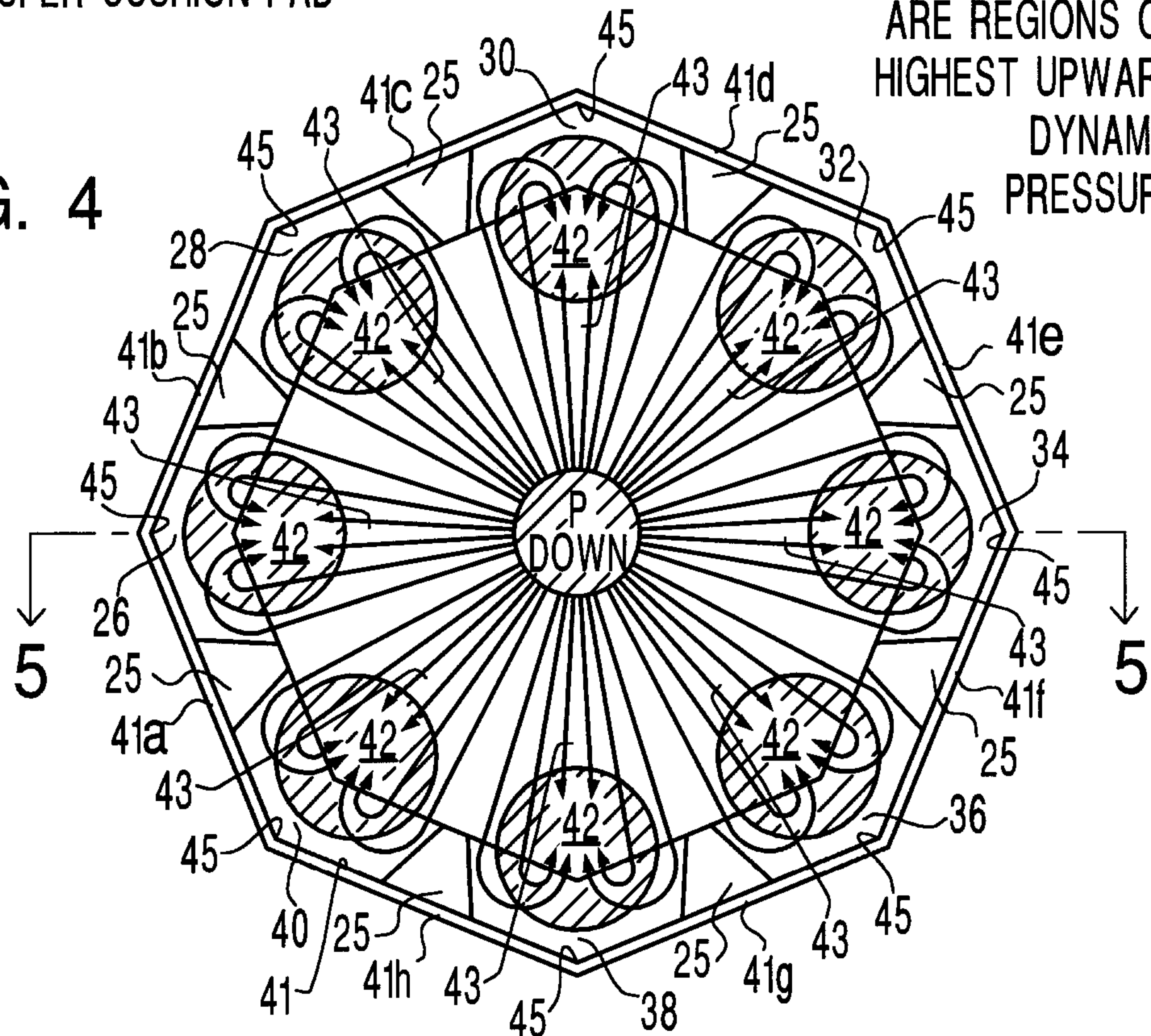
FIG. 3b

4/8

SCHEMATIC REPRESENTATION OF FLOW IN INTERIOR
OF SUPER CUSHION PAD

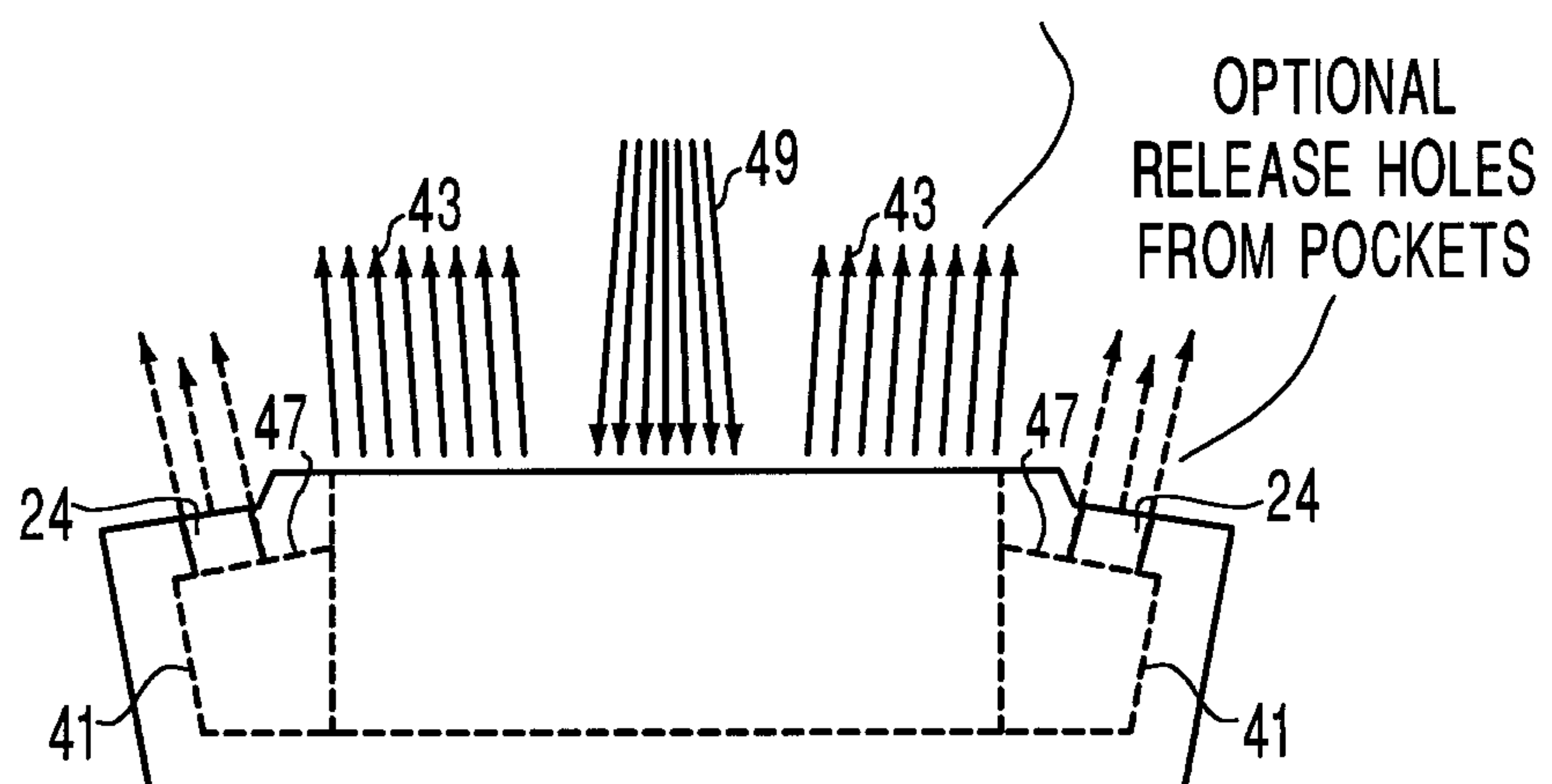
HATCHED AREAS
ARE REGIONS OF
HIGHEST UPWARD
DYNAMIC
PRESSURE

FIG. 4



STRONGEST UPWARD AND OUTWARD FLOWS EXIT PAD
FROM REGIONS OF HIGHEST DYNAMIC PRESSURE

FIG. 5



SCHEMATIC REPRESENTATION OF FLOW INTO
AND OUT OF SUPER CUSHION PAD ALONG VIEW 5

5/8

FIG. 6

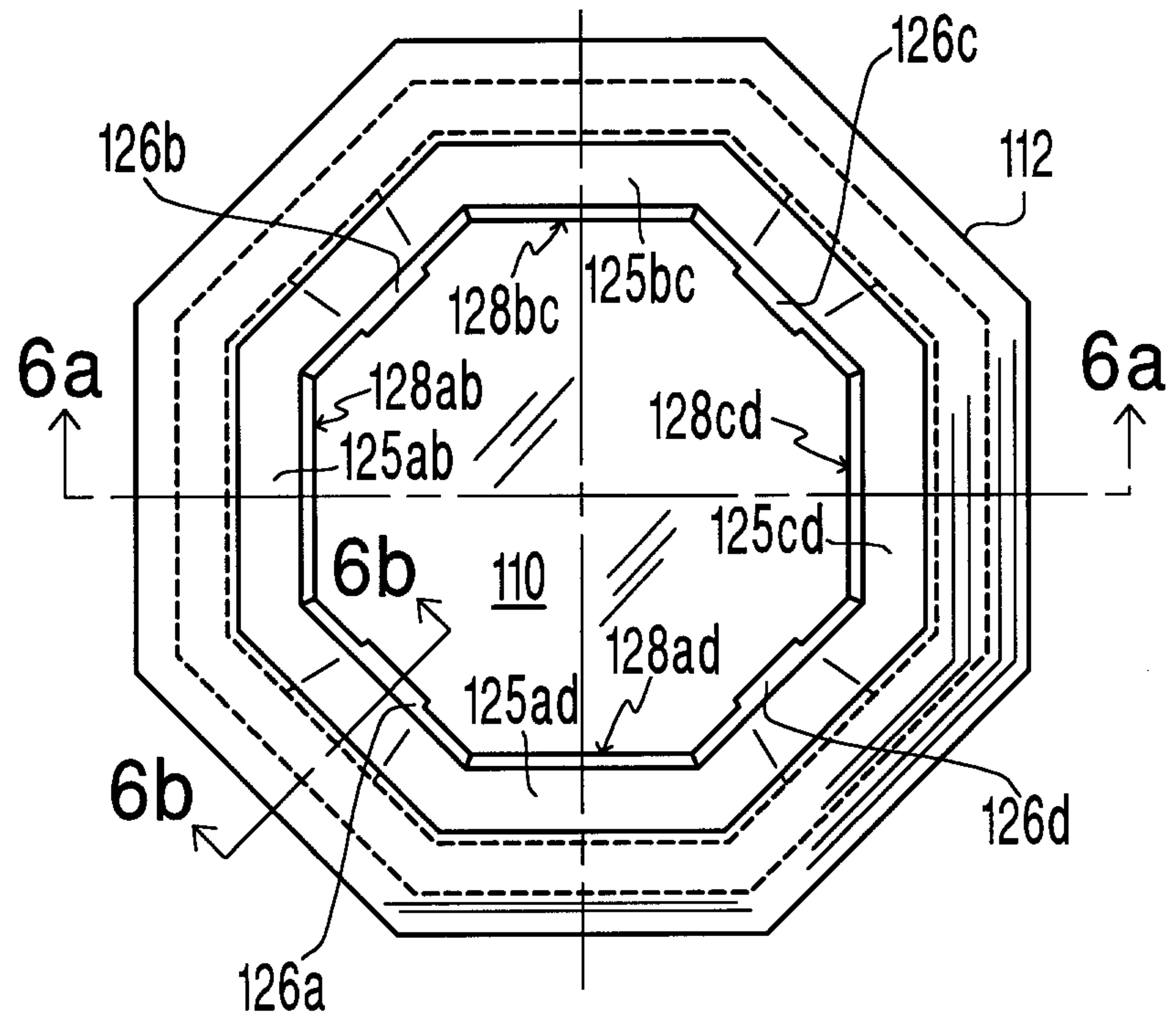


FIG. 6a

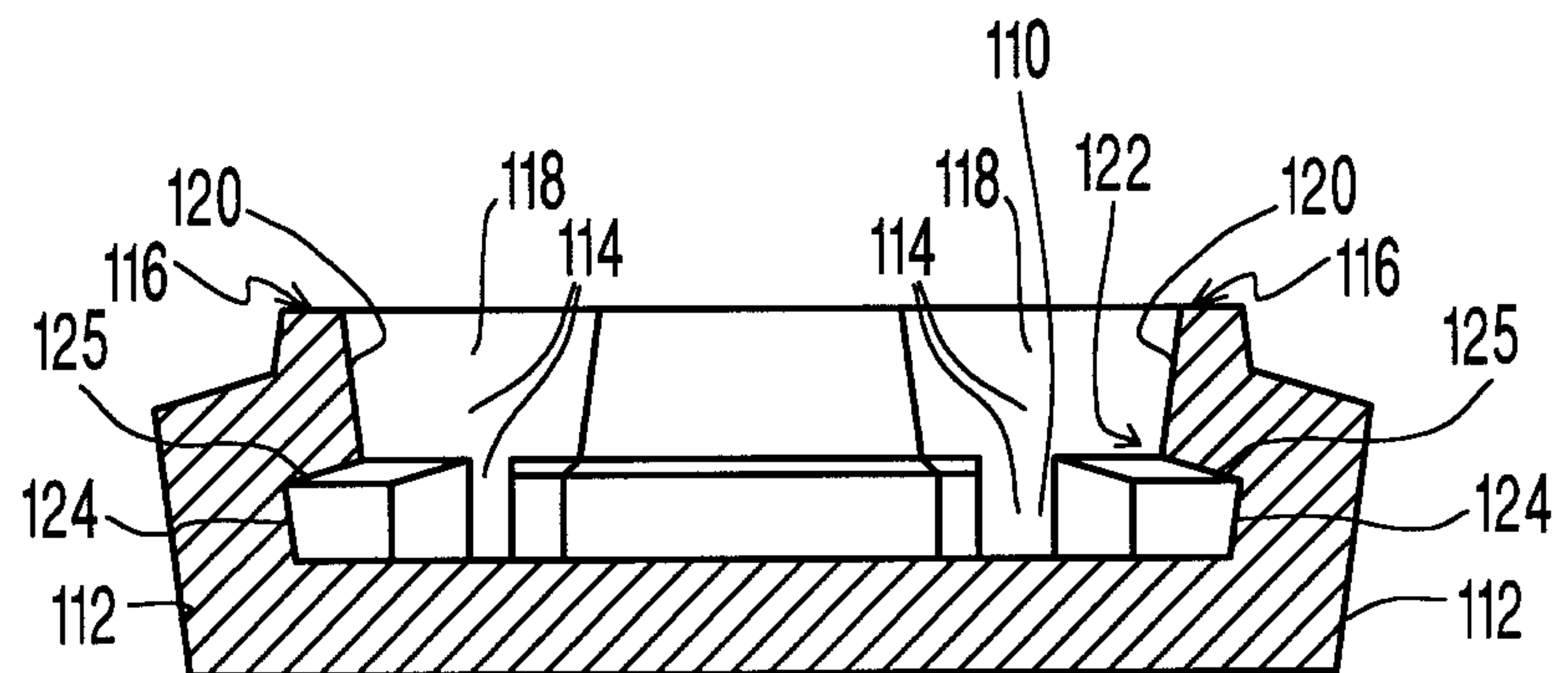
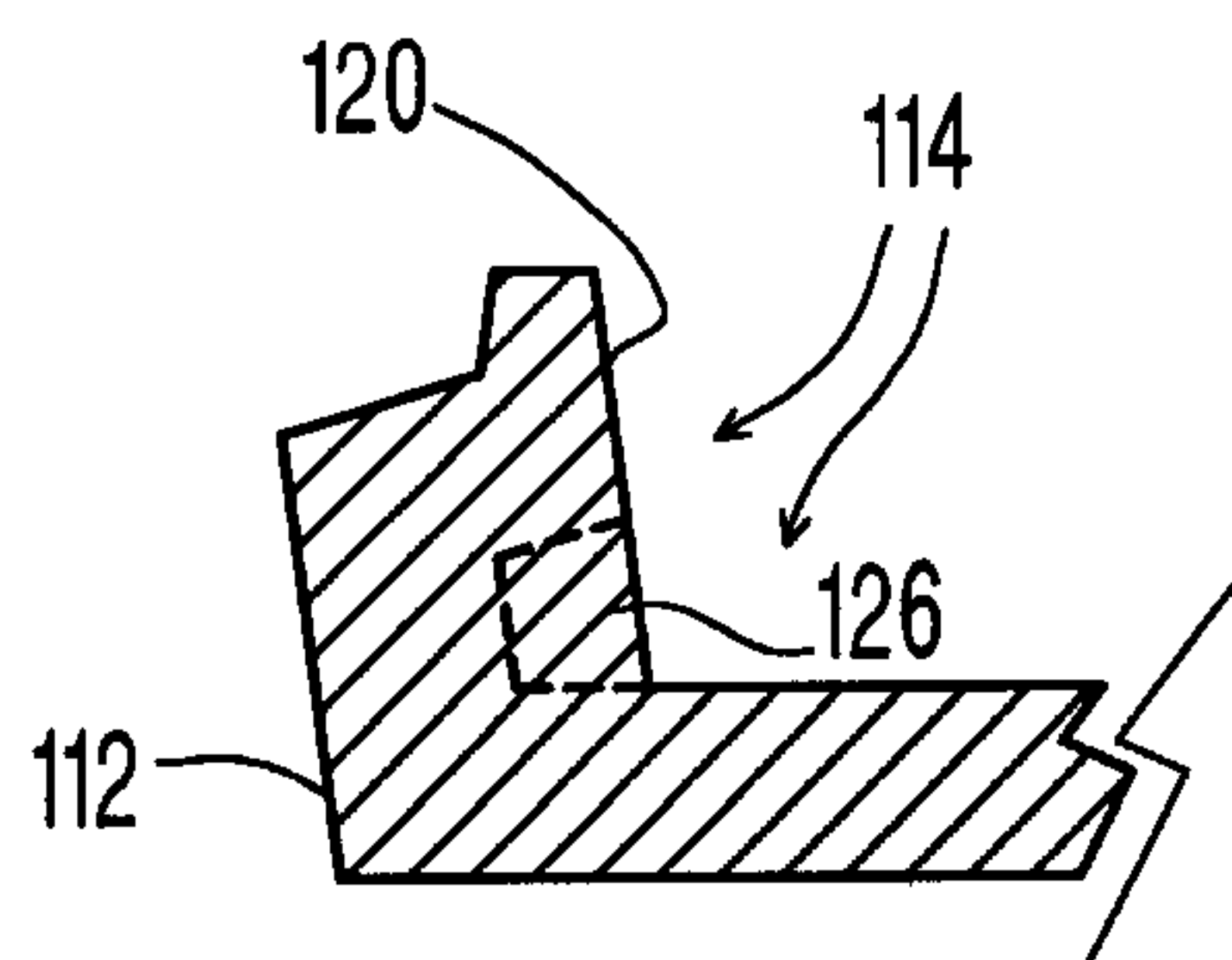


FIG. 6b



6/8

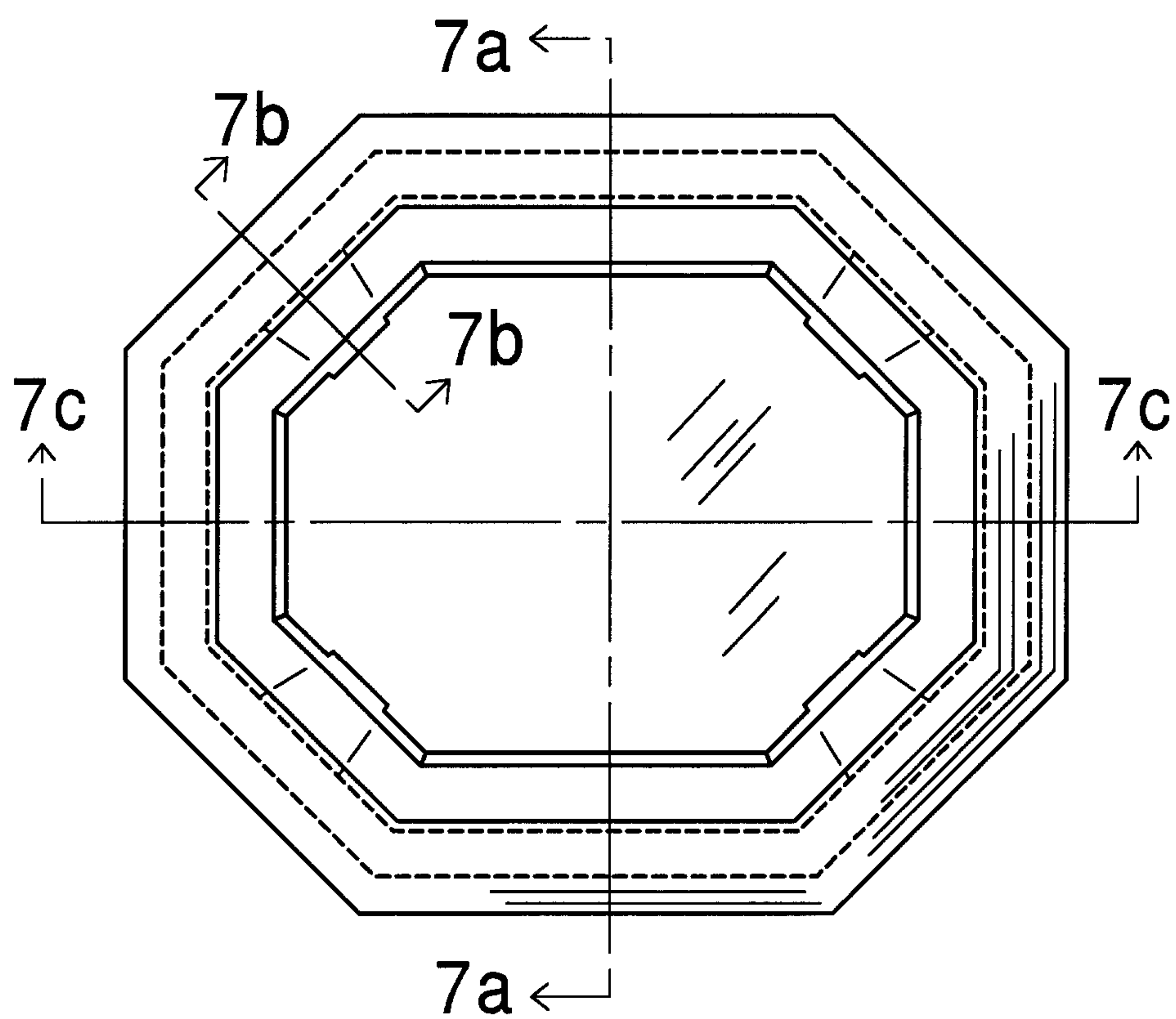


FIG. 7

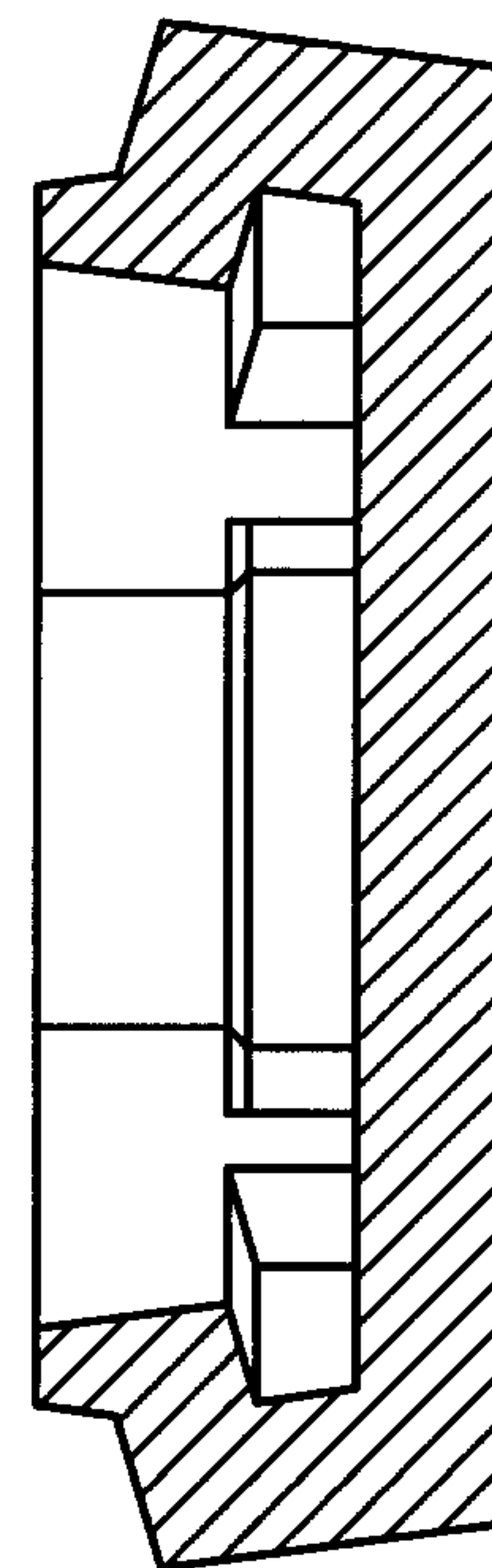


FIG. 7a

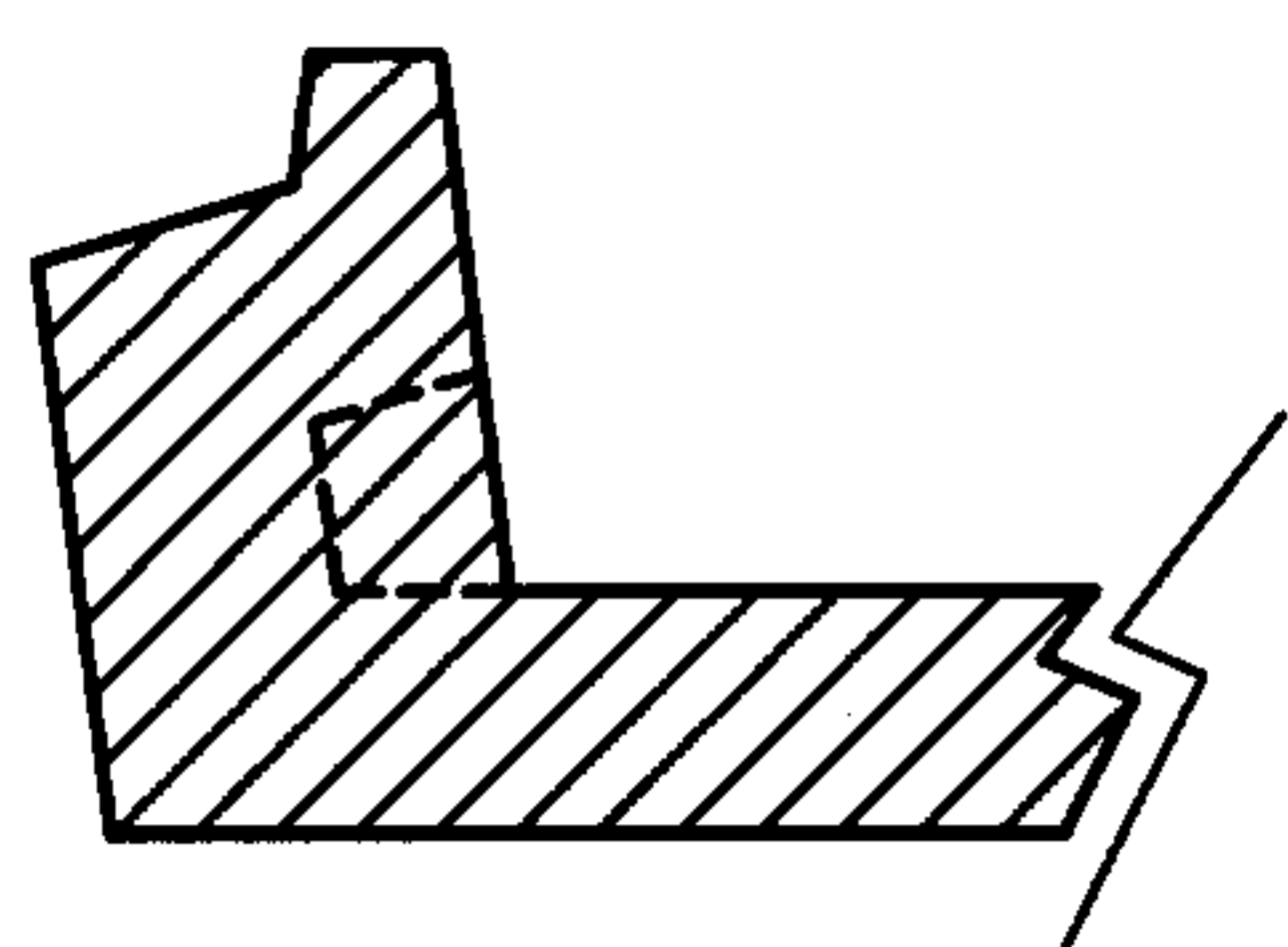


FIG. 7b



FIG. 7c

7/8

FIG. 8

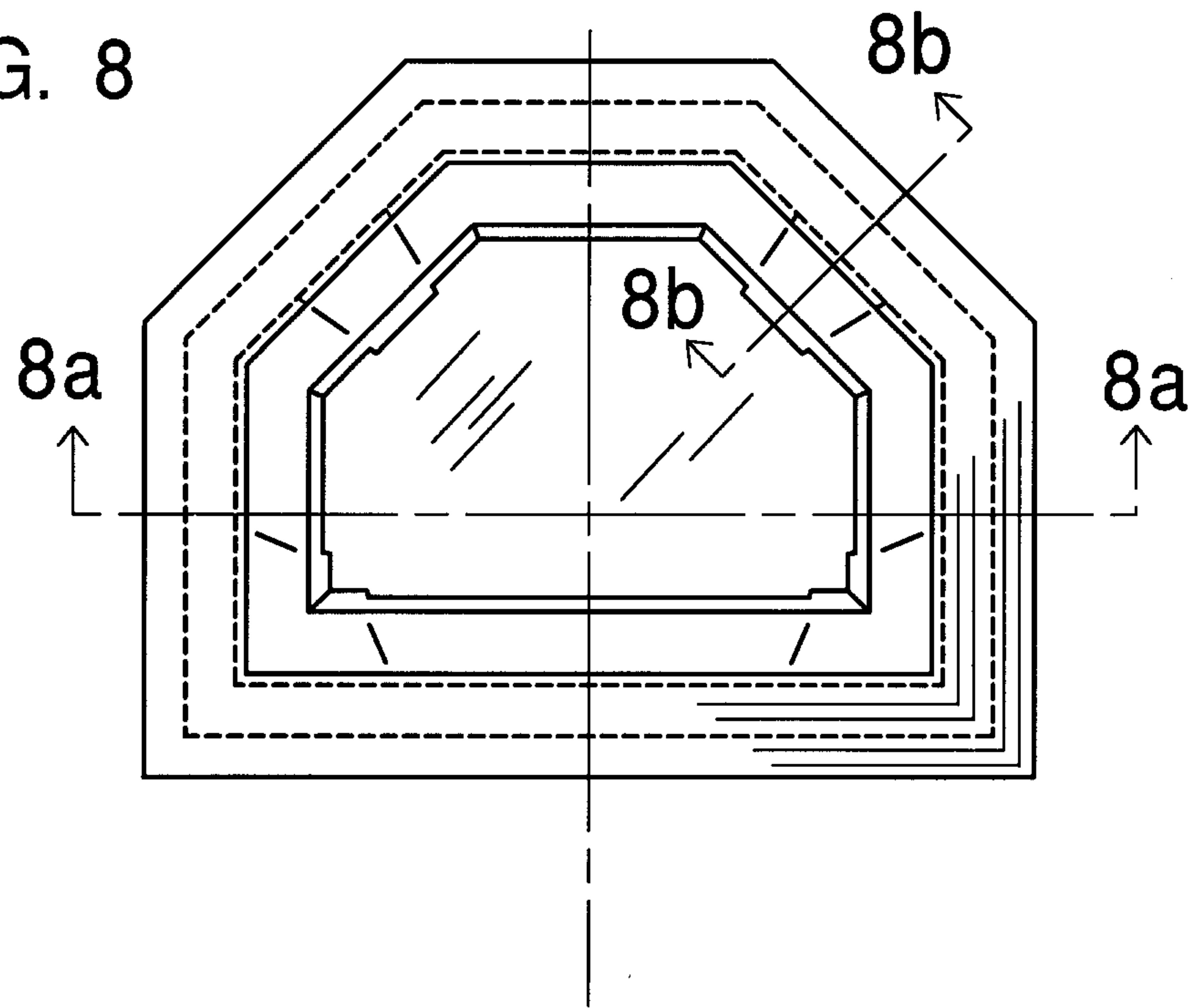


FIG. 8a

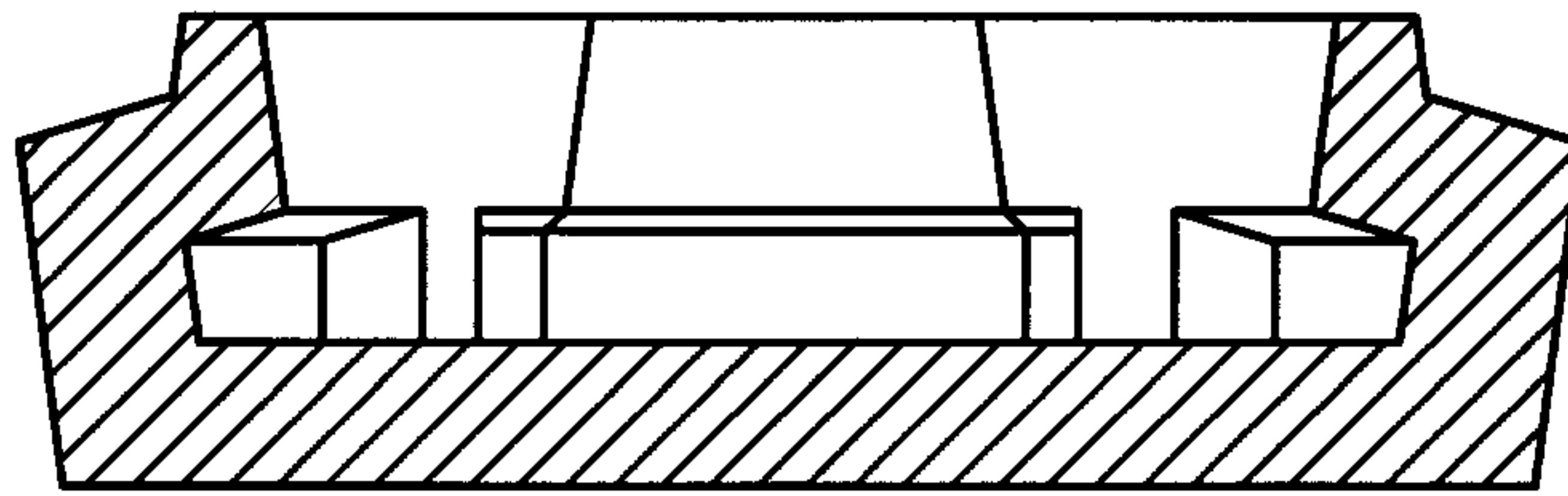
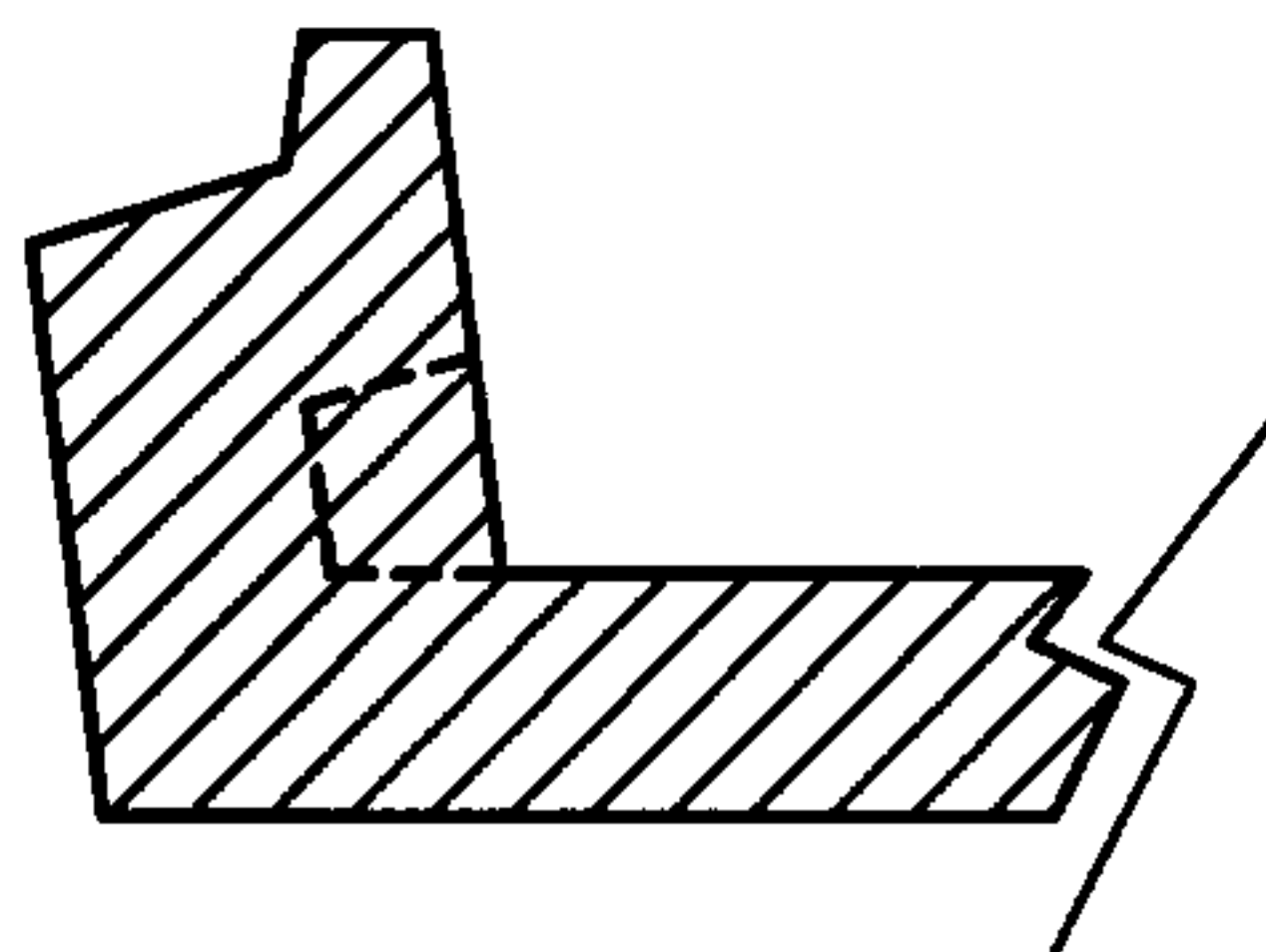


FIG. 8b



8/8

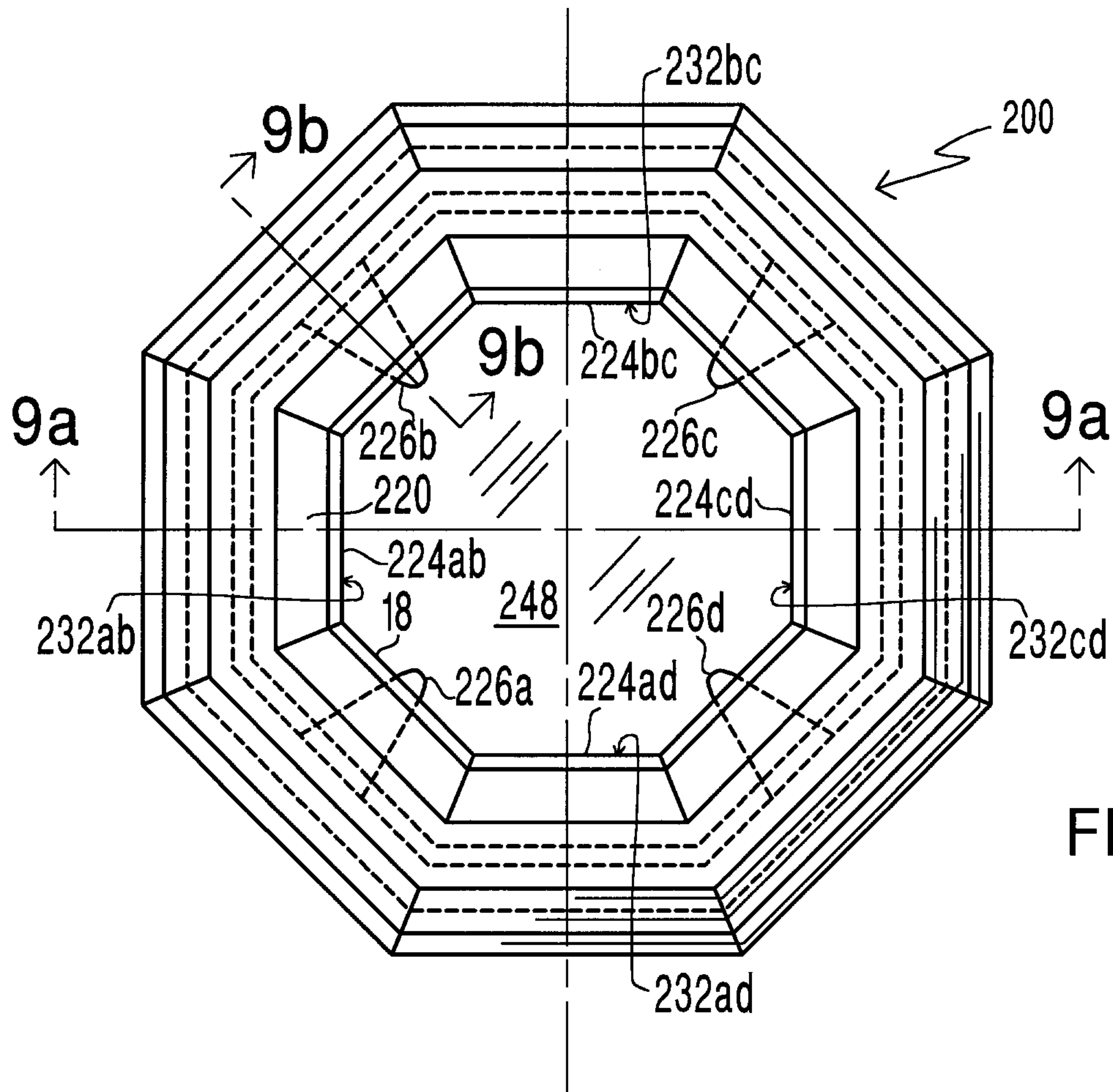


FIG. 9

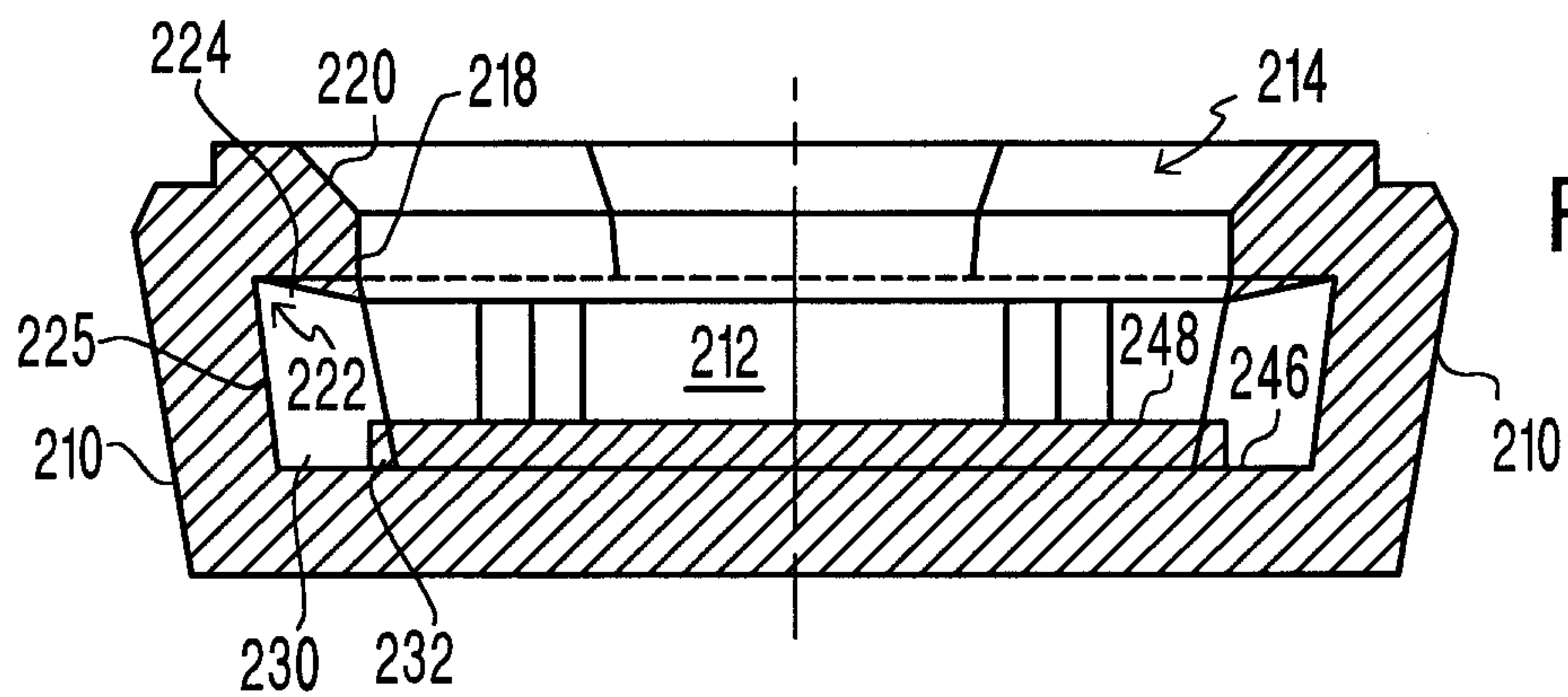


FIG. 9a

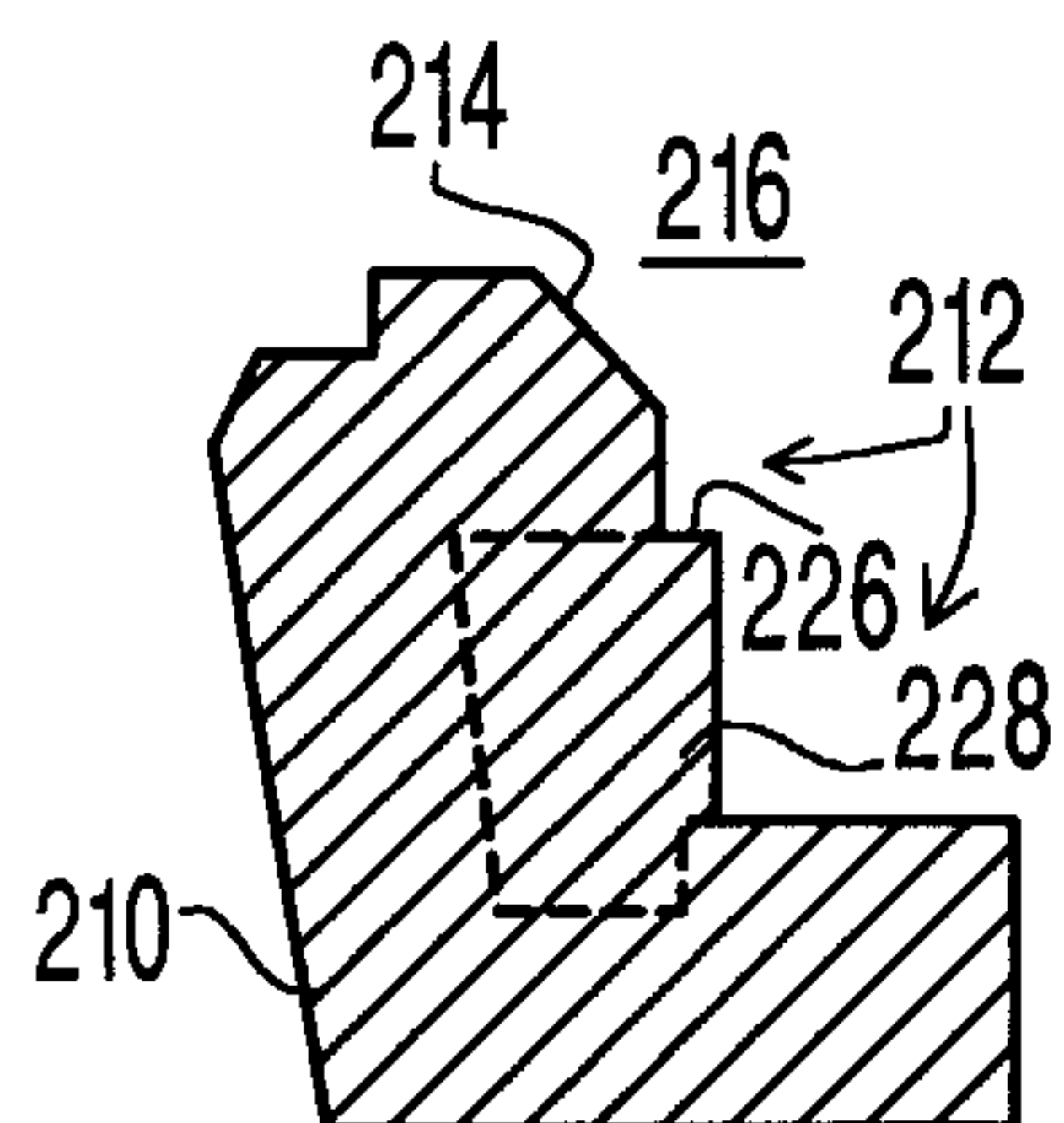


FIG. 9b

