US 20030192263A1

(19) **United States**

(12) **Patent Application Publication**

Kasinger et al.

(10) **Pub. No.: US 2003/0192263 A1**

(43) **Pub. Date: Oct. 16, 2003**

(54) **PORTABLE GREENHOUSE STRUCTURE AND METHOD AND APPARATUS FOR ASSEMBLING SAME**

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(21) Appl. No.: **10/446,473**

(22) Filed: **May 27, 2003**

Related U.S. Application Data

(63) Continuation of application No. 09/850,933, filed on May 7, 2001, now abandoned, which is a continuation of application No. 09/512,137, filed on Feb. 23, 2000, now Pat. No. 6,499,260.

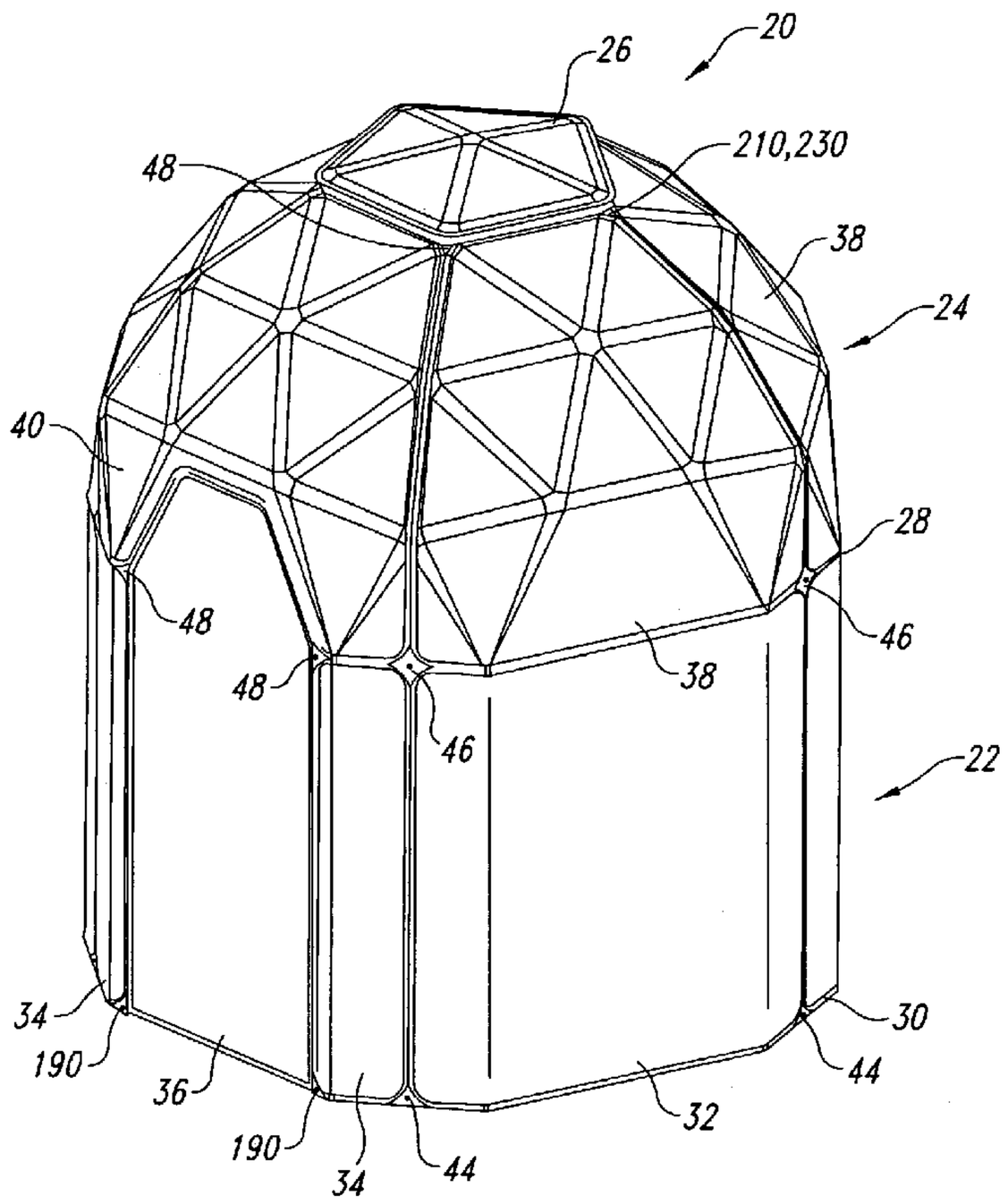
Publication Classification

(51) **Int. Cl.**[7] **E04H 1/00**

(52) **U.S. Cl.** **52/79.1**

(57) **ABSTRACT**

The present invention provides a portable greenhouse structure comprising a base in the shape of a right-polygonal cylinder having a top and a bottom, wherein the base comprises a plurality of wall panels connected along abutting edges; a hemispherical roof attached to the top of the base, wherein the hemispherical roof has a polygonal hole in the apex thereof; and a polygonal panel having the same shape as the polygonal hole, wherein the polygonal panel is moveable between an open position and a closed position, and wherein the polygonal panel sealably covers the polygonal hole when in the closed position. The present invention also provides an apparatus for joining a first panel to a second panel along abutting edges thereof, the apparatus comprising a first extrusion attached to the abutting edge of the first panel, wherein the first extrusion comprises a stem which projects away from a plane of the panel and has a panel side and a mating side; a second extrusion attached to the abutting edge of the second panel, wherein the second extrusion comprises a stem which projects away from a plane of the panel and has a panel side and a mating side; and a clamp which holds the stem of the first extrusion and the stem of the second extrusion together such that the mating side of the first extrusion is in contact with the mating side of the second extrusion.



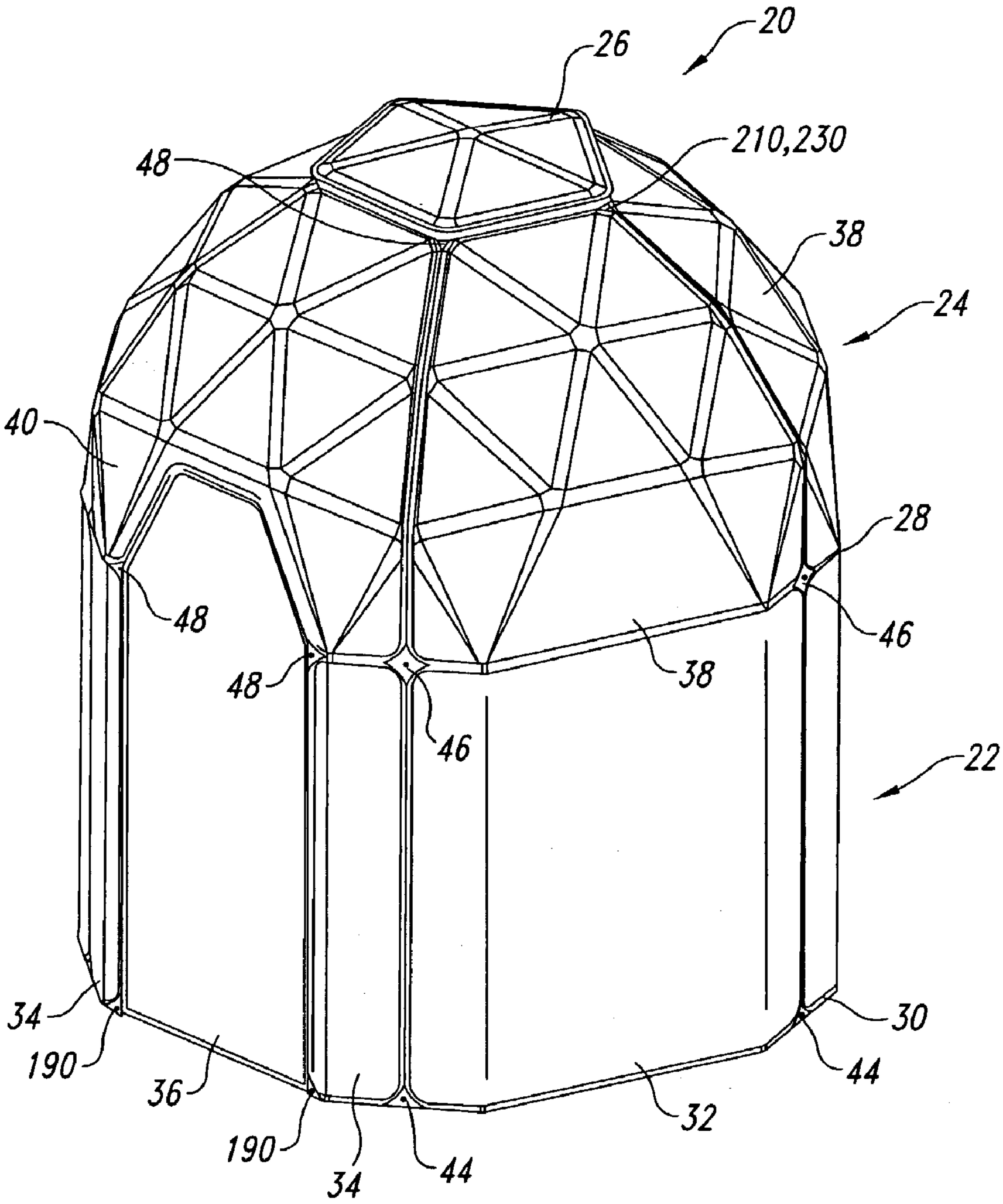

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Fig. 1A

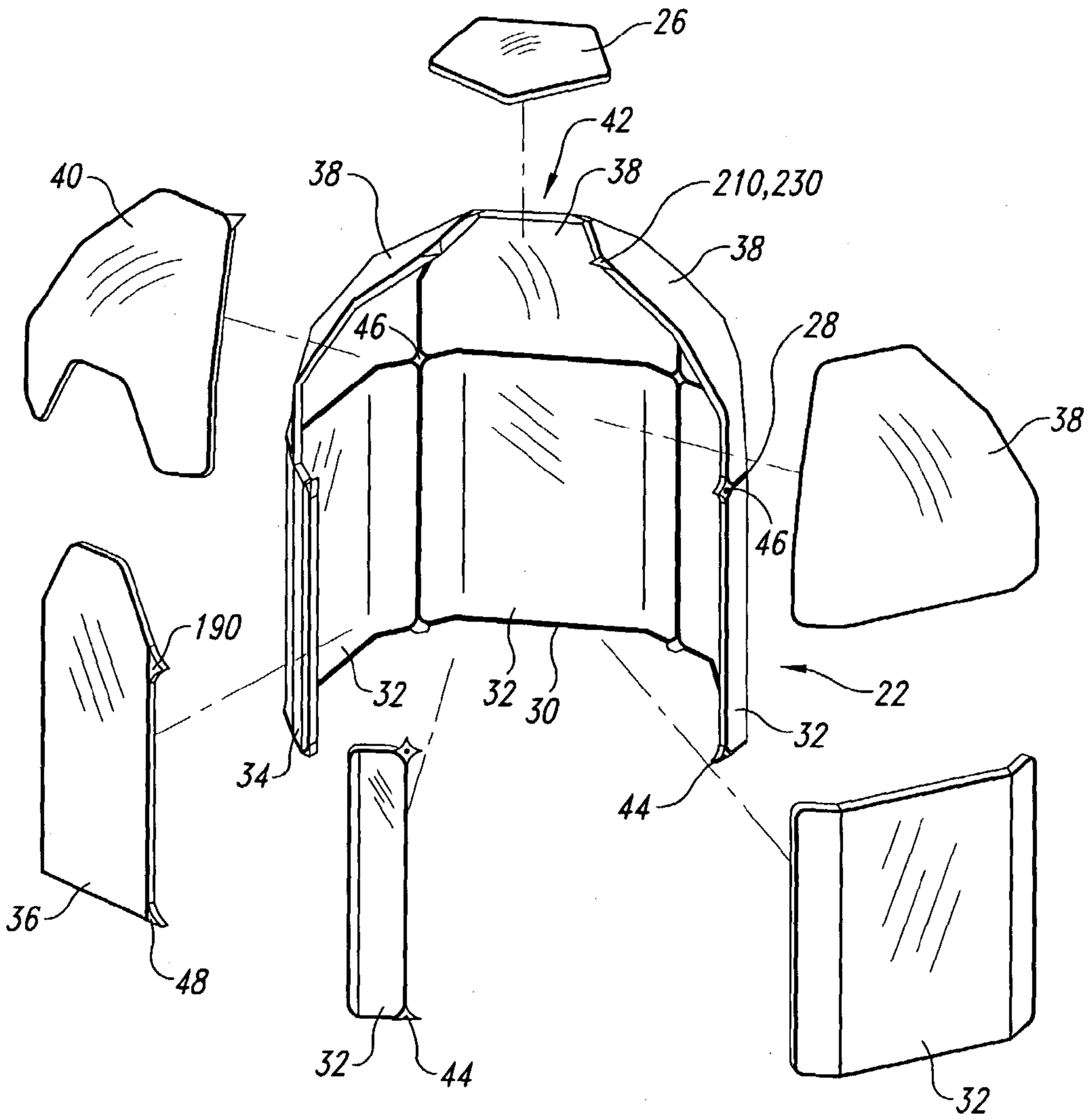

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Fig. 1B

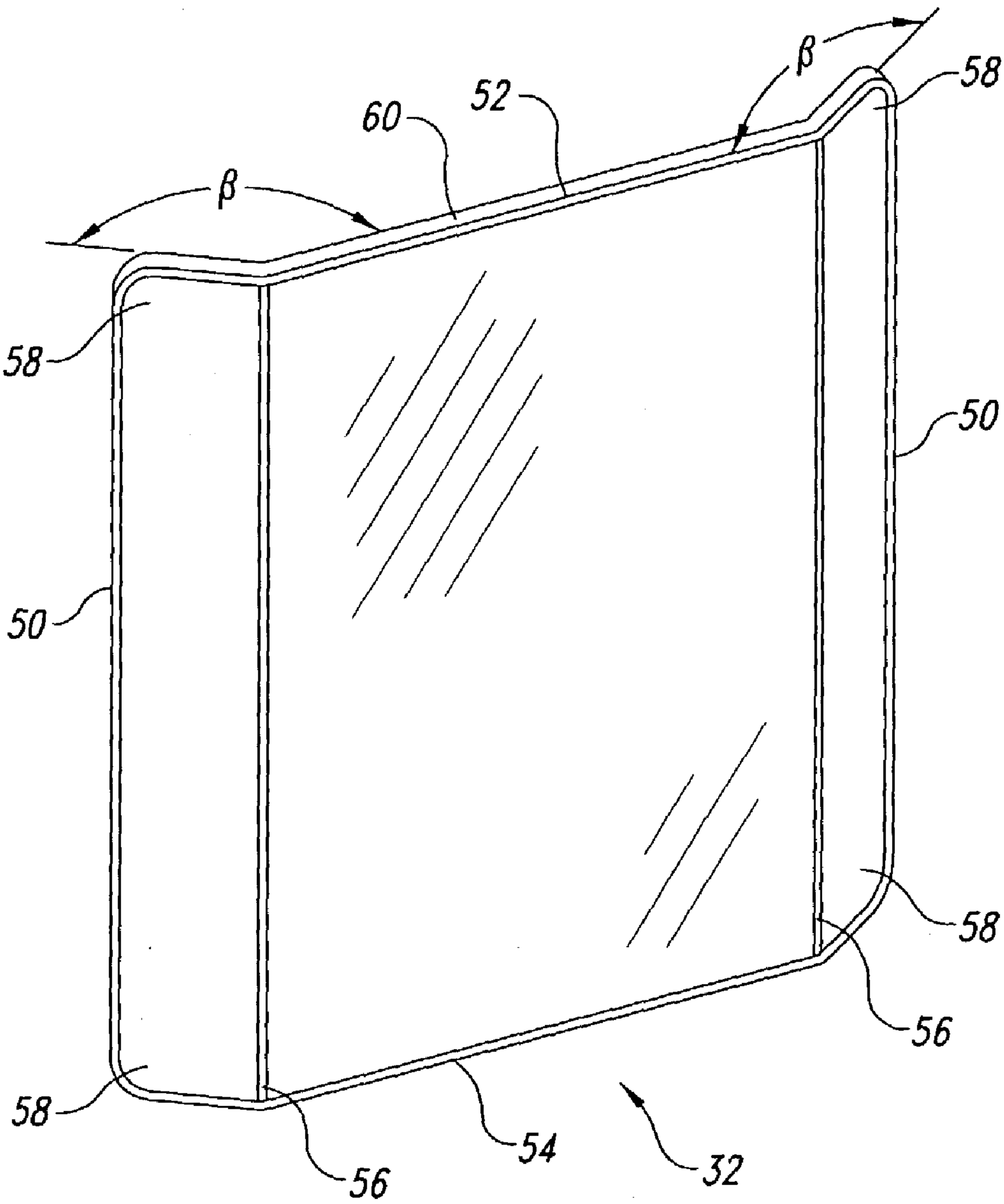


Fig. 2A

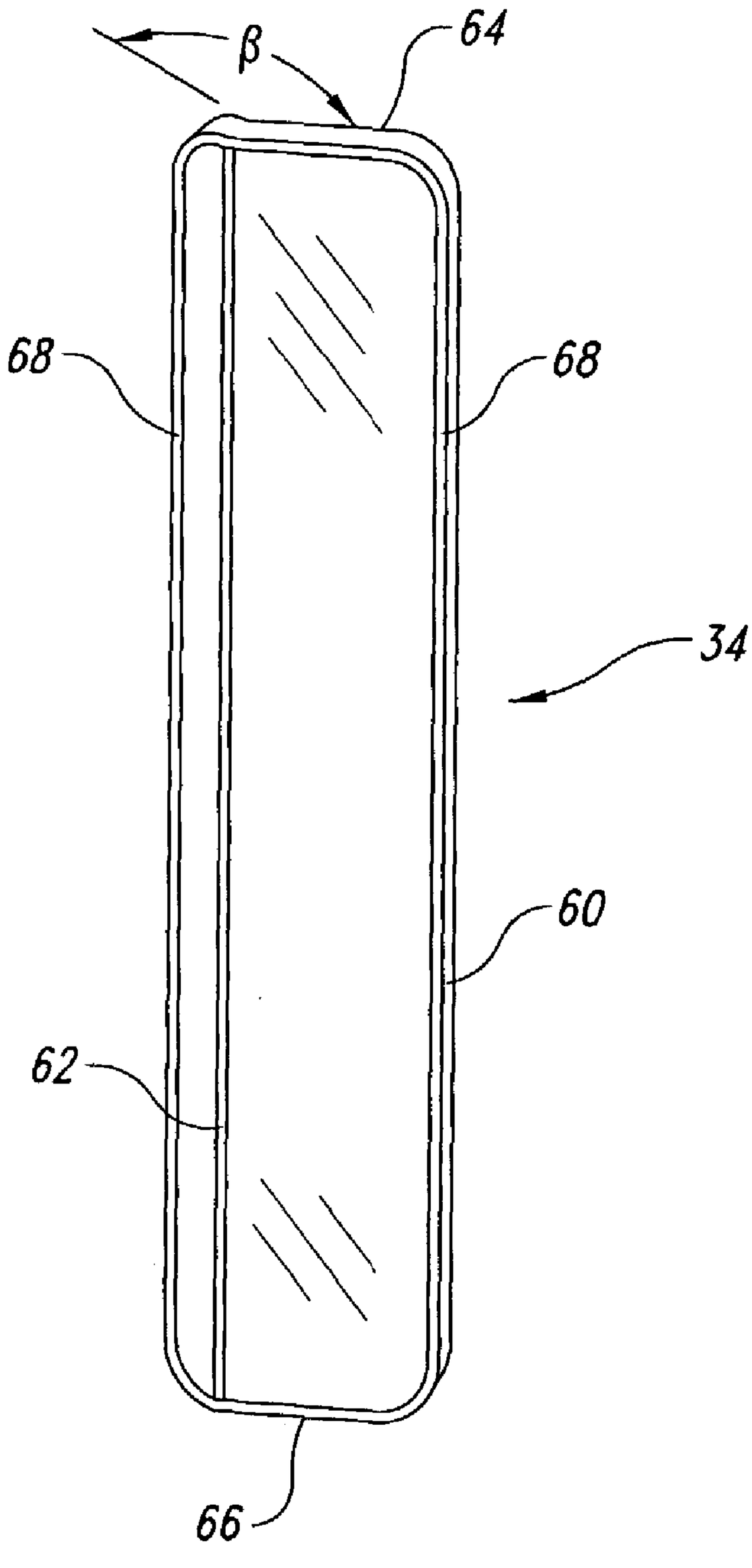


Fig. 2B

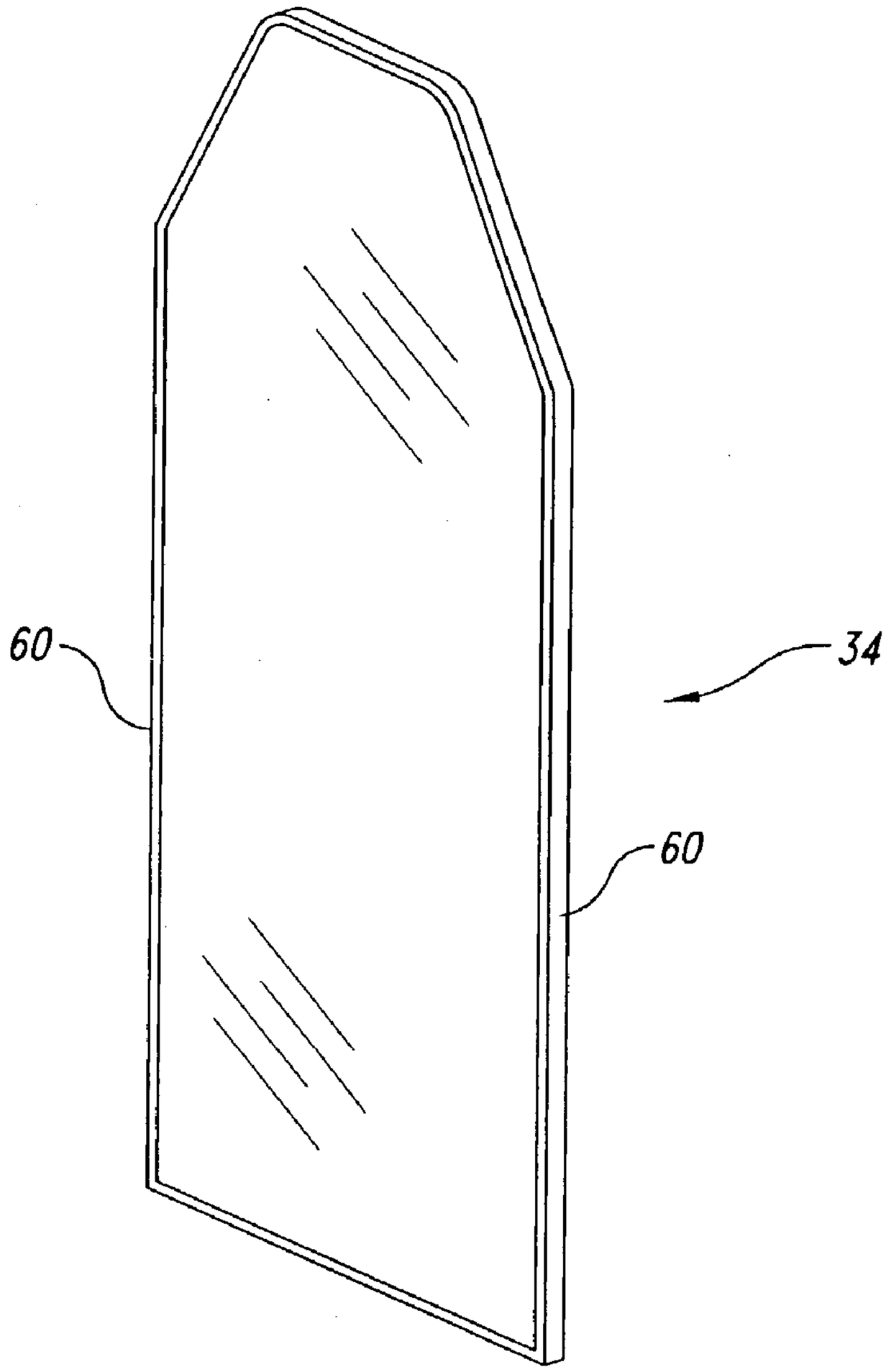


Fig. 2C

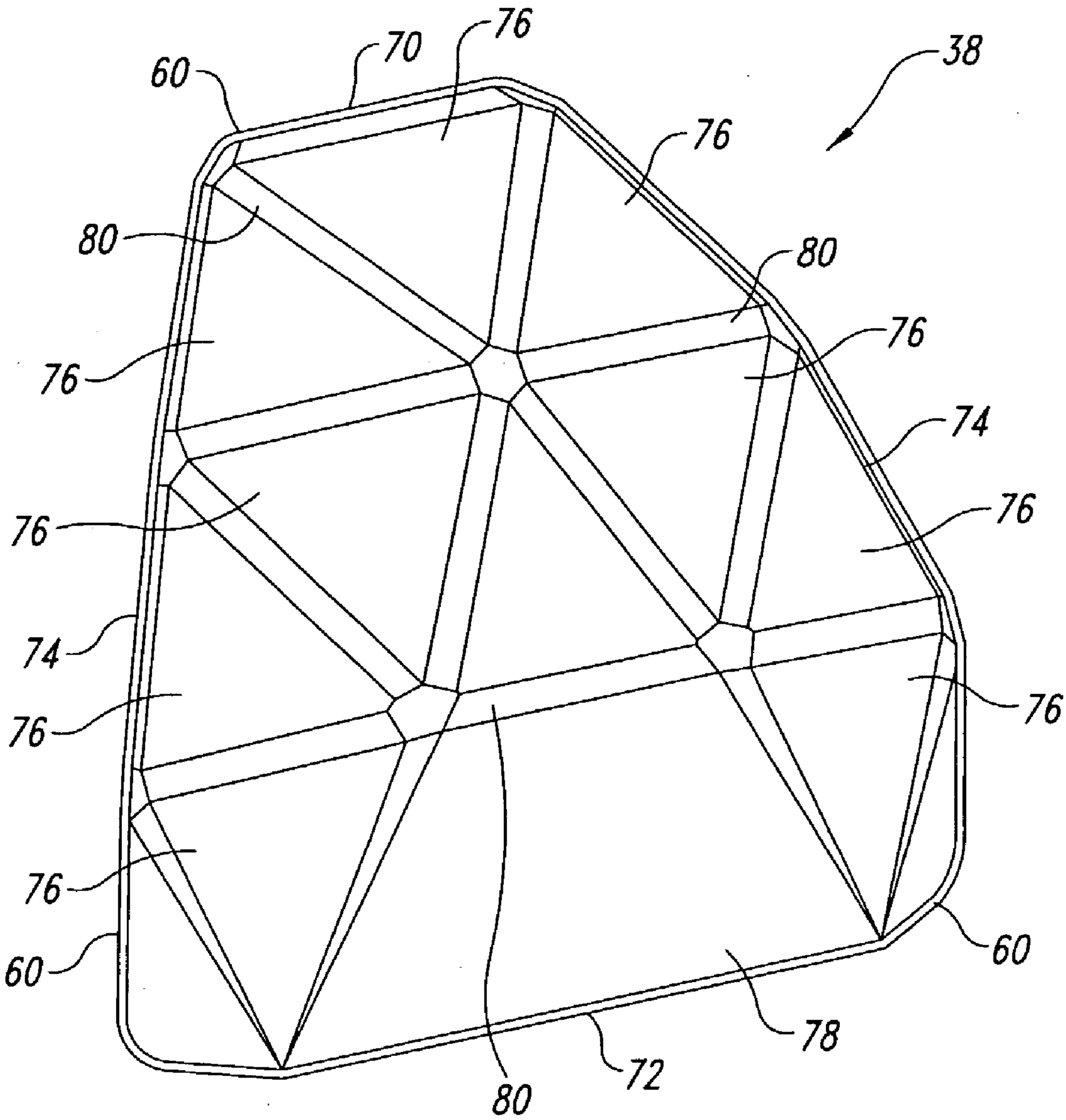


Fig. 3A

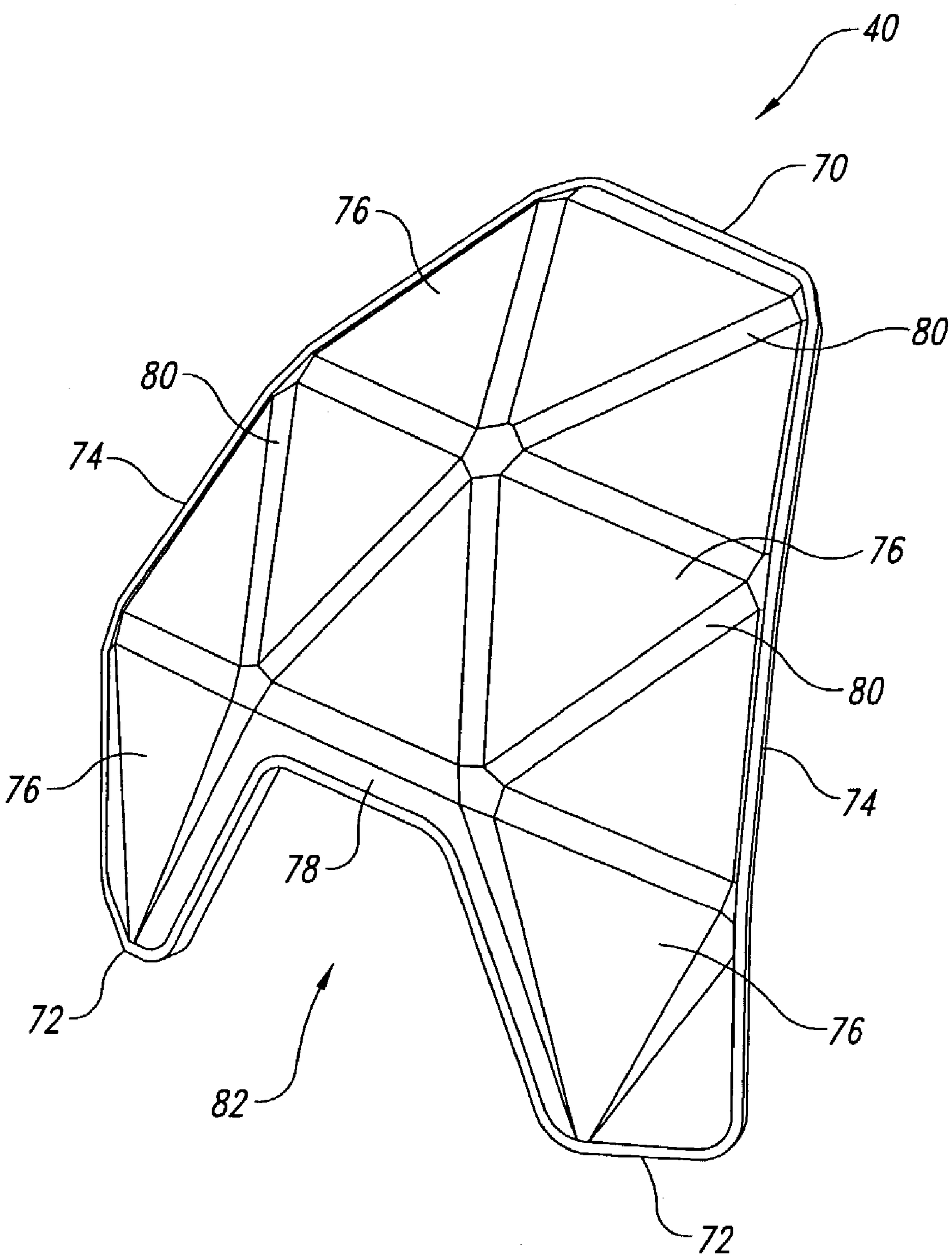


Fig. 3B

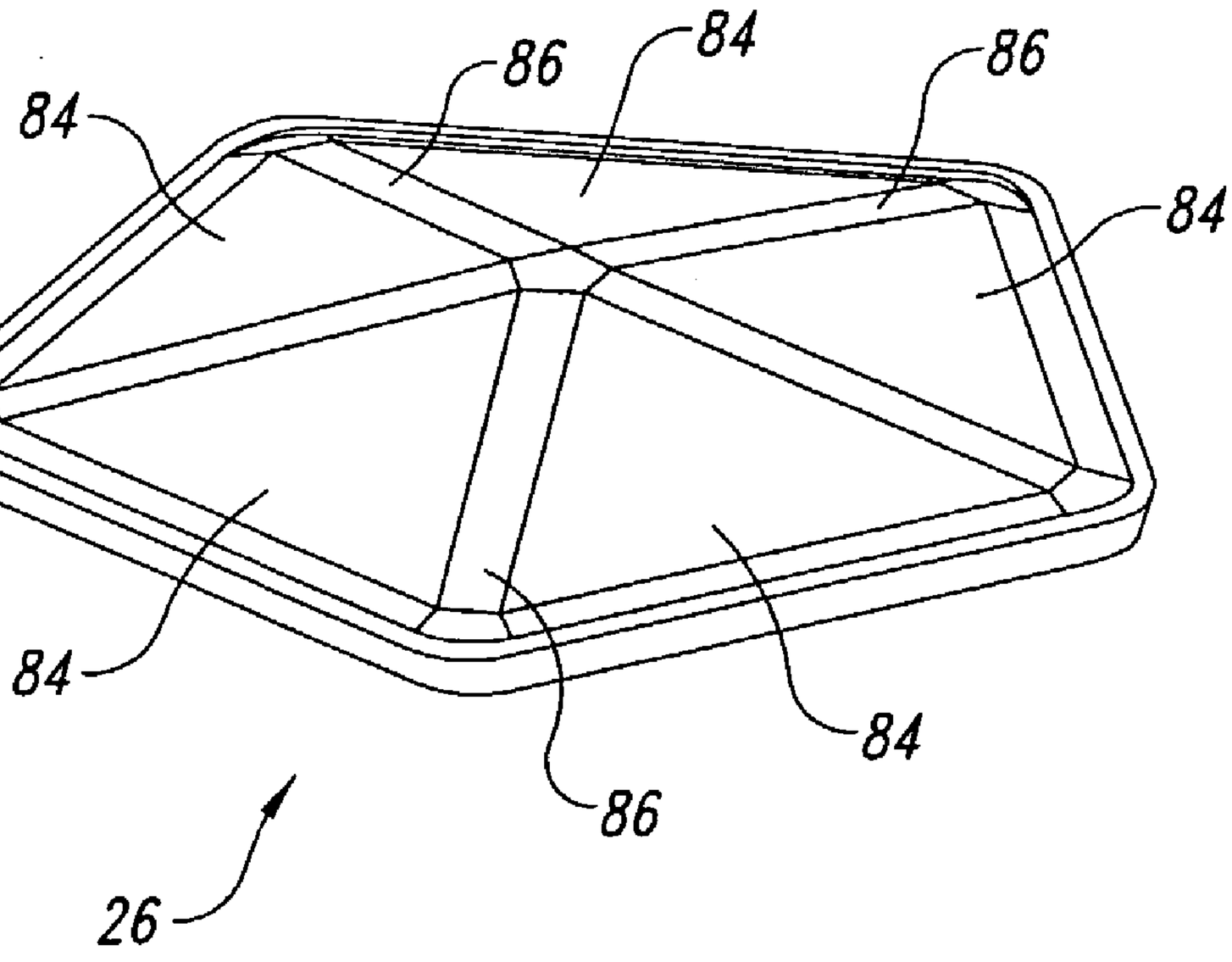


Fig. 4

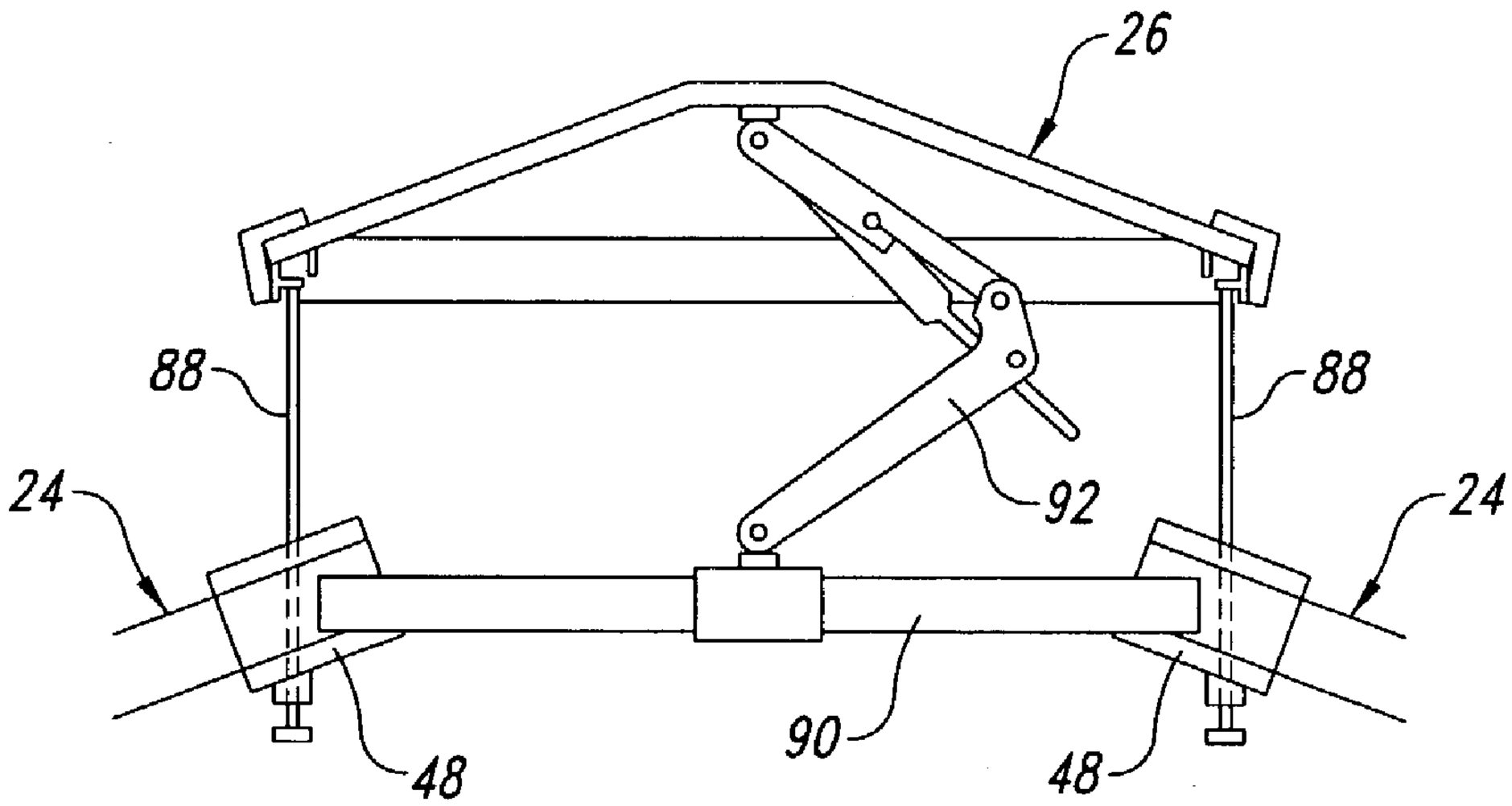


Fig. 5

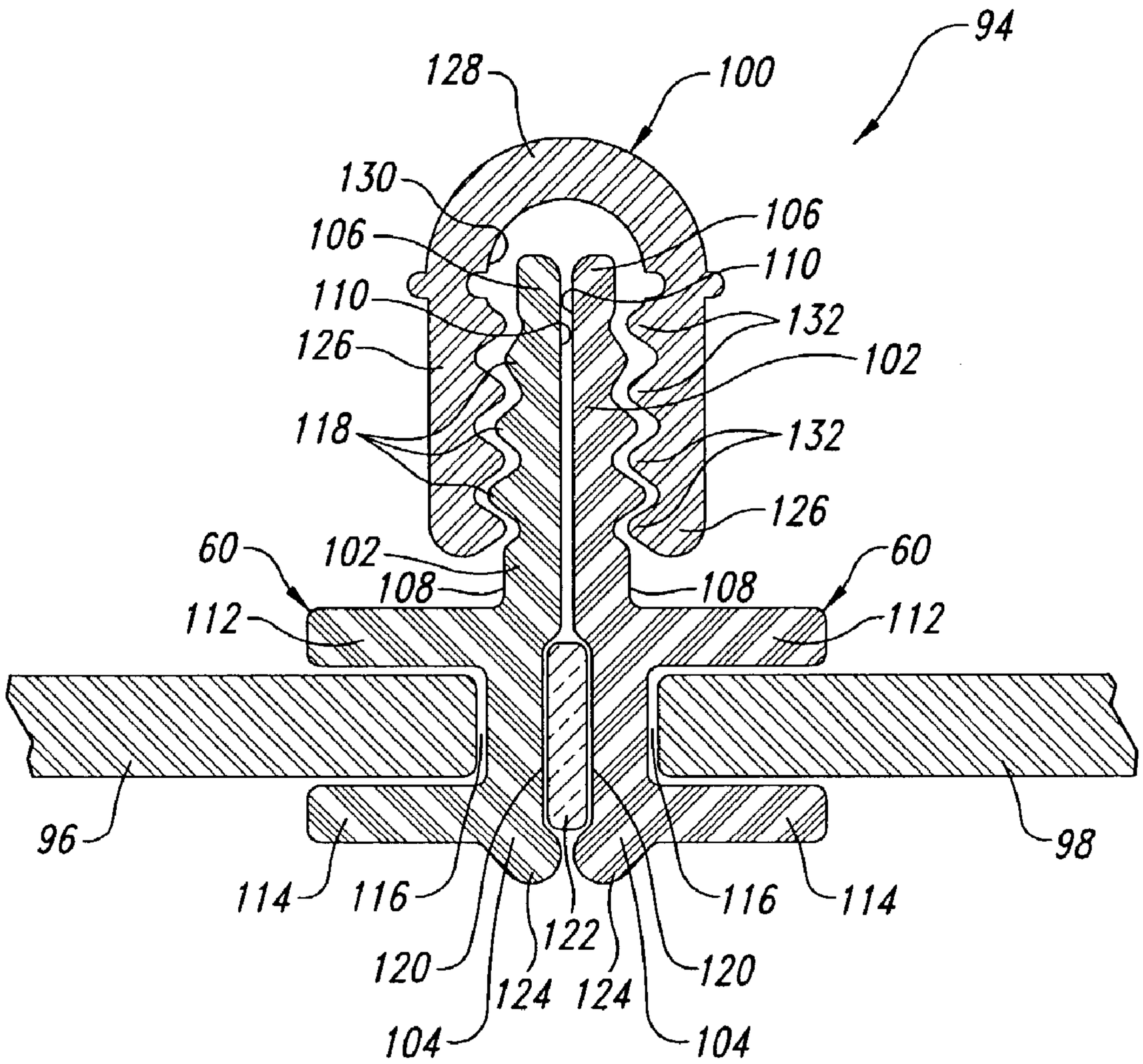

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Fig. 6

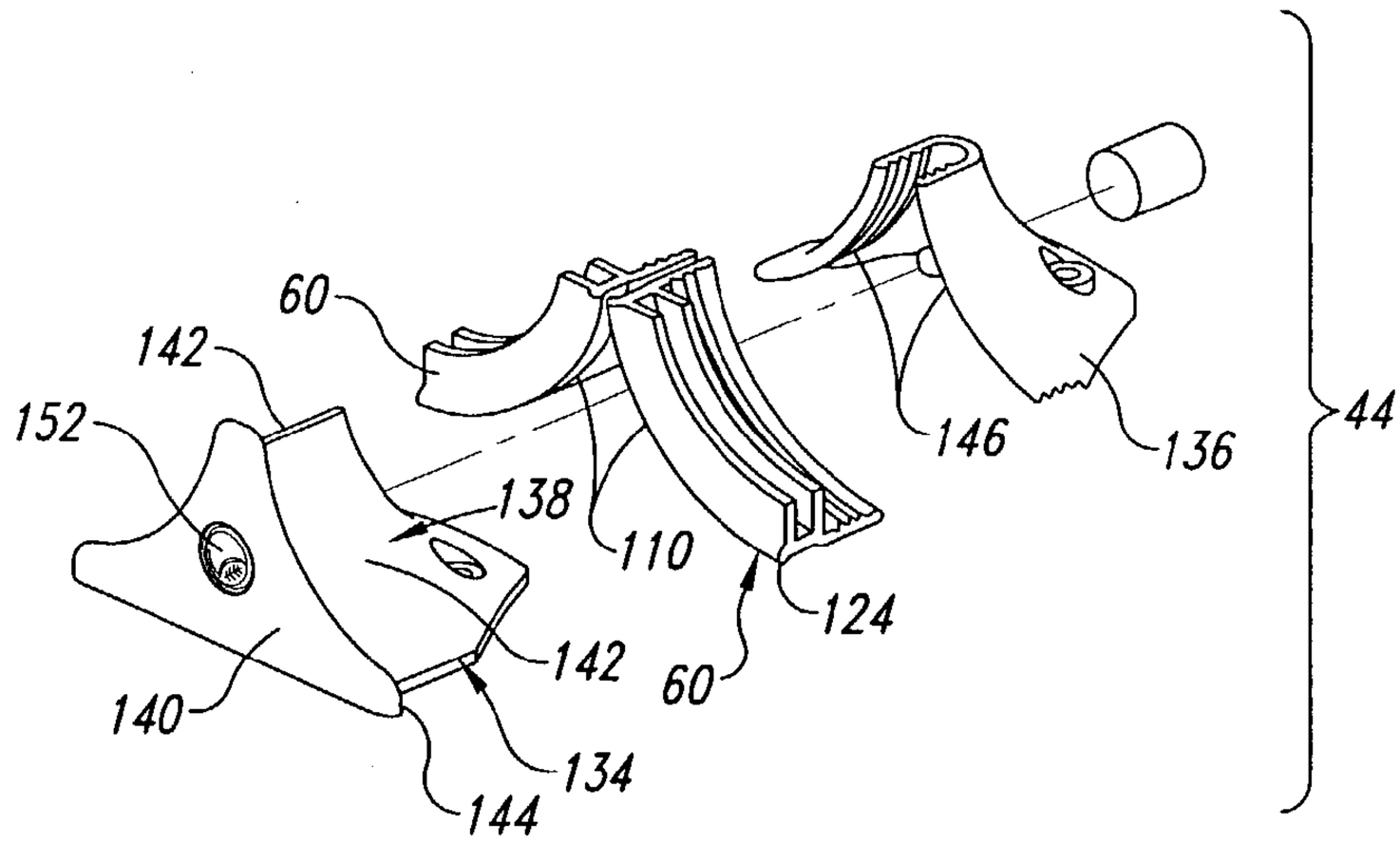

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Fig. 7A

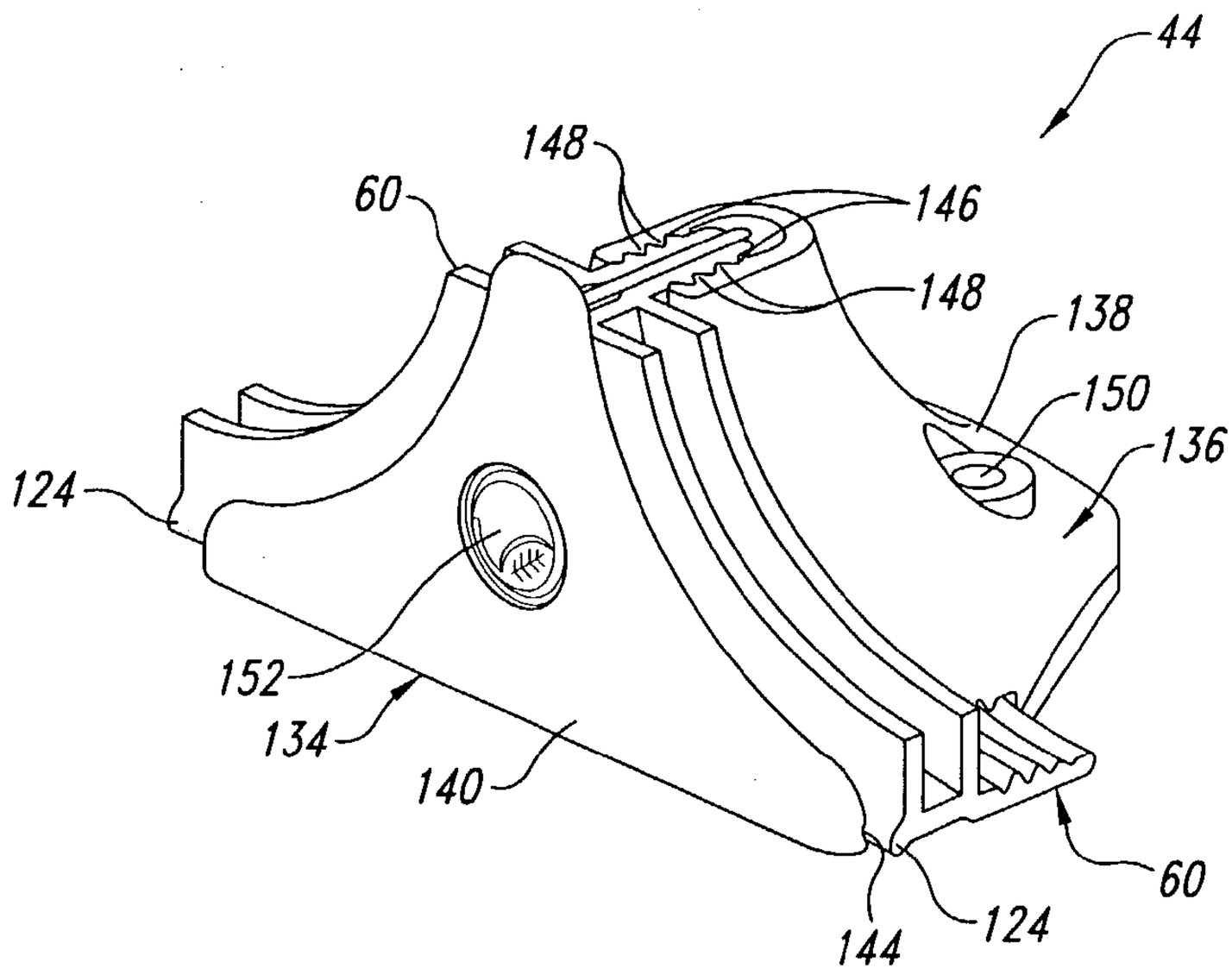

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Fig. 7B

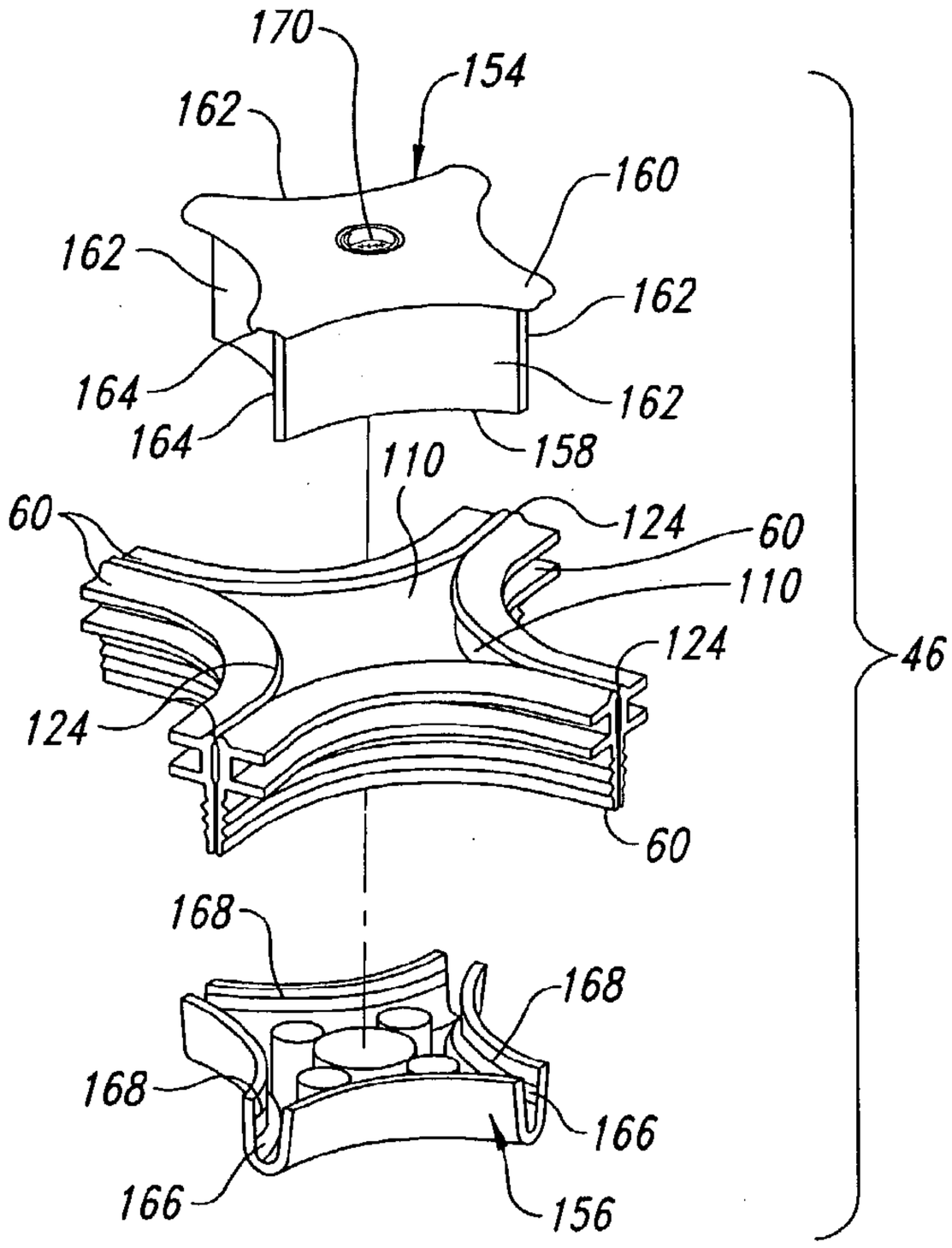

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Fig. 8A

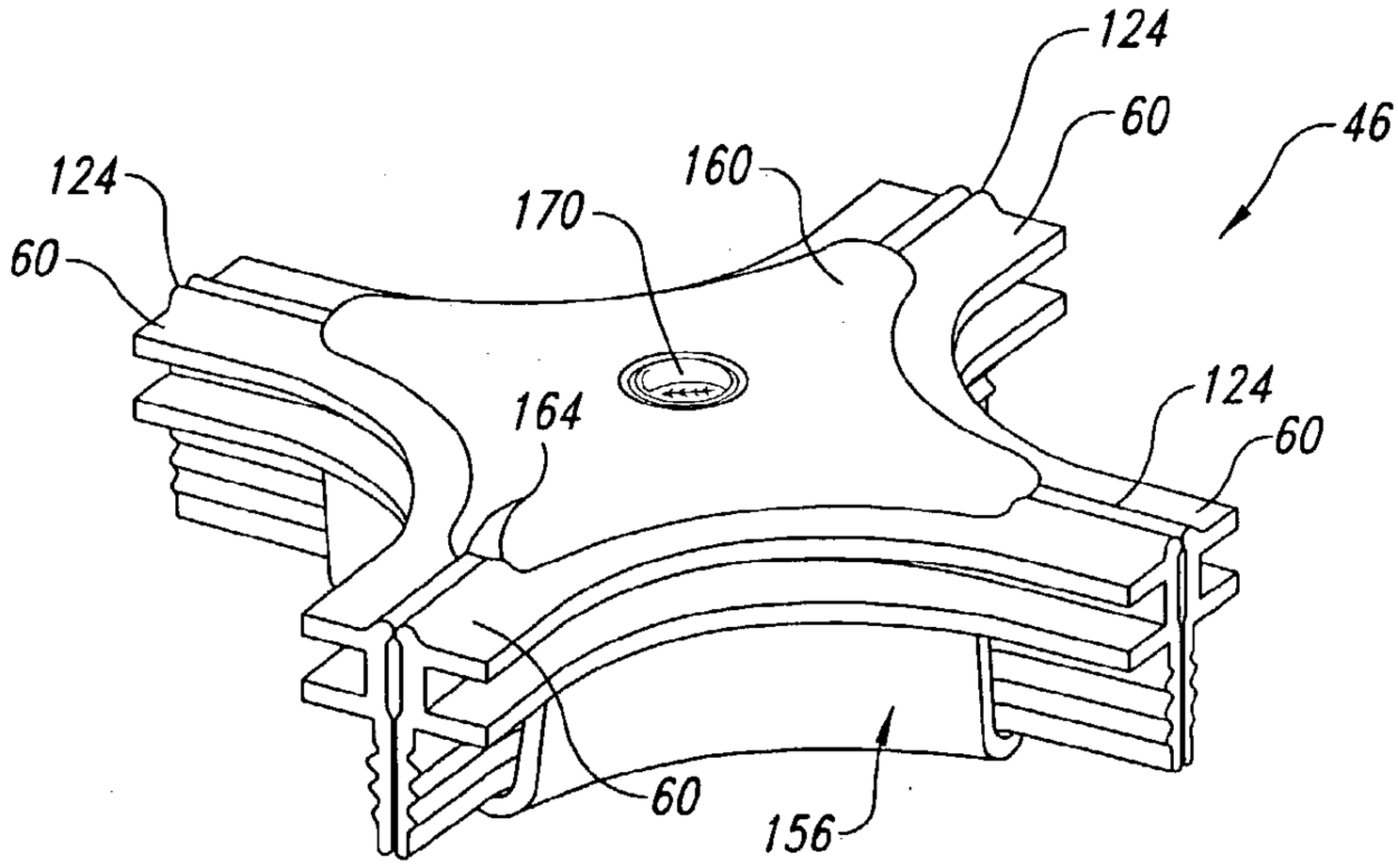

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Fig. 8B

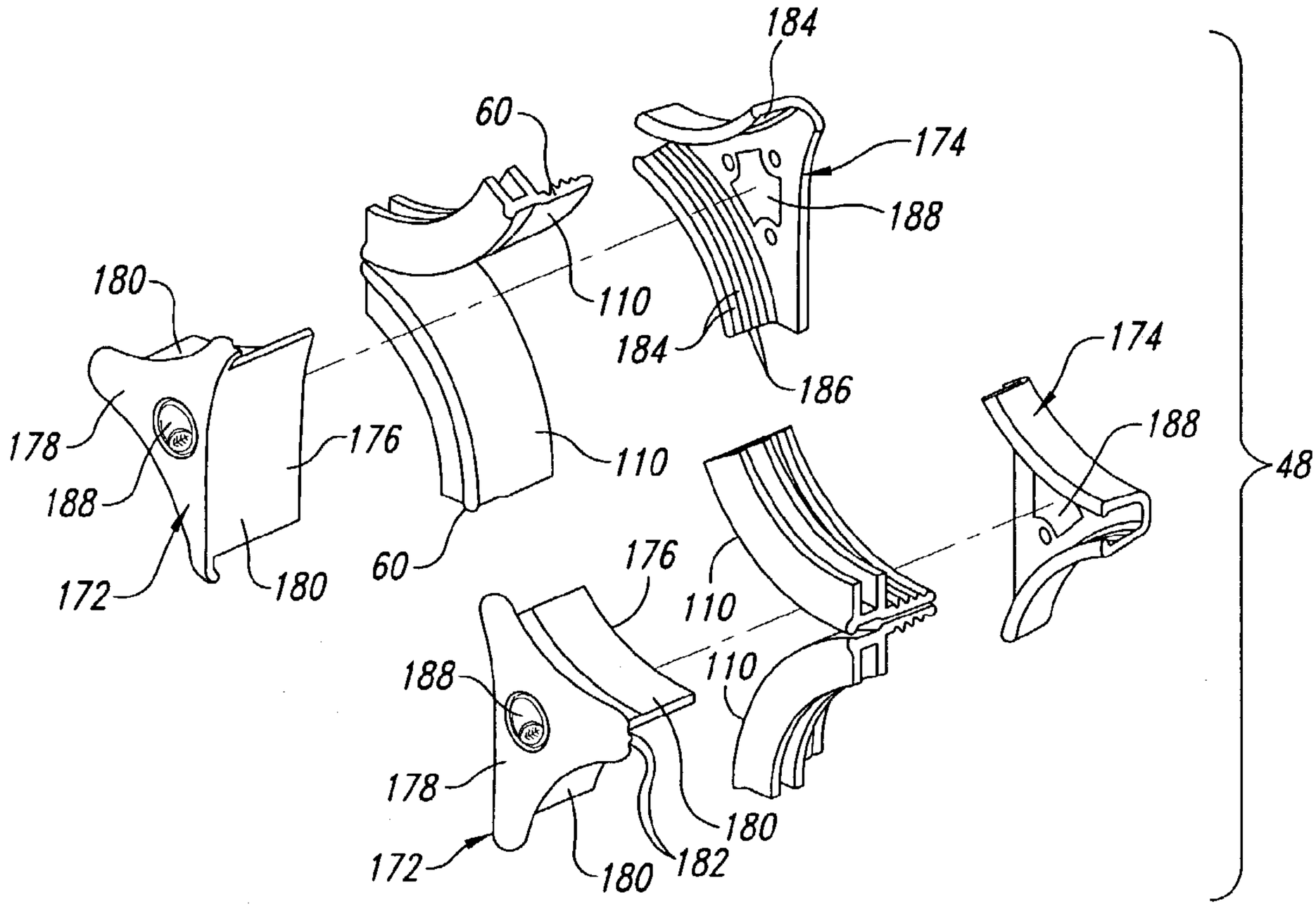

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Fig. 9A

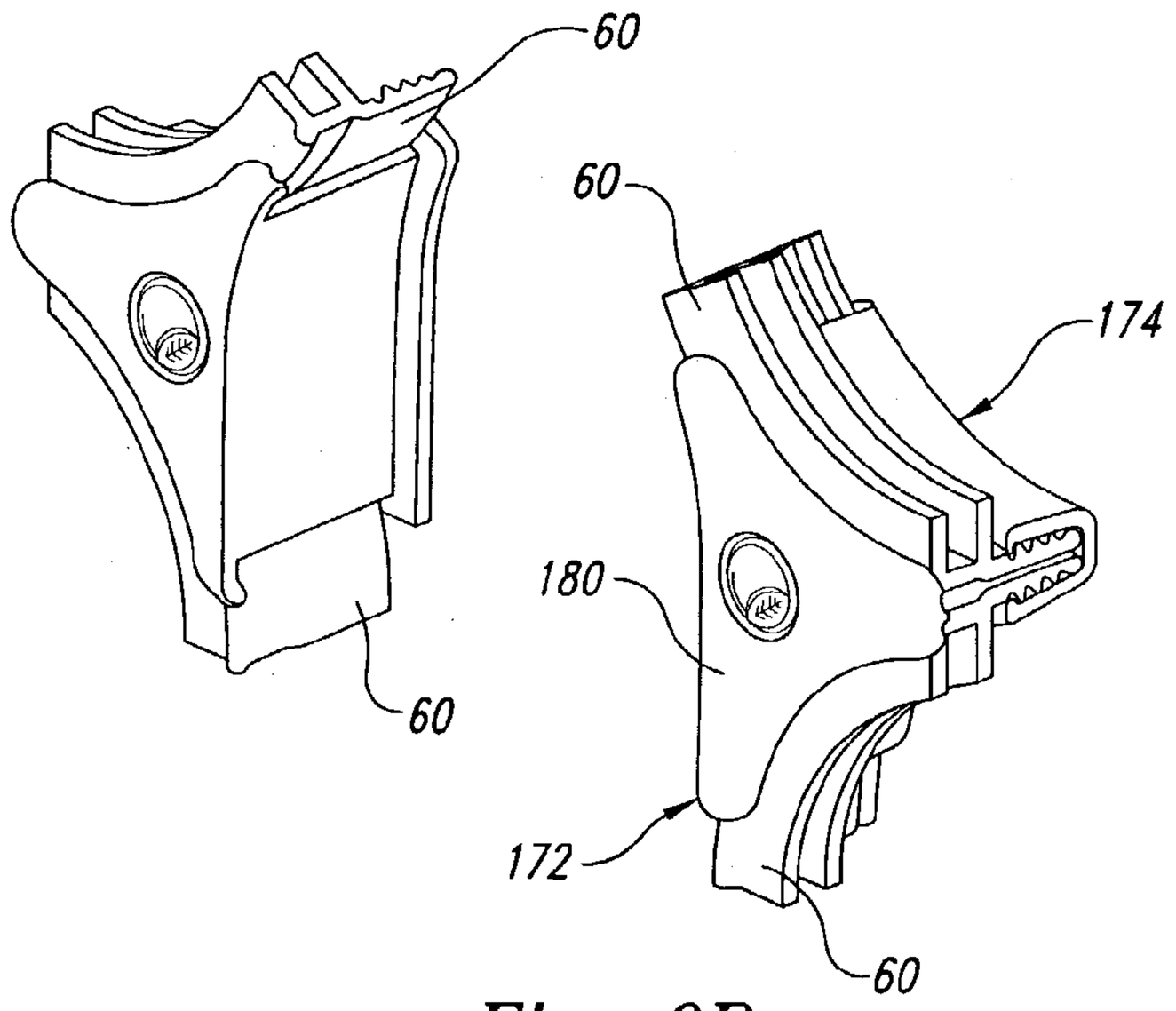

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Fig. 9B

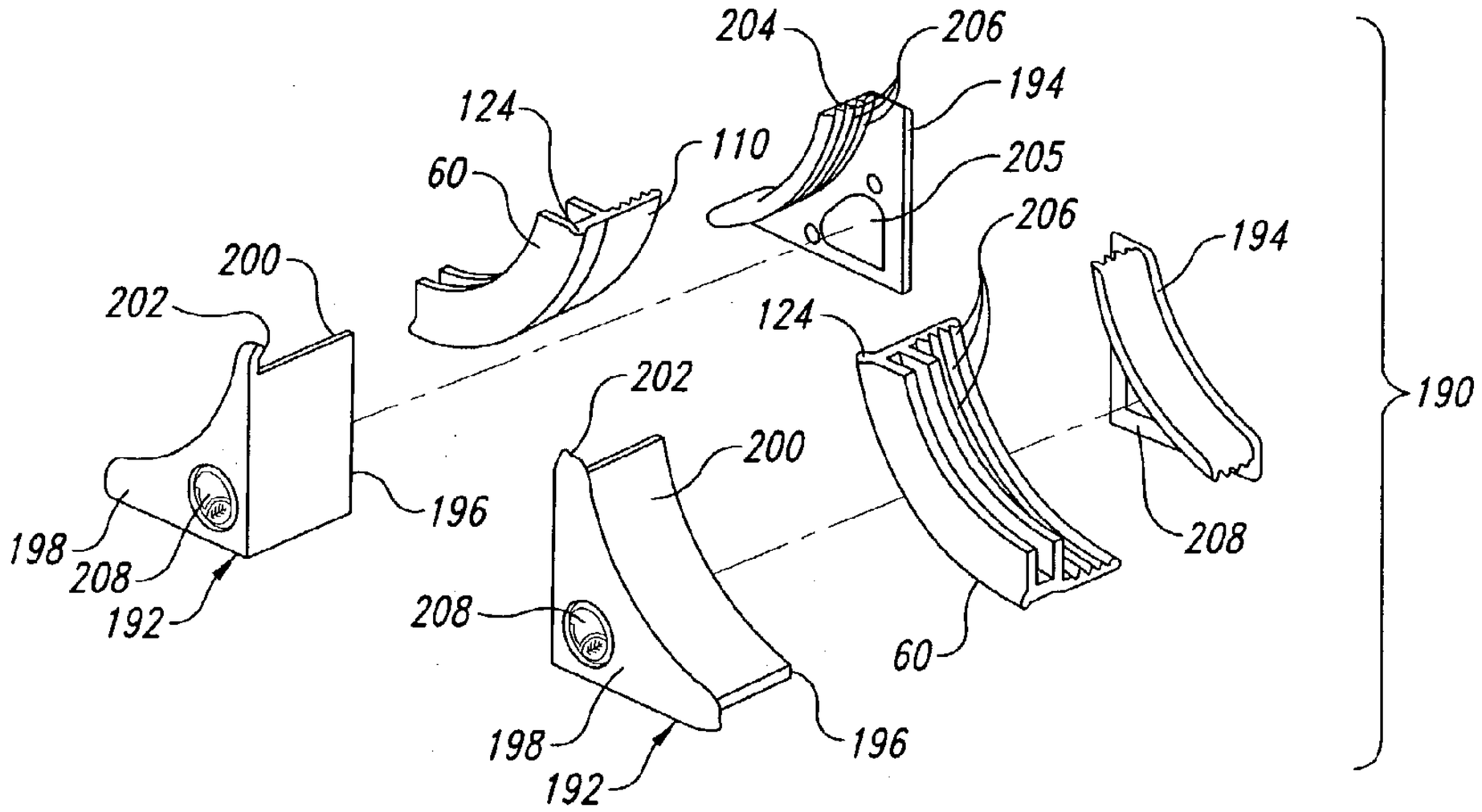


Fig. 10A

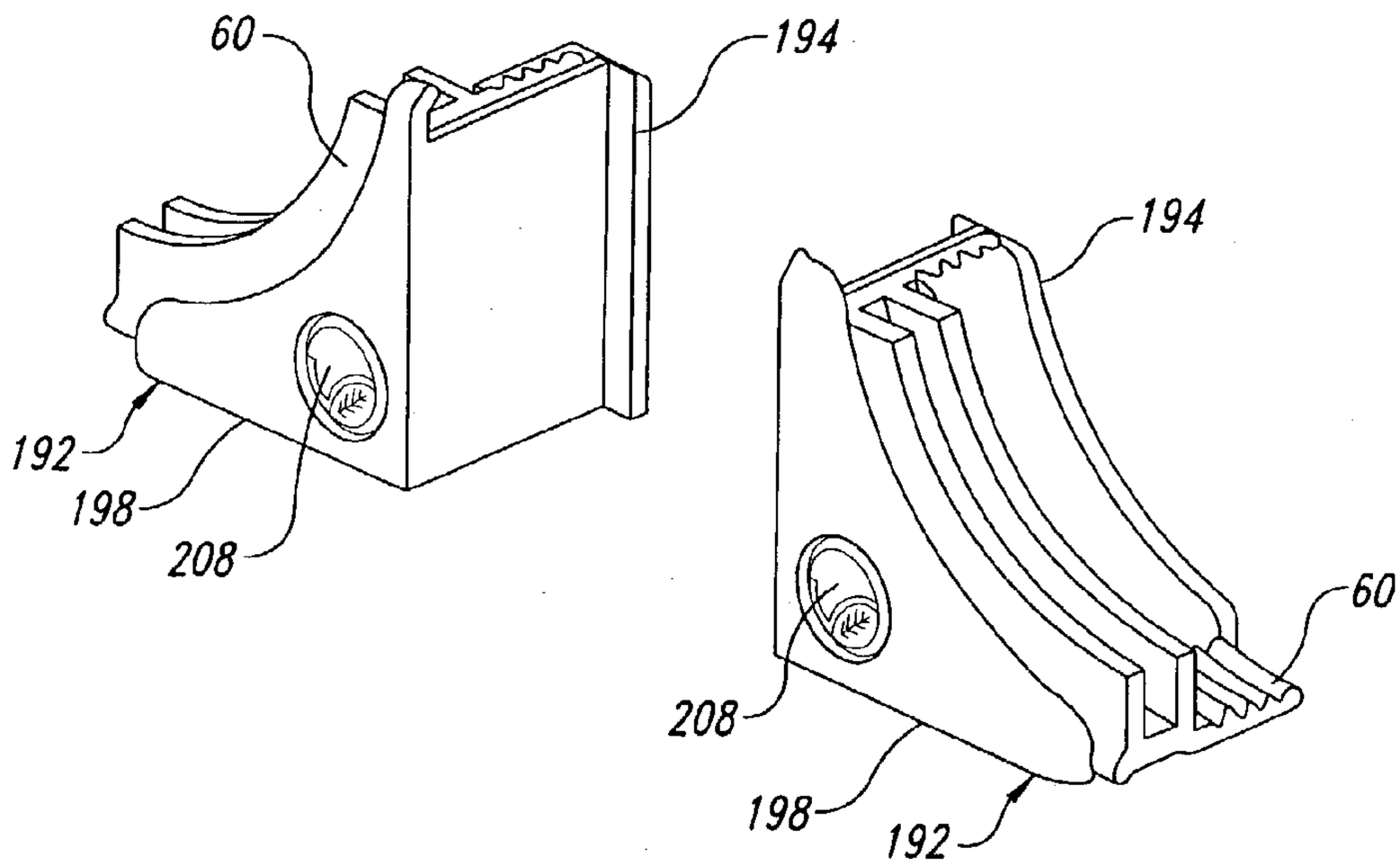


Fig. 10B

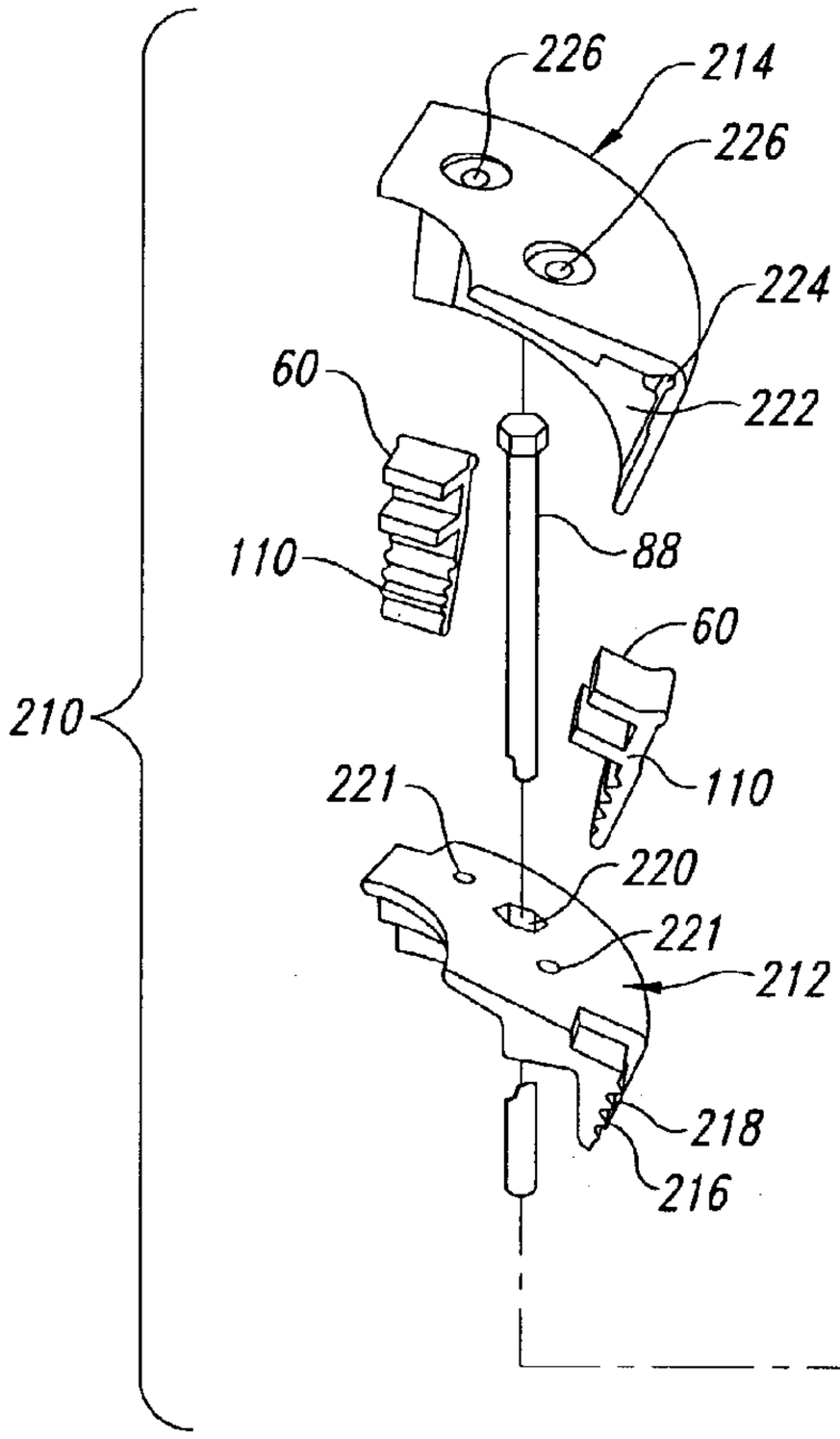


Fig. 11A

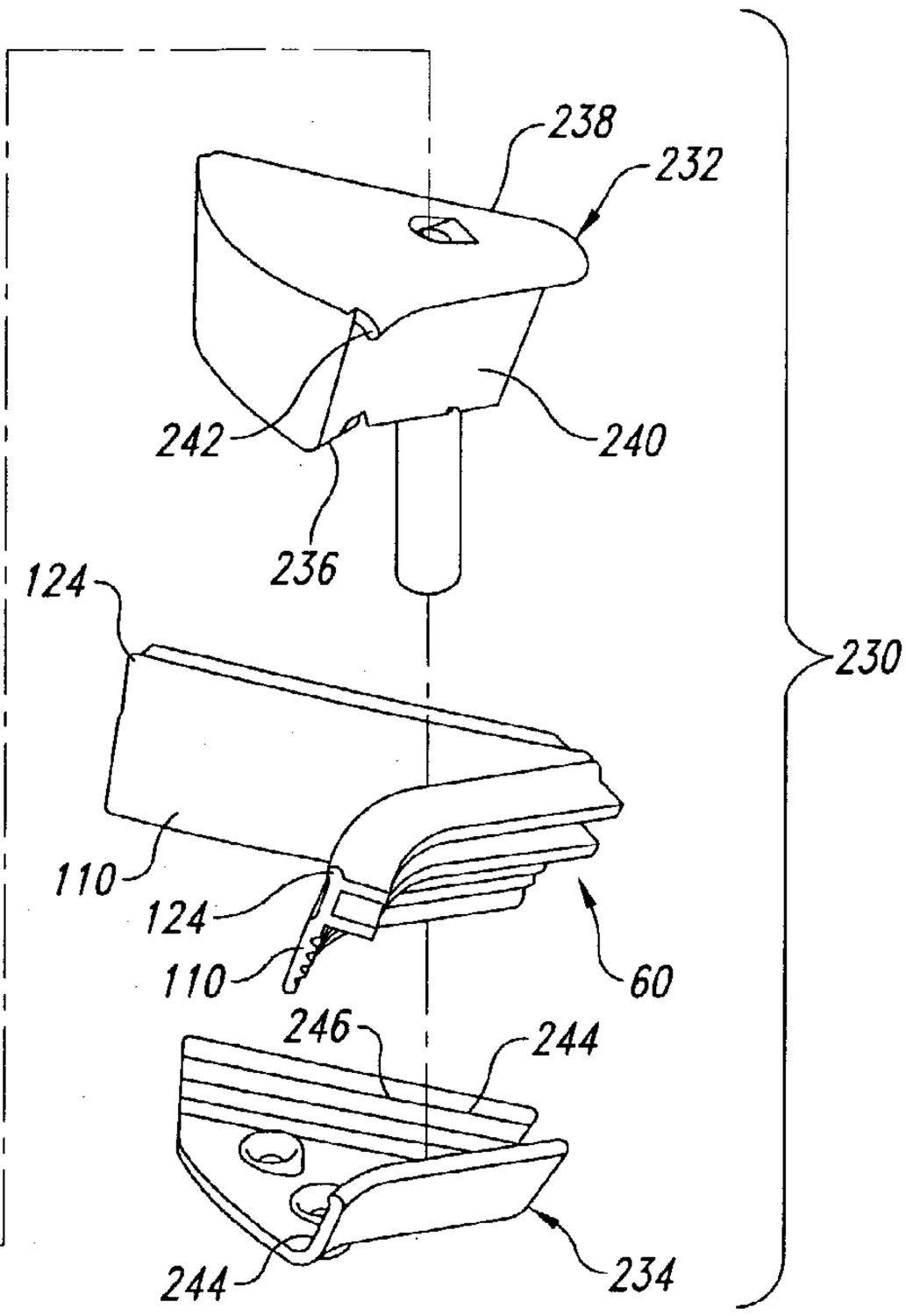


Fig. 11B

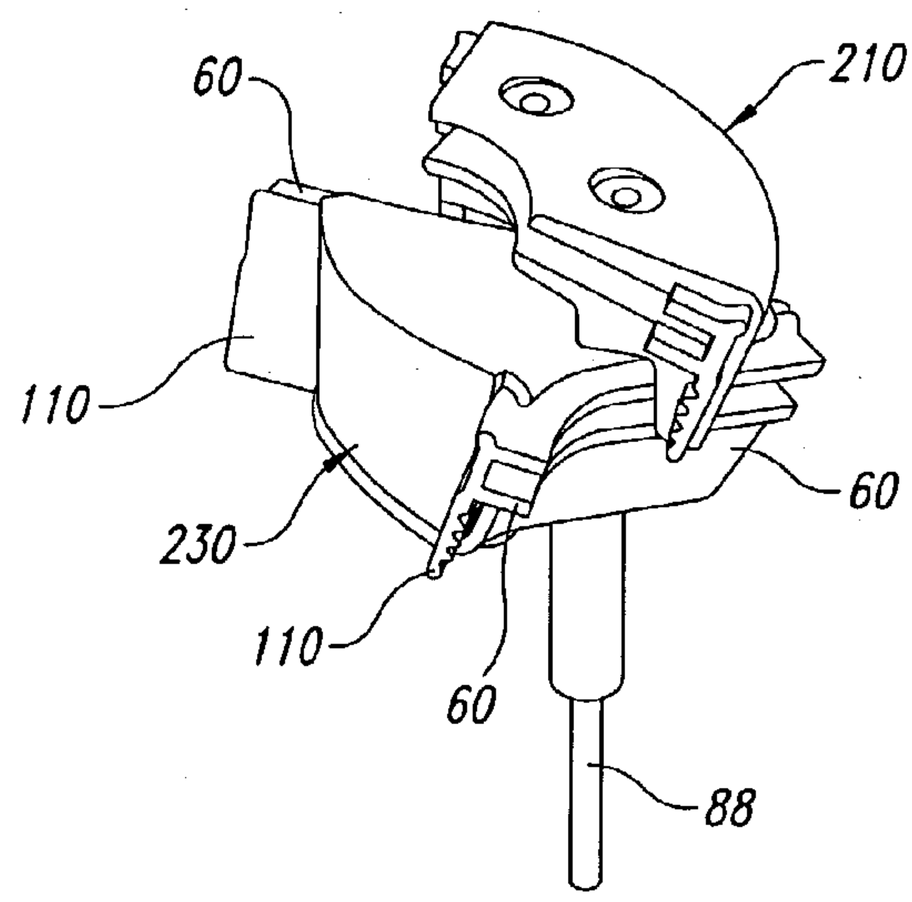


Fig. 11C

PORTABLE GREENHOUSE STRUCTURE AND METHOD AND APPARATUS FOR ASSEMBLING SAME

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application is a continuation of U.S. patent application Ser. No. 09/850,933, filed May 7, 2001, now pending, which application is incorporated herein by reference in it entirety.

FIELD OF THE INVENTION

[0002] The present invention relates to greenhouses, and in particular to greenhouses that are portable, structurally efficient, and easy to assemble and disassemble.

BACKGROUND

[0003] Greenhouses enable both commercial growers and serious hobbyists to produce an artificial environment in which plants can grow all year long.

[0004] Commercial growers and hobbyists alike can use their greenhouses for a variety of purposes, including growing decorative plants such as flowers and shrubs, or growing vegetables for consumption. Most existing greenhouses are permanent structures which vary in size according to their application—commercial growers use enormous greenhouses with elaborate heating and humidifying systems, while hobbyists have smaller ones without the elaborate systems, usually in the back yard of their house.

[0005] The permanent nature of most greenhouses means that a substantial investment is required to install and operate one. Before installing a greenhouse, an architect and engineer must be hired to design and properly situate the greenhouse to obtain the proper amount of light, the land for the greenhouse must be allocated and prepared, and a contractor must be hired to build the structure.

[0006] Once built, the costs of operating a traditional greenhouse are high as well. Depending on the climate, substantial heating may be necessary to maintain the proper temperature in the greenhouse. Special and expensive equipment may be necessary to ensure the right humidity inside.

[0007] For commercial growers, who derive revenue from the use of their greenhouses, a large investment in a greenhouse is less problematic. But for hobbyists the high investment involved in building a permanent greenhouse can deter all but the most serious and dedicated. Most hobbyists don't have room in their yards for such a structure, much less the money to pay for the construction and operation of one. Moreover, even if they have the room for a greenhouse, most hobbyists are constrained in the amount of freedom they have to place the greenhouse in its optimal geographic orientation for growing plants. There is therefore a need in the art for an inexpensive, small-scale greenhouse structure that can easily be set up by a hobbyist or other non-professional user.

SUMMARY OF THE INVENTION

[0008] The present invention provides a portable greenhouse structure comprising a base in the shape of a right-polygonal cylinder having a top and a bottom, wherein the base comprises a plurality of wall panels connected along abutting edges; a hemispherical roof attached to the top of the base, wherein the hemispherical roof has a polygonal hole in the apex thereof; and a polygonal panel having the same shape as the polygonal hole, wherein the polygonal panel is moveable between an open position and a closed position, and wherein the polygonal panel sealably covers the polygonal hole when in the closed position.

[0009] The present invention also provides an apparatus for joining a first panel to a second panel along abutting edges thereof, the apparatus comprising a first extrusion attached to the abutting edge of the first panel, wherein the first extrusion comprises a stem which projects away from a plane of the panel and has a panel side and a mating side; a second extrusion attached to the abutting edge of the second panel, wherein the second extrusion comprises a stem which projects away from a plane of the panel and has a panel side and a mating side; and a clamp which holds the stem of the first extrusion and the stem of the second extrusion together such that the mating side of the first extrusion is in contact with the mating side of the second extrusion.

BRIEF DESCRIPTION OF TILE DRAWINGS

[0010] **FIG. 1A** is an isometric drawing of an embodiment of the present inventive greenhouse.

[0011] **FIG. 1B** is an exploded isometric drawing of an embodiment of the present inventive greenhouse.

[0012] **FIG. 2A** is a drawing of the panels used to build the base of the embodiment shown in **FIG. 1**.

[0013] **FIG. 2B** is a drawing of a door wall panel used next to the door of the inventive greenhouse.

[0014] **FIG. 2C** is a drawing of a door.

[0015] **FIG. 3A** is an isometric drawing of one of the plurality of panels that make up the roof shown in **FIGS. 1A and 1B**.

[0016] **FIG. 3B** is an isometric drawing of the roof door panel which is attached at the part of the base where a door is attached.

[0017] **FIG. 4** is an isometric drawing of a polygonal panel which covers a polygonal hole remaining in the roof after the plurality of panels that make up the roof are assembled.

[0018] **FIG. 5** is a cross-section of the upper part of the roof illustrating the automatic opening and closing of the polygonal roof vent.

[0019] **FIG. 6** is a cross-sectional drawing of an embodiment of a fixture used to join a pair of panels along their abutting edges.

[0020] **FIG. 7A** is an isometric view of an embodiment of a fixture used to join the corners of two adjoining panels in the base to a foundation.

[0021] **FIG. 7B** is an isometric view of the fixture of **FIG. 7A**, shown in its assembled state.

[0022] **FIG. 8A** is an exploded isometric view of an embodiment of a fixture used to join the corners of four adjoining panels.

[0023] **FIG. 8B** is an isometric view of the fixture of **FIG. 8A**, shown in its assembled state.

[0024] **FIG. 9A** is an exploded isometric view of an embodiment of a fixture used to join the corners of a pair of roof panels and provide a support for a moveable panel connected thereto.

[0025] **FIG. 9B** is an isometric view of the fixture of **FIG. 9**A, shown in its assembled state.

[0026] **FIG. 10A** is an exploded isometric view of an embodiment of a fixture used to install a door in a wall panel.

[0027] **FIG. 10B** is an isometric view of the fixture of **FIG. 10**A, shown in its assembled state.

[0028] **FIG. 11A** is an exploded isometric view of a fixture used at vertices of the polygonal vent to attach the polygonal vent to the roof.

[0029] **FIG. 11B** is an exploded isometric view of a fixture used at the vertices of a polygonal hole to allow a polygonal vent to be attached thereto.

[0030] **FIG. 11C** is an exploded isometric view of the fixtures of **FIGS. 11A and 1113**, shown in their assembled state.

DETAILED DESCRIPTION OF THE INVENTION

[0031] Described below is an embodiment of the present invention, which illustrates a way in which the invention can be implemented. Although the embodiment shown is described in the context of greenhouse, the structure can also be used for other purposes. In the descriptions that follow, like numerals represent like elements in all figures. For example, where the numeral **20** is used to refer to a particular element in one figure, the numeral **20** appearing in any other figure refers to the same element.

[0032] **FIGS. 1A and 1B** show a first embodiment of the inventive greenhouse **20**. **FIG. 1A** shows the greenhouse in its assembled state. The greenhouse **20** comprises a right-polygonal cylindrical base **22**, a hemispherical roof **24** attached to the base, and a polygonal vent **26** at the apex of the hemispherical roof. In the embodiment shown, the greenhouse has an overall diameter of 8 feet and an overall height of 9 feet, although the greenhouse **20** can be built to any size desired.

[0033] **FIG. 1B** illustrates the components of the greenhouse **20** and how they are put together. The base **22** is a right-polygonal cylinder (i.e., a cylinder whose cross-section is a polygon), and has a top **28** to which the roof **24** is joined and a bottom **30** which can be, but need not be, secured to some sort of permanent foundation, such as a concrete pad or wooden deck. The base comprises a plurality of wall panels **32**, a pair of door wall panels **34**, and a door **36**. The lateral edges **50** of the wall panels **32** and the lateral edges **68** of the door wall panels **34** are joined together along their lateral edges to form the cylindrical shape of the base; details of how the panels are joined are further explained below in connection with **FIG. 6**. The wall panels **32** are all identical in shape and size, while the door wall panels **34** positioned on either side of the door **36** are smaller so that the door **36** can be accommodated. The door **36** allows access to the interior of the greenhouse and, although only one door is shown, there may be more than one door per greenhouse. In a preferred embodiment, the base (and thus the wall panels and door wall panels) has a height of 5 feet and the cross-section of the base is a regular ten-sided polygon, although a greater or lesser number of sides is possible.

[0034] The hemispherical roof **24** is attached to the top **28** of the base and comprises a plurality of substantially wedge-shaped panels joined along their lateral edges **74** (see **FIGS. 3A and 3B**). The plurality of panels comprises a plurality of identical roof panels **38** (see **FIG. 3A**) and one or more roof door panels **40** (see **FIG. 3B**). The roof door panel **40**, whose position coincides with the position of the door **36**, is identical to the roof panels **38** except for a cutout in the lower portion of the panel to accommodate the upper part of the door **36**. When the roof is attached to the base **22**, the roof is positioned such that the joints along the lateral edges of the roof panels **38** and roof door panel **40** align with the joints of abutting wall panels. In a preferred embodiment of the greenhouse, there are four roof panels **38** and one roof door panel **40**, although any number between 2 and 20 may be used depending on the size of the greenhouse being produced and the number of doors in the greenhouse. In addition, the preferred embodiment has a hemispherical roof with a height of 4 feet that is geodesic; this is shown in **FIG. 1A**. The roof **24** need not, however, be geodesic, as illustrated in **FIG. 1B**.

[0035] At the apex of the roof **24** is a polygonal vent **26**, which corresponds in size and shape to the polygonal hole **42** left at the apex of the roof when the roof panels are assembled. As further described below, the polygonal vent **26** covers and seals the polygonal hole **42** and allows the automatic release of hot air trapped near the apex of the roof. For the preferred embodiment of the greenhouse **20** having a roof **24** made up of five panels, the polygonal hole **42** is a regular pentagon, and therefore the polygonal vent **26** is also a regular pentagon.

[0036] In addition to being joined to each other along their lateral edges **74**, the roof panels are joined to the top **28** of the base **22** using the same apparatus used to join the lateral edges of the wall panels **32**. Once all the edges are joined, there remain gaps near the corners of adjacent panels, so there is still a need to join the panels at their corners to provide a fully enclosed environment inside the greenhouse and to enhance the structural strength of the greenhouse. Since both the roof panels **38** and **40** and the wall panels **32** and **34** have rounded corners, joining the corners requires various special fixtures whose construction depends on the angle of the corner and how many corners are to be joined. At the bottom of the base, there are only two panels to be joined, so this is done using a fixture **44** (see **FIG. 7A**). At the top **28** of the base where the roof **24** is connected, there are four corners to be joined, and a fixture **46** (see **FIG. 8A**) is used. At the vertices of the polygonal hole **42**, where the top edges of the roof panels come together, fixtures **210** and **230** (see **FIGS. 11A and 11B**) are used to join those corners and support the polygonal vent. Other fixtures **48** and **190** are used to join the corners of the door **36** to the panels which it abuts. All these fixtures for joining corners are further discussed below.

[0037] **FIGS. 2A, 2B** and 2C, illustrate the construction of the wall panels **32**, door wall panels **34** and the door **36** that make up the base **22**. **FIG. 2A** illustrates a wall panel **32**. Each wall panel has lateral edges **50**, a top edge **52**, a bottom edge **54** and bends **56** therein. The number of bends **56** in the wall panel and the bend angle β both depend on the number

of sides in the polygonal shape of the base **22** and the number of wall panels **32** used. For the preferred ten-sided base with four wall panels **32**, there are two bends **56** and β is 144 degrees. Each wall panel **32** and door wall panel **34** has rounded corners **58**, preferably with about a 3 inch radius of curvature.

[**0038**] An F-extrusion **60** (discussed below in connection with **FIG. 6**) wraps around the entire perimeter of each wall panel **32**. The F-extrusion, so called because it is shaped like the letter "F," is extruded from poly vinyl chloride (PVC), helps to stiffen each panel, and provides a means by which each panel is joined along its edges and corners to adjacent wall panels and to the roof. The F-extrusions are preferably bonded to the perimeter of the wall panels using a methylacrylate adhesive which fuses the F extrusion **60** and the wall panel **32** together, although any suitable sealant or adhesive or combinations thereof could be used. As further explained below, the panels are joined by abutting the lateral edges of adjacent panels, whether they be wall panels **32**, door wall panels **34**, or a door **36**, and clamping the F-extrusions together.

[**0039**] **FIG. 2B** illustrates a door wall panel **34**. There are two of these for each door in the greenhouse—one on either side of the door—and they are necessary for the base **22** to be able to accommodate the door **36**. The door wall panel **34** shown in the figure is a right panel; a left panel is simply a mirror image of the right panel. Whether a left or right panel, the door wall panel is very similar to the wall panel. It has the same height as a wall panel **32**, but a lesser width. The door wall panel has lateral edges **68**, a top edge **64**, a bottom edge **66** and one bend **62** therein with a bend angle β of about 144 degrees, instead of two such bends as in the wall panel **32**. The door wall panels are made of the same polycarbonate material as the wall panels **32**, are formed in the same way, and also have an F-extrusion **60** attached around their entire perimeter for additional strength and joining to other panels.

[**0040**] **FIG. 2C** illustrates the construction of the door **36**. The door is a flat sheet of polycarbonate material cut to the proper shape-in this case, a rectangle with a tapered top. As with the other panels that make up the base, the door **36** has an F-extrusion **60** attached around its entire perimeter to strengthen it and so that it can be attached to adjacent door wall panels.

[**0041**] The wall panels **32**, door wall panels **34**, and door **36** are all built using any transparent, partially transparent, or translucent material that allows for spectral transmission of light needed for plant growth. Preferably, they are built using a rigid polymer material having two parallel layers supported by a plurality of ribs positioned between the layers. The ribs may be the same or a different material as the parallel layers. Most preferably, the material used is a double-walled horticultural grade polycarbonate material. Polycarbonate is ideal for this application because of its high strength, low weight, and favorable optical and heat transfer characteristics. The polycarbonate material is transparent and has two thin walls separated and supported by a plurality of ribs. To promote drainage and maximize panel strength, the ribs are oriented so that they will run vertically when the wall panels are installed. The polycarbonate panels are formed using a heat-forming process.

[**0042**] **FIGS. 3A and 3B** illustrate the construction of the panels that comprise the hemispherical roof **24**; as explained above, the roof comprises a plurality of roof panels **38** and one or more roof door panels **40** joined together along their lateral edges. **FIG. 3A** illustrates the construction of a roof panel **38**; all the roof panels **38** are identical. Each roof panel **38** is substantially wedge-shaped and has a top edge **70**, a bottom edge **72**, and a pair of lateral edges **74**. Since the roof **24** is preferably geodesic, each roof panel has geodesic features, including a plurality of polygonal facets. The polygonal facets include several triangles **76** and a trapezoid **78**. Between the facets there are elongated strips **80** that can be used to position and attach solar cells to the roof. As with the wall panels, an F-extrusion **60** is attached to the edges of the roof panel around the entire perimeter. The F extrusion stiffens the roof panel and provides a means for joining to other panels. **FIG. 3B** illustrates the construction of a roof door panel **40**. The roof door panel, so called because it is the roof panel whose position in the roof coincides with the position of the door **36**, is identical to the roof panels **38** in every respect, except that the door roof panel has a cutout **82** in the trapezoid **78** to accommodate the door **36**.

[**0043**] When the roof **24** is assembled, the roof panels **38** are joined to adjacent roof panels and the roof door panel **40** along their lateral edges. Once the roof is assembled, the lower edges **72** of the roof panels and the roof door panel are joined to the top **28** of the base. The roof **24** is aligned on the base **22** such that the lateral edges **72** of the roof panels **38** and roof door panels **40** align with the lateral edges **50** of the wall panels and the lateral edges **68** of the door wall panels. When all the roof panels are assembled, the top edges **70** of the roof panels form a polygonal hole **42** at the apex of the roof. In the preferred embodiment, the roof **24** comprises four roof panels **38** and one roof door panel **40** which, when joined together, form a pentagonal hole at the apex of the roof. A different number of panels, ranging between 2 and 20 panels, may be used for the roof. The number of panels will depend on the size of the greenhouse to be produced. Like the panels that make up the base, the roof panels **38** and roof door panels **40** are formed using a transparent, partially transparent or translucent material, and are preferably made using a double-walled polycarbonate material. The polycarbonate material is formed into the roof panels **38** and roof door panels **40** using a heat forming process.

[**0044**] **FIG. 4** illustrates the polygonal vent **26**, which covers the polygonal hole **42** at the apex of the roof **24**. The polygonal vent illustrated is a regular pentagon. Since the roof **24** is geodesic, the polygonal vent **26** is likewise part of a geodesic structure and includes facets **84**, as well as elongated strips **86** between the facets which can be used to install solar cells. Since the hole **42** at the apex is pentagonal and the polygonal vent is meant to cover the hole, the polygonal vent is also pentagonal, although it shape will vary depending on the number of panels that make up the roof. The polygonal vent **26** is slightly larger than the hole and, as further discussed below, can move between an open position and a closed position. The polygonal vent **26** also has a gasket or other seal around its perimeter, so that is seals the polygonal hole **42** when it is in the closed position. Like the panels that make up the base and the roof, the polygonal vent **26** is made of formed polycarbonate and has F extrusions attached to the straight portions of its perimeter. Each vertex of the polygonal vent **26** has attached thereto the fixture **210** shown in **FIG. 11A**, which connects the ends of the F extrusions **60** attached along the straight edges of the vent **26**. The F extrusions **60** attached to the vent **26** create

a sealing surface, while the F extrusions and the fixtures **210** together enhance the stiffness of the vent **26**.

[**0045**] **FIG. 5** illustrates how the polygonal vent **26** is attached to the apex of the roof **24**, and the means by which the vent opens and closes automatically in response to the air temperature at the apex of the roof. At each of its vertices, the polygonal vent **26** has attached a rod **88**. Similarly, at each vertex of the polygonal hole **42** there is attached a fixture **48** which receives the rod **88** and allows the rod a limited range of vertical movement whilst preventing horizontal movement. The fixtures **48** at each vertex also support a platform **90** on which rests a temperature-sensitive actuator **92** of a type well known in the art. In response to the temperature of the air at the apex of the roof, the actuator **92** lifts and lowers the polygonal vent **26**; when the temperature inside is hot, the vent opens, and when the temperature inside is cold, the vent closes. When the vent **26** is open, warm air convects out, drawing cooler outside air into the interior of the greenhouse through vents (not shown) at the bottom of the base. Thus, the vent **26** regulates the air temperature in the interior of the greenhouse **20**.

[**0046**] **FIG. 6** illustrates an embodiment of the apparatus **94** used to join a first panel **96** and a second panel **98** together along their abutting edges. In the greenhouse **20**, the apparatus **94** is used to join the wall panels **32** and the roof panels **38** to each other along their lateral edges, and used to join the lower edges **72** of the roof panels **38** and the roof door panel **40** to the top **28** of the base **22**. The apparatus **94** comprises a pair of F-extrusions **60** and a C-extrusion **100**; both the F extrusions and C extrusion can be made using any material, but are preferably made using a moldable plastic, and most preferably are made using poly vinyl chloride (PVC) material.

[**0047**] Each F-extrusion **60** comprises a stem **102** having an outer end **104**, an inner end **106**, a panel side **108** and a mating side **110**. A pair of flanges **112** and **114** are positioned toward the outer end of the stem **102** and project from the panel side **108** of the F-extrusion to form a channel **116** therebetween. The channel **116** receives the edges of panels **96** and **98**, which are bonded to the F-extrusion. In the preferred embodiment, the F extrusions are bonded to the panels using a methylacrylate adhesive that fuses the PVC material of the extrusion to the polycarbonate material of the panels. The F extrusions **60** may, however, be attached to the panels **96** and **98** using any suitable adhesives, sealants, or combinations thereof. Closer to the inner end of the stem **102**, and positioned along the panel side **108**, are a plurality of teeth **118** projecting from the panel side **108**. As further explained below, these teeth **118** are used to retain a C-extrusion placed on a pair of abutting F-extrusions. The mating side of each F-extrusion has a notch **120** therein designed to form a cavity when the mating sides **110** of two F-extrusions are placed together. The cavity is designed to receive some form of sealant **122** so that the joint will be impervious to the entrance of dirt, air, or water. The F extrusion also includes a sealing tab **124** projecting from the outer end **104** of the stem. The sealing tab **124** helps seal the joint to prevent the entry of moisture or other contaminants.

[**0048**] The C-extrusion, so called because it is shaped like the letter "C," comprises a pair of legs **126** and a connecting portion which connects both legs **126** at one end thereof. The inside surfaces **130** of the legs have thereon a plurality of teeth **132** which engage the plurality of teeth **118** on the stem of the F-extrusions **60**. There are two sets of teeth; each set is designed to engage the teeth **118** on one of the F-extrusions.

[**0049**] In use, the F-extrusions are attached to the edges of adjoining panels **96** and **98**, and are positioned in a mirror-image relation with a mating side **110** of one F-extrusion in contact with the mating side **110** of the other F-extrusion. The C-extrusion is placed over the stems **102** of both F extrusions and holds the two extrusions securely together with their mating sides abutting each other. In this way, any two panels in the greenhouse structure can be held together securely along their edges.

[**0050**] **FIGS. 7A and 7B** illustrate a first embodiment of a fixture **44** used to join the radiused, 90-degree corners of two wall panels and, having joined the two panels, optionally attaching the wall panels to a foundation. In the greenhouse **20**, this fixture **44** is used to join the wall panels **32** and **34** to a foundation to which the greenhouse is attached. **FIG. 7A** illustrates the different parts of the fixture **44** and how they fit together. The fixture **44** comprises a base **134** and a clip **136**. The clip **136** generally has the same shape as the base and attaches to the base to secure the corners of the panels to the base. The base includes a front surface **138**, a rear surface **140**, and a pair of curved bearing surfaces **142** extending between the front surface **138** and rear surface **140**. The bearing surfaces turn through the same angle as the panel corners (90 degrees in this case), are normal to the rear surface **140**, and contact the mating sides **110** of F extrusions attached around the rounded corners of the panels to be joined. In the fixture **44**, the bearing surfaces turn through 90 degrees, but the fixture **44** could be made to accommodate any two panels as long as their corner angles sum to 180 degrees. A groove **144** at the intersection of the curved bearing surfaces **142** and the rear surface **140** is designed to receive the sealing tab **124** which projects from the F-extrusion (see **FIG. 6**), thus sealing the intersection of the panels with the fixture **44** and preventing the movement of moisture or contaminants through the joint.

[**0051**] The clip **136** has the same general shape as the base **134**, and has a pair of gripping surfaces **146** having a plurality of teeth **148**. The teeth **148** are designed to engage the teeth on the stems of the F-extrusions whose mating sides are positioned along the curved bearing surfaces **142**, much the same way the teeth on the C extrusion **100** engage the teeth on the F extrusion **60**. In operation, the panels are placed such that the F extrusions **60** attached thereto contact the bearing surfaces **142**. The clip **136** is then secured to the base such that it engages the F extrusions, and is then attached to the base by a fastener inserted into the hole **150** in the front surface **138**, thereby securing the corners of the panels to the fixture **44** and to each other. **FIG. 7B** illustrates the fixture in its assembled, operational state. Both the base **134** and the clip **136** have a hole **152** therein through which items such as hoses or electric cords can be fed.

[**0052**] **FIGS. 8A and 8B** illustrate a second embodiment of a fixture **46** used to join the corners of four panels. The fixture **46** is a four-panel variation of the two-panel fixture **44**. In the greenhouse **20**, the fixture **46** is used at the four-way intersections of panels in the base (the wall panels **32** and the door wall panels **34**) and panels in the roof (roof panels **38** and the roof door panels **40**). **FIG. 8A** illustrates

the different parts of the fixture **46** and how they fit together. The fixture **46** comprises a base **154** and a clip **156**. The clip has the same general shape as the base, and attaches to the base to secure F extrusions on the corners of the panels to the base. The base includes a front surface **158**, a rear surface **160**, and four curved bearing surfaces **162** extending between the front surface **158** and rear surface **160**. The bearing surfaces turn through the same angle as the panel corners, are normal to the rear surface **160**, and contact the mating sides of F extrusions attached around the rounded corners of four panels. In the fixture **46**, the bearing surfaces turn through 90 degrees, but the fixture **46** could be made to accommodate any four panels as long as their corner angles sum to 360 degrees. A groove **164** at the intersection of the curved bearing surfaces **162** and the rear surface **160** is designed to receive the sealing tab **124** which projects from the F-extrusion (see **FIG. 6**), thus sealing the intersection of the panels with the fixture **46** and preventing the movement of moisture or contaminants through the joint.

[**0053**] The clip **156** has the same general shape as the base **154**, and has four gripping surfaces **166** having a plurality of teeth **168**. The teeth **168** are designed to engage the teeth on the stems of the F-extrusions whose mating sides are positioned along the curved bearing surfaces **162**, much the same way the teeth on the C extrusion **100** engage the teeth on the F extrusion **60**. In operation, the panels are placed such that the mating sides **110** of the F extrusions **60** attached thereto contact the bearing surfaces **162**. The clip **156** is then secured to the base such that it engages the F extrusions, thereby securing the F extrusions and the corners of the panels to the fixture **46** and to each other. **FIG. 8B** illustrates the fixture in its assembled, operational state. Both the base **154** and the clip **156** have a hole therein through which items such as hoses or electric cords can be fed.

[**0054**] **FIGS. 9A and 9B** illustrate a third embodiment of a fixture **48** used to join the rounded corner of one panel to a rounded corner of another. In the greenhouse **20**, this fixture **48** is used to attach an upper portion of the door **36** to a door wall panel **62**. **FIG. 9A** illustrates the different parts of the fixture **48** and how they fit together. The fixture **48** comprises a base **172** and a clip **174** which generally has the same shape as the base and attaches to the base to secure the corners of the panels to the base. The base includes a front surface **176**, a rear surface **178**, and a pair of curved bearing surfaces **180** extending between the front surface **176** and rear surface **178**. The bearing surfaces **180** turn through the same angle as the panel corners, are normal to the rear surface **178**, and contact the mating sides **110** of F extrusions attached around the rounded corner of the door panel **36**. In the fixture **48**, the bearing surfaces turn through 126 degrees, but the fixture **48** could be made to accommodate any two corners. A groove **182** at the intersection of the curved bearing surfaces **180** and the rear surface **178** is designed to receive the sealing tab **124** which projects from the F-extrusion **60** (see **FIG. 6**), thus sealing the intersection of the panels with the fixture **48** and preventing penetration of moisture or contaminants through the joint.

[**0055**] The clip **174** has the same general shape as the base **172**, and has a pair of gripping surfaces **184** having a plurality of teeth **186**. The teeth **186** are designed to engage the teeth on the stems of the F-extrusions **60** whose mating sides **110** are positioned along the curved bearing surfaces **180**, much the same way as the teeth on the C extrusion **100** engage the teeth on the F extrusion **60**. In operation, the door panel **36** is placed such that the mating sides **110** of the F extrusions **60** attached thereto contact the bearing surfaces **180**. The clip **174** is then secured to the base such that it engages the F extrusions, thereby securing the corners of the door to the fixture **48** and to door wall panel. **FIG. 9B** illustrates the fixture in its assembled, operational state.

[**0056**] **FIGS. 10A and 10B** illustrate a fourth embodiment of a fixture **190** used to square off the rounded corner of a panel. In the greenhouse **20**, the fixture **190** is used at the bottom of the door wall panels **62** to stabilize, anchor and make rigid the door frame. **FIG. 10A** illustrates the different parts of the fixture **190** and how they fit together. The fixture **190** comprises a base **192** and a clip **194** which generally has the same shape as the base and attaches to the base to secure the corner of the panel to the base. The base includes a front surface **196**, a rear surface **198**, and a curved bearing surface **200** extending between the front surface **196** and rear surface **198**. The bearing surface **200** turns through the same angle as the panel corner, is normal to the rear surface **198**, and contacts the mating side **110** of the F extrusions attached around the rounded corner of the panel. In the fixture **190**, the bearing surface turns through 90 degrees, but the fixture **190** could be made to accommodate any corner angle. A groove **202** at the intersection of the curved bearing surface **200** and the rear surface **198** is designed to receive the sealing tab **124** which projects from the F-extension (see **FIG. 6**), thus sealing the intersection of the panel with the fixture **190** and preventing penetration of moisture or contaminants through the joint. The base **192** additionally has a slot therein into which a bolt or other fastener can be inserted to attach the base **192** to a foundation.

[**0057**] The clip **194** has the same general shape as the base **192**, and has a gripping surface **204** having a plurality of teeth **206**. The teeth **206** are designed to engage the teeth on the stem of the F-extrusion whose mating side is positioned along the curved bearing surface **200**, much the same way the teeth on the C extrusion **100** engage the teeth on the F extrusion **60**. In operation, the panels are placed such that the mating sides **110** of the F extrusions **60** attached thereto contact the bearing surfaces **200**. The clip **194** is then secured to the base such that it engages the F extrusion, thereby securing the corner of the panel to the fixture **190**. **FIG. 10B** illustrates the fixture in its assembled, operational state.

[**0058**] **FIGS. 11A, 11B** and 11C illustrate two fixtures **210** and **230** used to connect a moving panel to the rounded corners of two panels while providing support to the moving panel. The fixture **230** functions similarly to the fixtures **44** and **46**, but provides some additional utility in supporting a moveable panel. In the greenhouse **20**, these fixtures **210** and **230** are used at the vertices of the polygonal hole **42** to support the polygonal vent **26**.

[**0059**] **FIG. 11A** illustrates the different parts of the fixture **210** and how they fit together. This fixture **210** differs from the others in that it holds only the ends of the F extrusions, instead of a middle portion of the extrusion. The fixture **210** comprises a base **212** and a clip **214** that has generally the same shape as the base and attaches thereto. The base **212** includes a pair of gripping surfaces **216** on its ends which hold the end of the F extrusions **60** attached to the straight portions of the polygonal vent **26**. The gripping surfaces **216** include a plurality of teeth **218** that engage the teeth on the panel side of the F extrusion **60**, much the same way the teeth on the C extrusion **100** engage the teeth on the F extrusion **60**. The base **212** also has therein a hole **220** to receive the rod **88**, which then allows the polygonal vent **26**

to move vertically but not horizontally and a pair of holes **221** for receiving fasteners to attach the clip to the base **212**. The clip **214** includes a bearing surface **222** designed to engage the mating sides **110** of the F extrusions whose ends are positioned in the base, a groove **224** therein to receive the sealing tab **124** of the F extrusion, and a pair of holes **226** to allow the clip **214** to be attached to the base **212** with fasteners. In operation, a base **212** is positioned at each vertex of the polygonal panel **26** with the ends of the F extrusions **60** positioned in the sides of the base such that the teeth on the extrusion engage the teeth **218** on the gripping surfaces **216** of the base. The rod **88** is inserted in the hole **220**, and the clip **214** is then attached to the base **212** such that the bearing surface **222** contacts the mating sides **110** of the F extrusions **60**. Fasteners are inserted into the holes **221** and **226** and tightened so that the clip **212** is secured to the base and engages the ends of the F extrusions, thereby securing the fixture **210** and the rod **88** to the vertices of the polygonal panel **26** to which the F extrusions are attached.

[**0060**] **FIG. 11B** illustrates the different parts of the fixture **230** and how they fit together. The fixture comprises a base **232** and a clip **234** which generally has the same shape as the base and attaches to the base to secure the corners of the panels to the base. The base includes a front surface **236**, a rear surface **238**, and a pair of curved bearing surfaces **240** extending between the front surface **236** and rear surface **238**. The bearing surfaces **240** turn through the same angle as the panel corners, are normal to the rear surface **238**, and contact the mating sides **110** of F extrusions attached around the rounded corners of the panels. In the fixture **230**, the bearing surfaces turn through 126 degrees, but the fixture **230** could be made to accommodate any two corners. A groove **242** at the intersection of the curved bearing surfaces **240** and the rear surface **238** is designed to receive the sealing tab **124** which projects from the F-extrusion **60** (see **FIG. 6**), thus sealing the intersection of the panels with the fixture **230** and preventing penetration of moisture or contaminants through the joint.

[**0061**] The clip **234** has the same general shape as the base **232**, and has a pair of gripping surfaces **244** having a plurality of teeth **246**. The teeth **246** are designed to engage the teeth on the stems of the F-extrusions **60** whose mating sides **110** are positioned along the curved bearing surfaces **240**, much the same way as the teeth on the C extrusion **100** engage the teeth on the F extrusion **60**. In operation, the panels are placed such that the mating sides **110** of the F extrusions **60** attached thereto contact the bearing surfaces **240**. The clip **234** is then secured to the base such that it engages the F extrusions, thereby securing the corners of the panels to the fixture **48** and to each other. **FIG. 11C** illustrates the fixtures **210** and **230** in their assembled, operational state.

[**0062**] The fixtures **44**, **46**, **48**, **190**, **210** and **230** can be made using any material, but are preferably made using a moldable plastic, and most preferably are made using poly vinyl chloride (PVC) material. Where the fixtures are made using a moldable plastic, molds are made of both the base and the clip of each fixture, and the pieces are then formed by injection molding the moldable plastic material.

[**0063**] Several embodiments of the present invention have been described. A person skilled in the art, however, will recognize that many other embodiments are possible within the scope of the claimed invention. For this reason, the scope of the invention is not to be determined from the description of the embodiments, but must instead be determined solely from the claims that follow.

1. A portable greenhouse structure comprising:

a base in the shape of a right-polygonal cylinder having a top and a bottom, wherein the base comprises a plurality of wall panels connected along abutting edges;

a hemispherical roof having a plurality of wedged-shaped roof panels, the roof panels having a top edge, a bottom edge, and a pair of lateral edges, the roof panels joined together along adjacent lateral edges and wherein the lower edges of the roof panels are attached to the top of the base, and wherein the top edges of the roof panels form a polygonal hole in an apex thereof; and

a polygonal panel having the same shape as the polygonal hole, wherein the polygonal panel is moveable between an open position and a closed position, and wherein the polygonal panel sealably covers the polygonal hole when in the closed position.

2. The greenhouse of claim 1 further comprising a foundation to which the bottom side of the base is attached.

3. The greenhouse of claim 1 further comprising a door in one of the wall panels.

4. The greenhouse of claim 1 further comprising a plurality of vents near the bottom of the base.

5. The greenhouse of claim 1 wherein a diameter of the base is between about 5 feet and about 20 feet.

6. The greenhouse of claim 1 wherein the hemispherical roof further includes one or more roof door panels containing a cutout in the lower portion of the panel to accommodate an upper part of a door.

7. The greenhouse of claim 1 wherein the plurality of wedge-shaped sections comprises between about 2 and about 20 sections.

8. The greenhouse of claim 1 wherein the hemispherical roof is geodesic and includes a plurality of polygonal facets therein.

9. The greenhouse of claim 8 wherein the hemispherical roof further comprises a plurality of elongated flat areas formed therein between the polygonal facets.

10. The greenhouse of claim 9 further comprising one or a plurality of solar cells positioned on and attached to the elongated flat areas.

11. The greenhouse of claim 1 wherein the polygonal panel automatically opens and closes according to the temperature inside the greenhouse.

12. The greenhouse of claim 1 wherein the polygonal panel is a regular pentagon.

13. The greenhouse of claim 1 wherein the base, the hemispherical roof and the polygonal panel are made with a transparent, semi-transparent, or translucent material.

14. The greenhouse of claim 13 wherein the base, the hemispherical roof and the polygonal panel are made with polycarbonate.

15. The greenhouse of claim 14 wherein the base, the hemispherical roof and the polygonal panel are made with a laminated polycarbonate comprising a first sheet spaced apart from a second sheet by a plurality of ribs.

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