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(12) **United States Patent**  
**Villarreal et al.**

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(54) **INJECTION MOLD WITH MULTI-AXIAL  
CORE INSERTS**

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(\*) Notice: Subject to any disclaimer, the term of this  
patent is extended or adjusted under 35  
U.S.C. 154(b) by 556 days.

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(22) Filed: **Sep. 26, 2013**

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**Related U.S. Application Data**

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15, 2013.

(51) **Int. Cl.**  
**H01R 31/06** (2006.01)  
**H05K 5/02** (2006.01)  
(Continued)

(52) **U.S. Cl.**  
CPC ..... **B29C 45/376** (2013.01); **B29C 45/4421**  
(2013.01); **H01R 31/065** (2013.01);  
(Continued)

(58) **Field of Classification Search**

CPC ..... H05K 5/02; H05K 5/0217; H05K 5/0278;  
H05K 7/18; G06F 1/16; G06F 1/181;  
H01R 13/665; H01R 31/065

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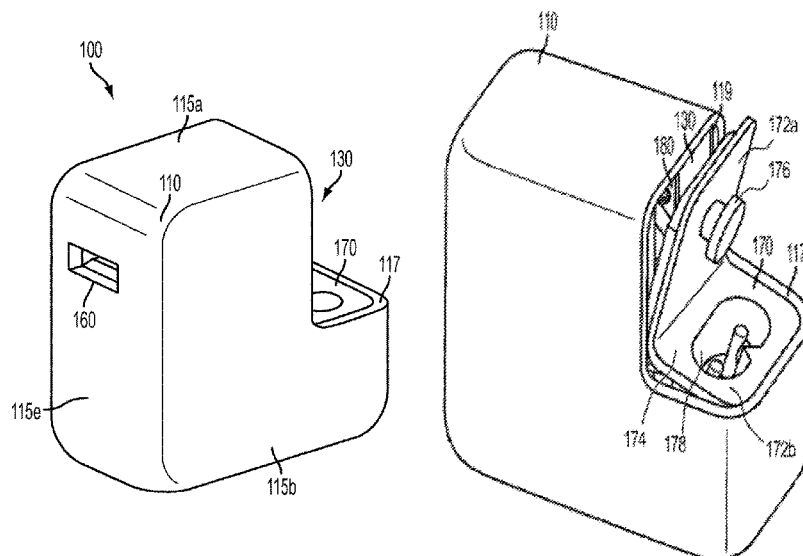
*Primary Examiner* — James O Hansen

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Stockton LLP

(57) **ABSTRACT**

Systems and methods of providing a tooling system for  
forming a unitary housing are disclosed herein. One embod-  
iment may utilize a plurality of injection cavity slides. The  
slides may form the interior cavity of the housing. Utilizing  
a plurality of injection cavity slides to form a single cavity  
insert may allow the slides to be remove from an opening in  
the housing which is smaller than the cavity of the housing.  
Removing the slides from housing allows for the formation  
of housing having a unitary structure.

**17 Claims, 46 Drawing Sheets**



- (51) **Int. Cl.** 2012/0274155 A1\* 11/2012 Deluliis ..... H01R 31/065  
**B29C 45/37** (2006.01) 307/150  
**B29C 45/44** (2006.01)  
**B29C 45/26** (2006.01)  
**B29C 45/33** (2006.01)  
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- (52) **U.S. Cl.**  
CPC ..... **H05K 5/0278** (2013.01); **B29C 45/2628**  
(2013.01); **B29C 45/33** (2013.01)

- (58) **Field of Classification Search**  
USPC ..... 312/223.1, 223.2; 307/150, 151;  
439/131, 502  
See application file for complete search history.

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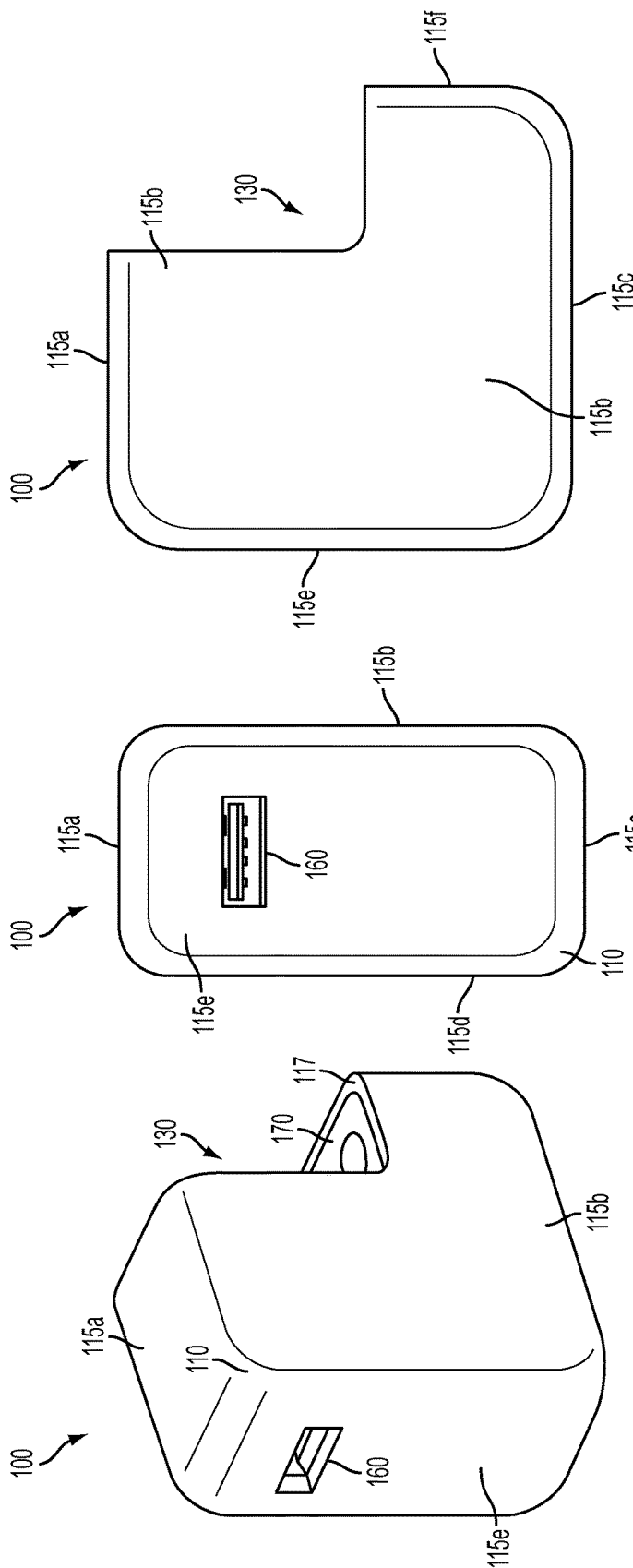


FIG. 1C

FIG. 1B

FIG. 1A

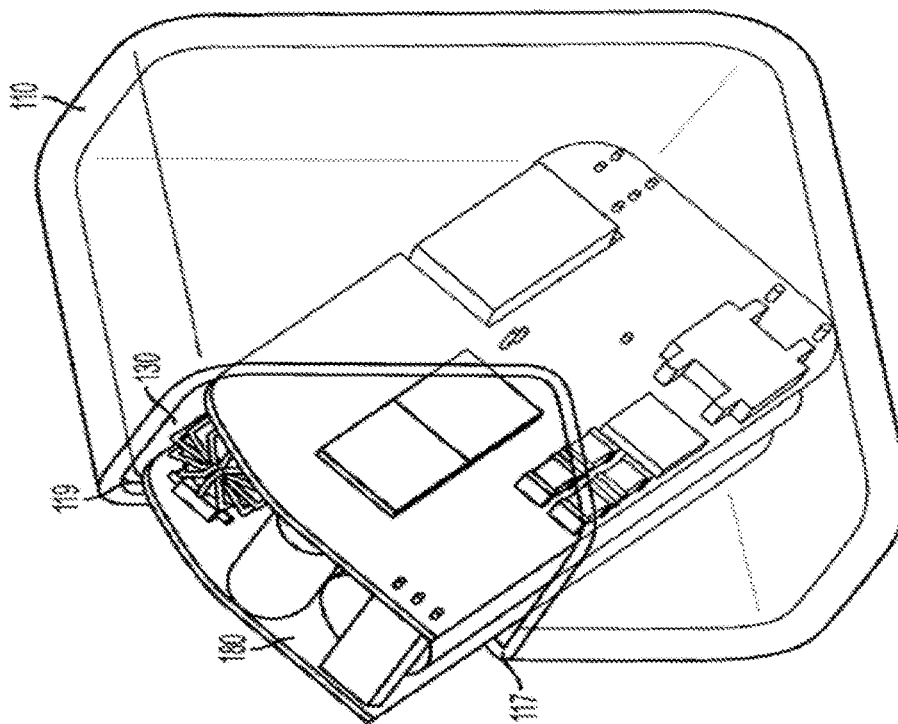


FIG. 1D

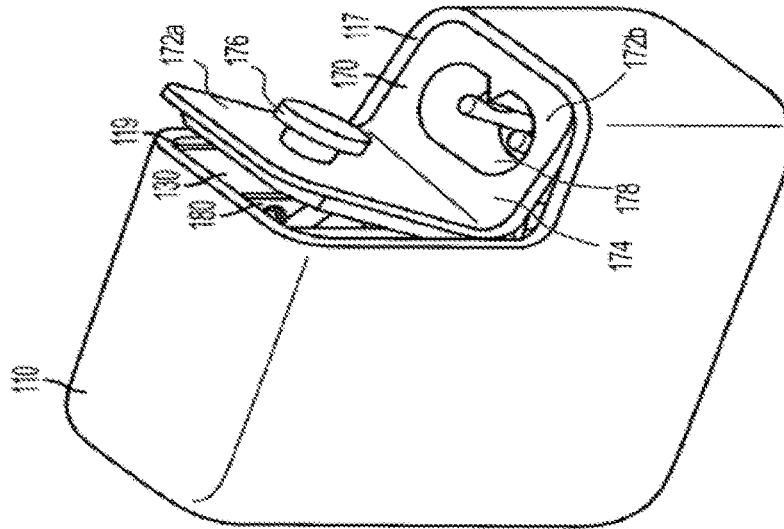


FIG. 1E

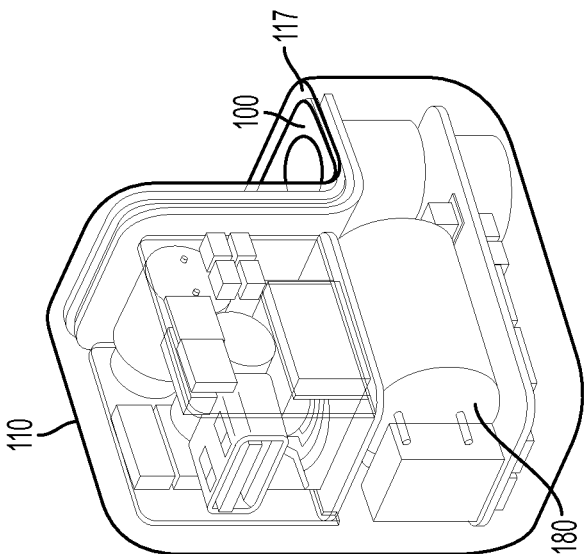


FIG. 1G

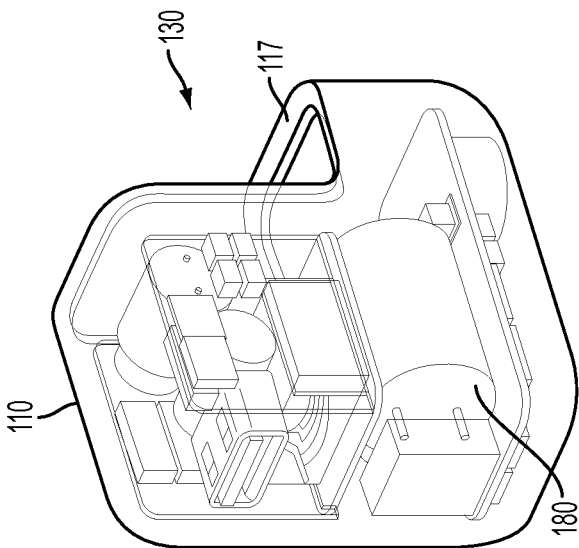


FIG. 1F

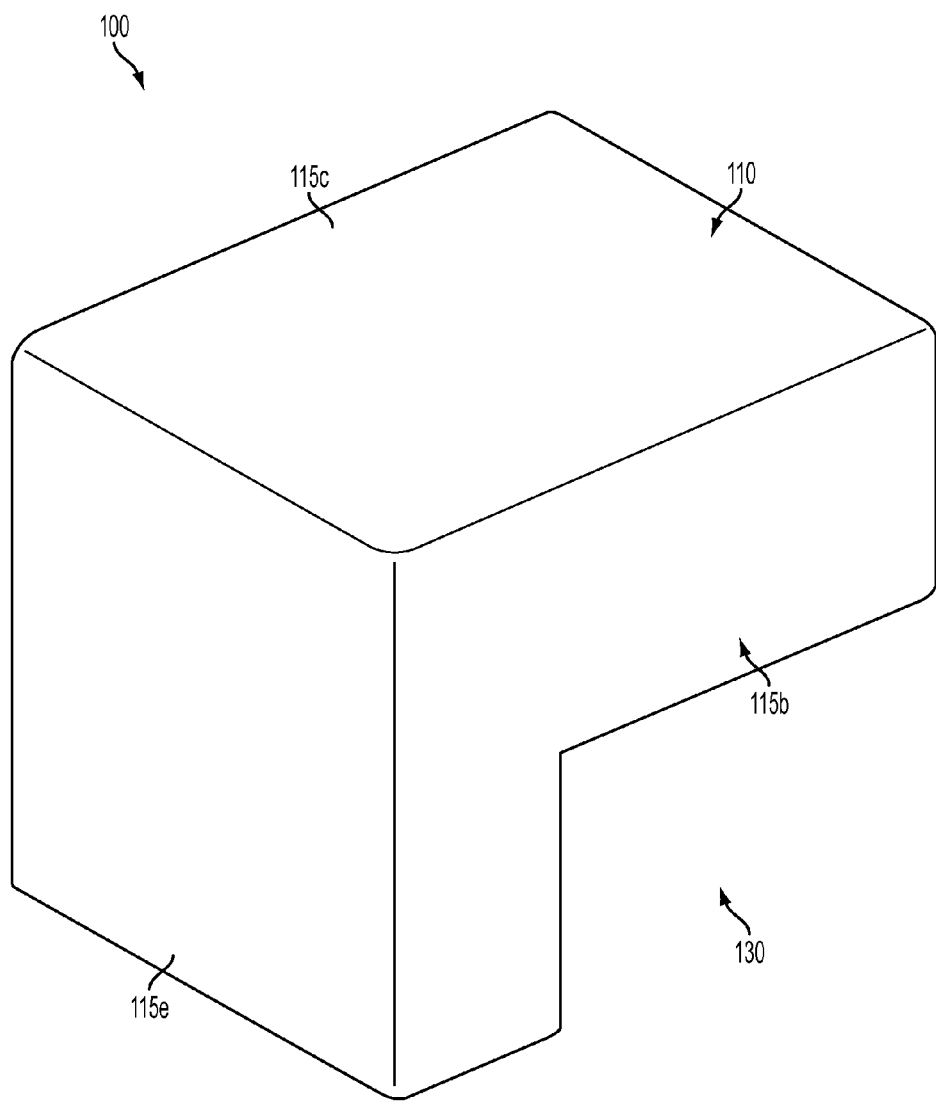


FIG. 2

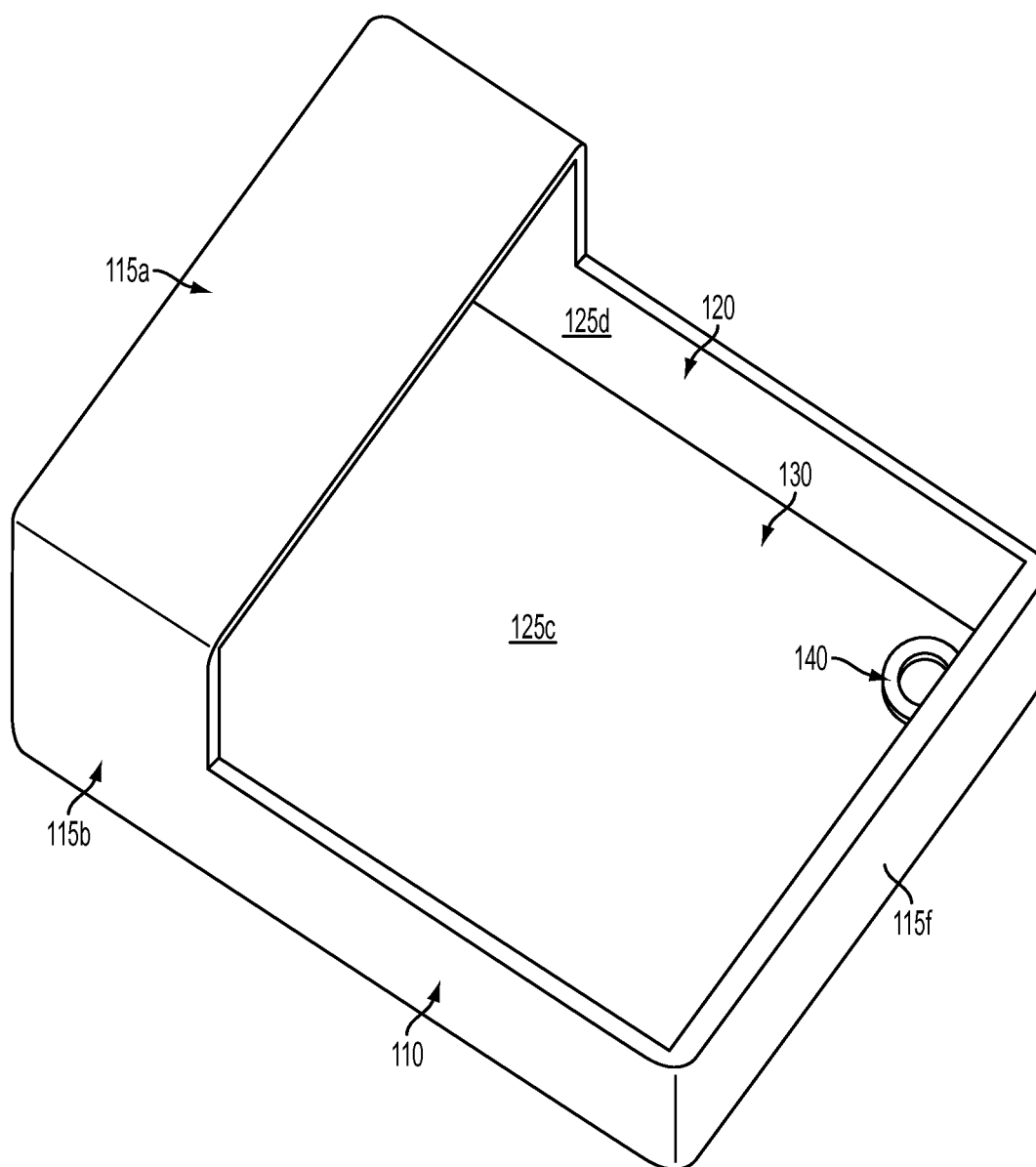


FIG. 3

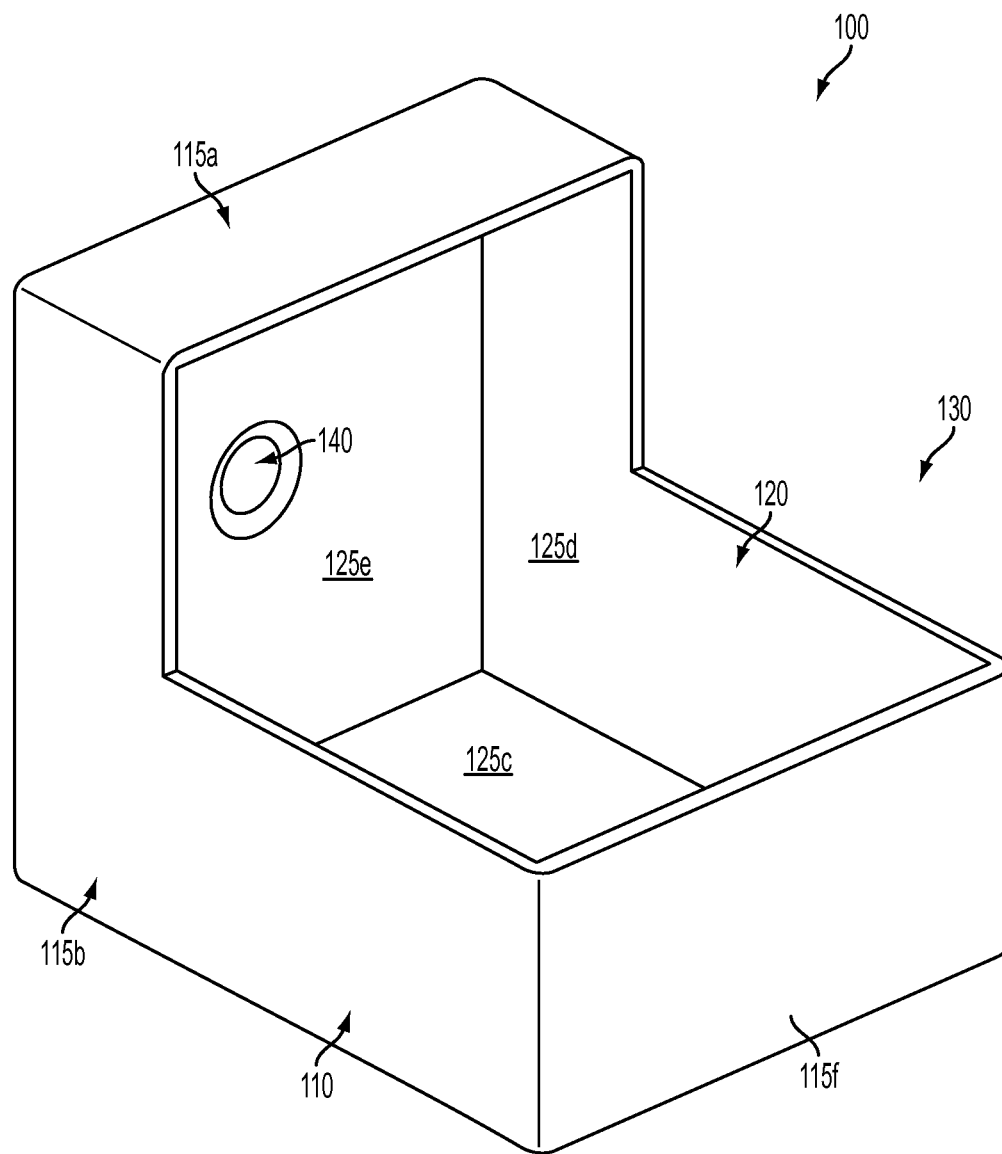


FIG. 4



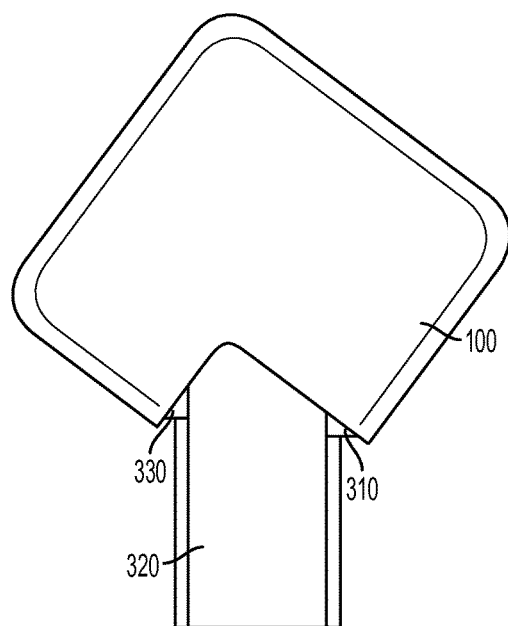


FIG. 5A

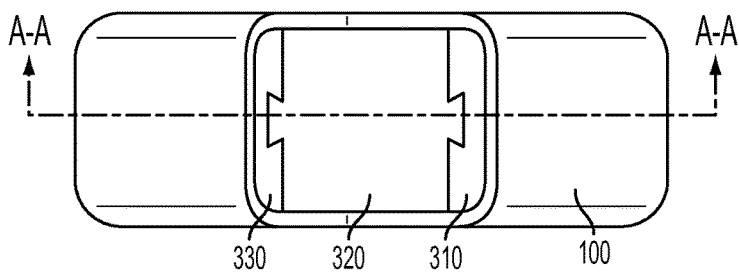


FIG. 5B

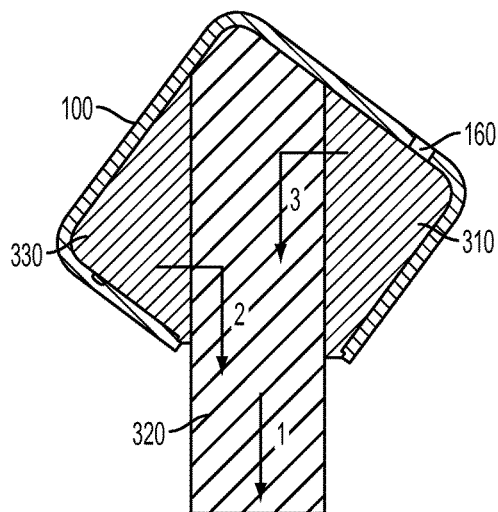


FIG. 5C

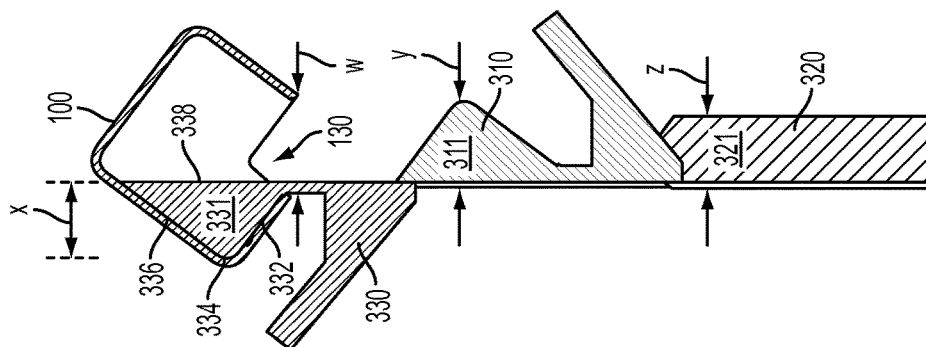


FIG. 5G

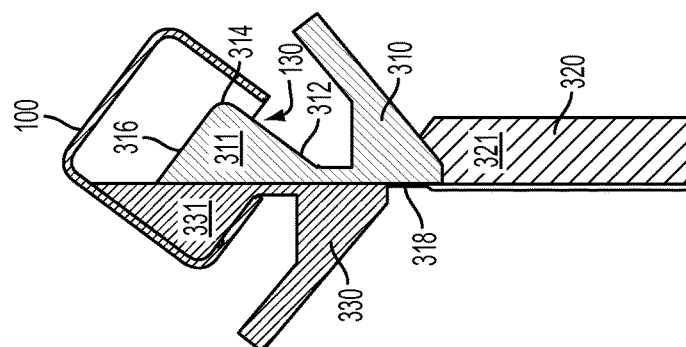


FIG. 5F

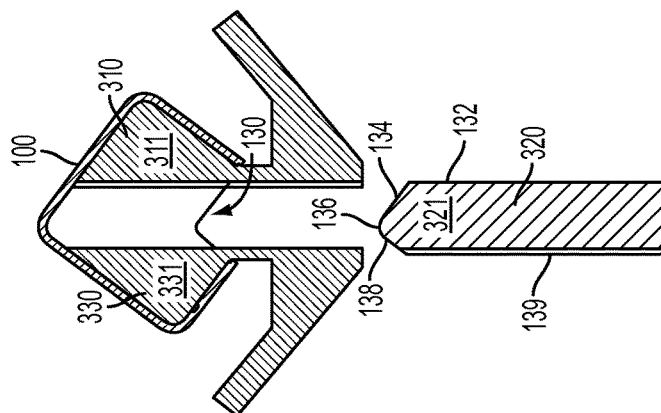


FIG. 5E

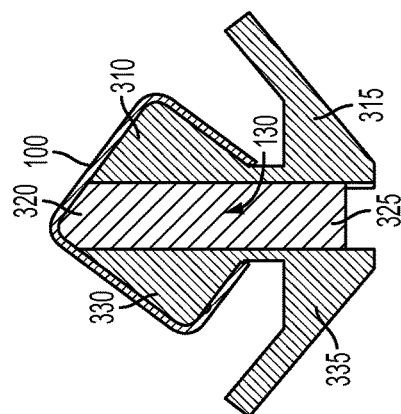


FIG. 5D

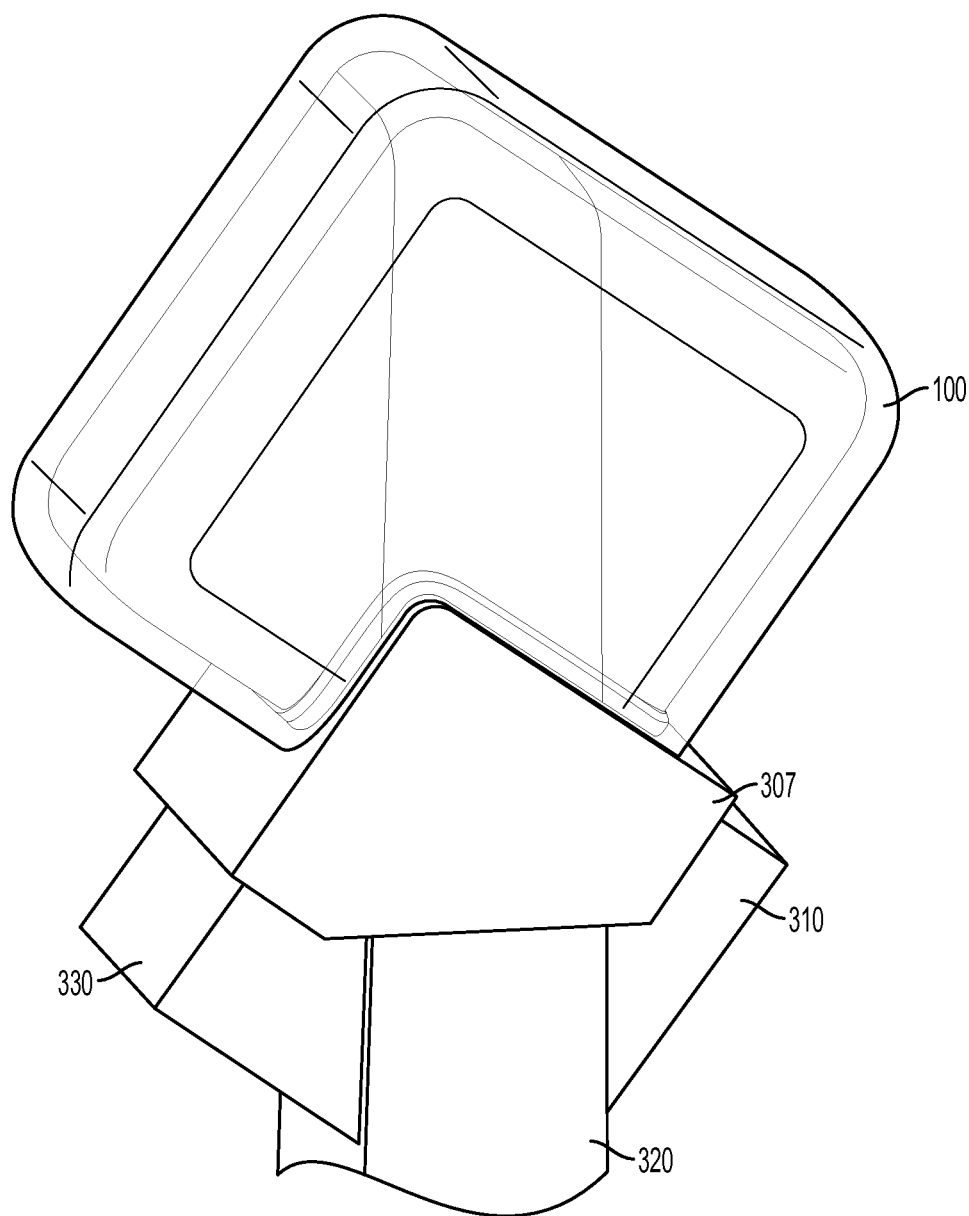


FIG. 5H

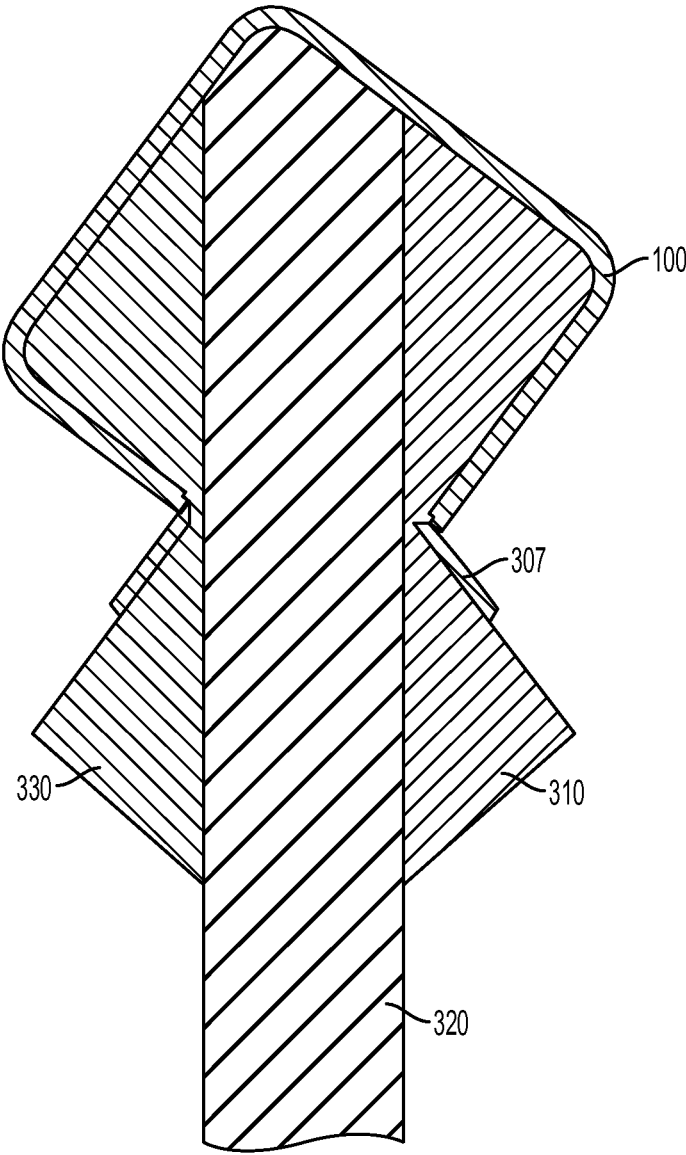


FIG. 5I

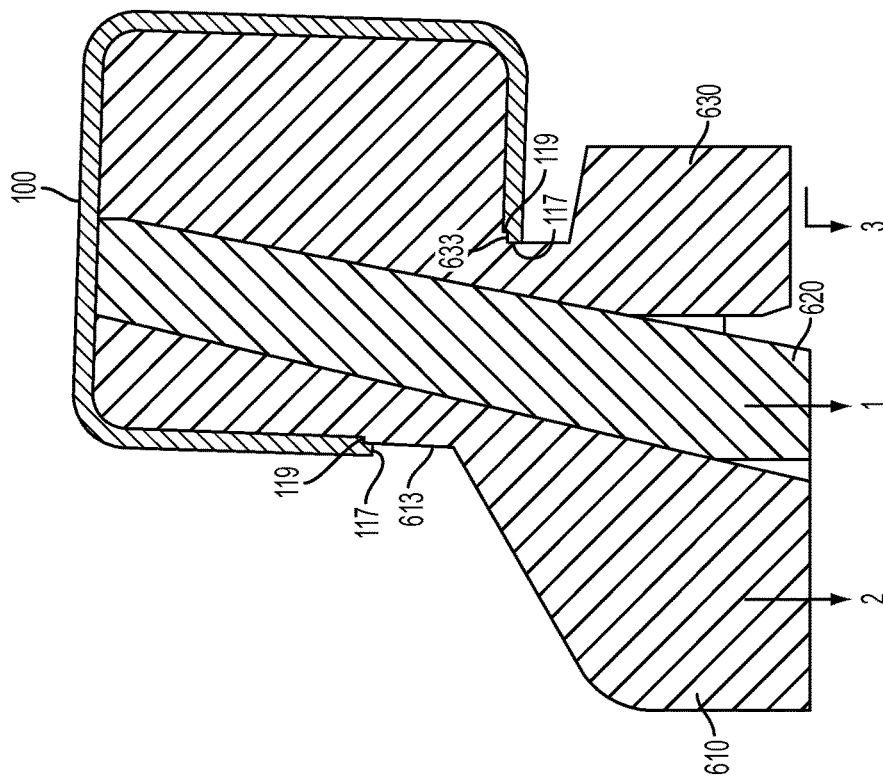


FIG. 6B

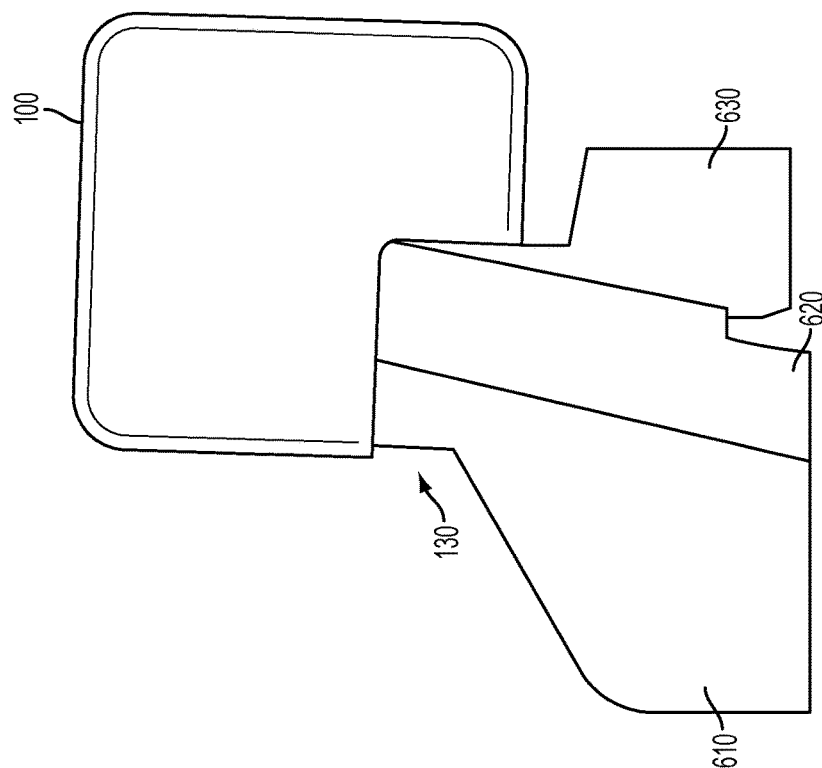


FIG. 6A

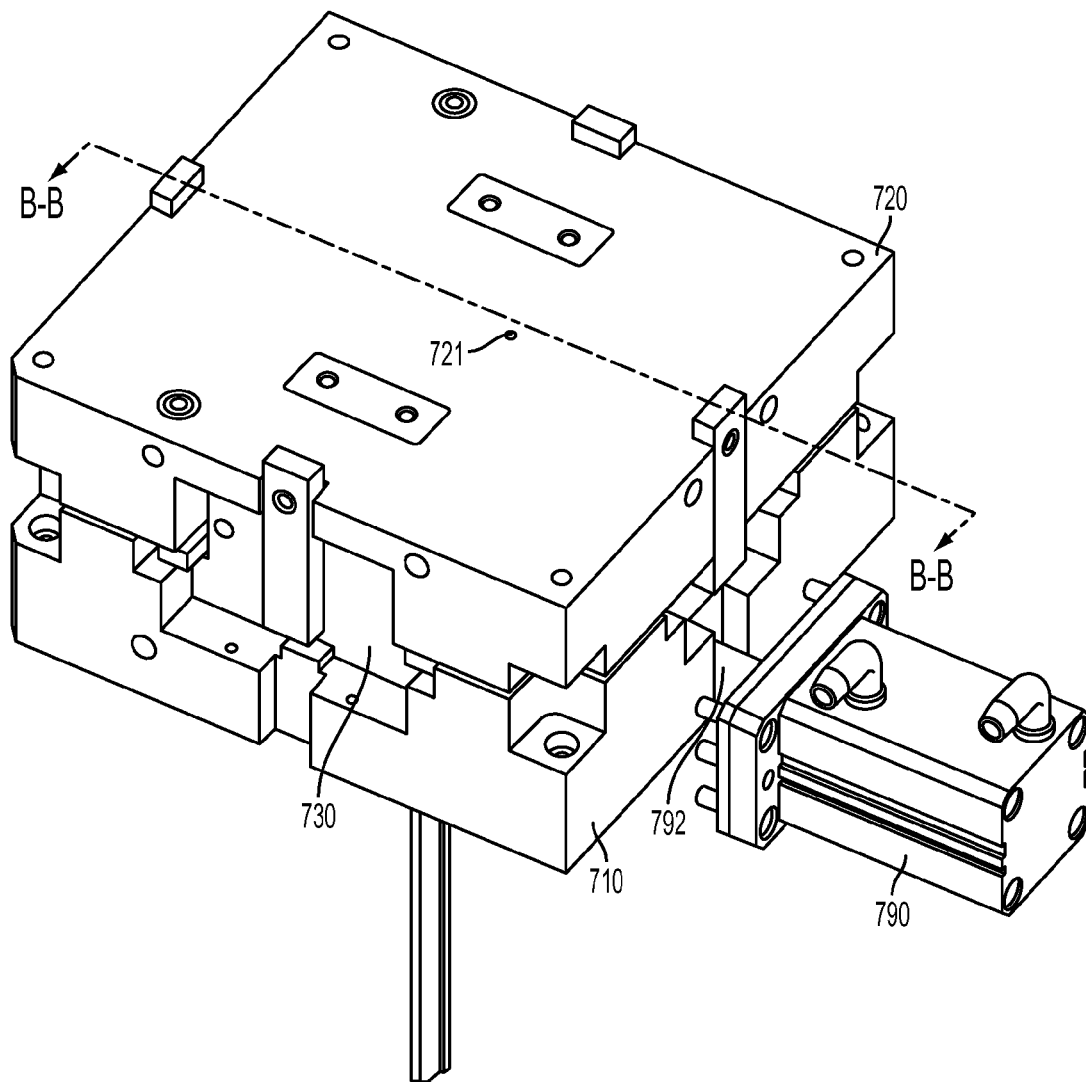


FIG. 7A

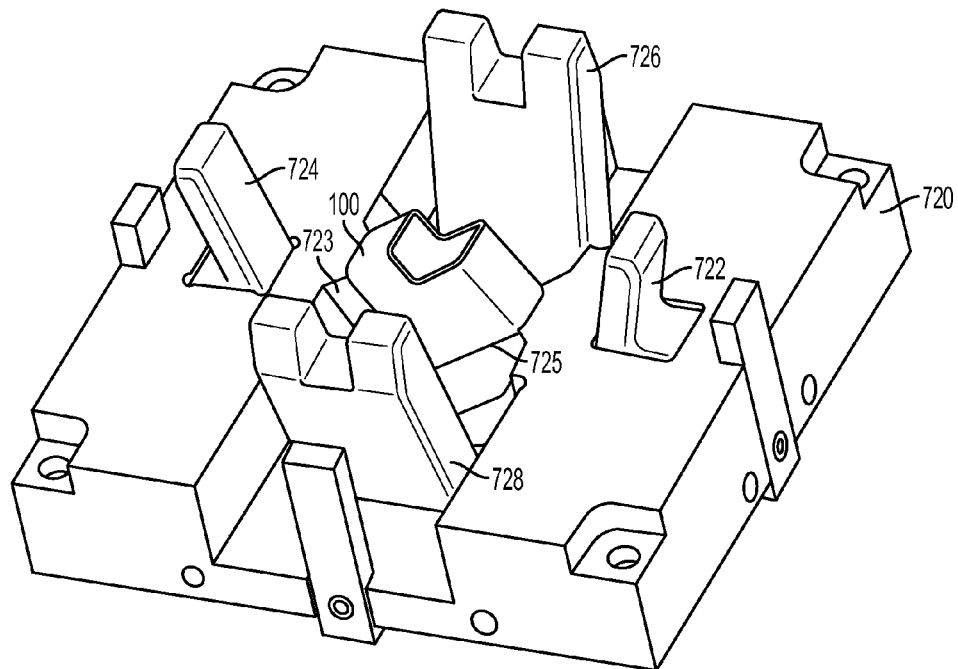


FIG. 7B

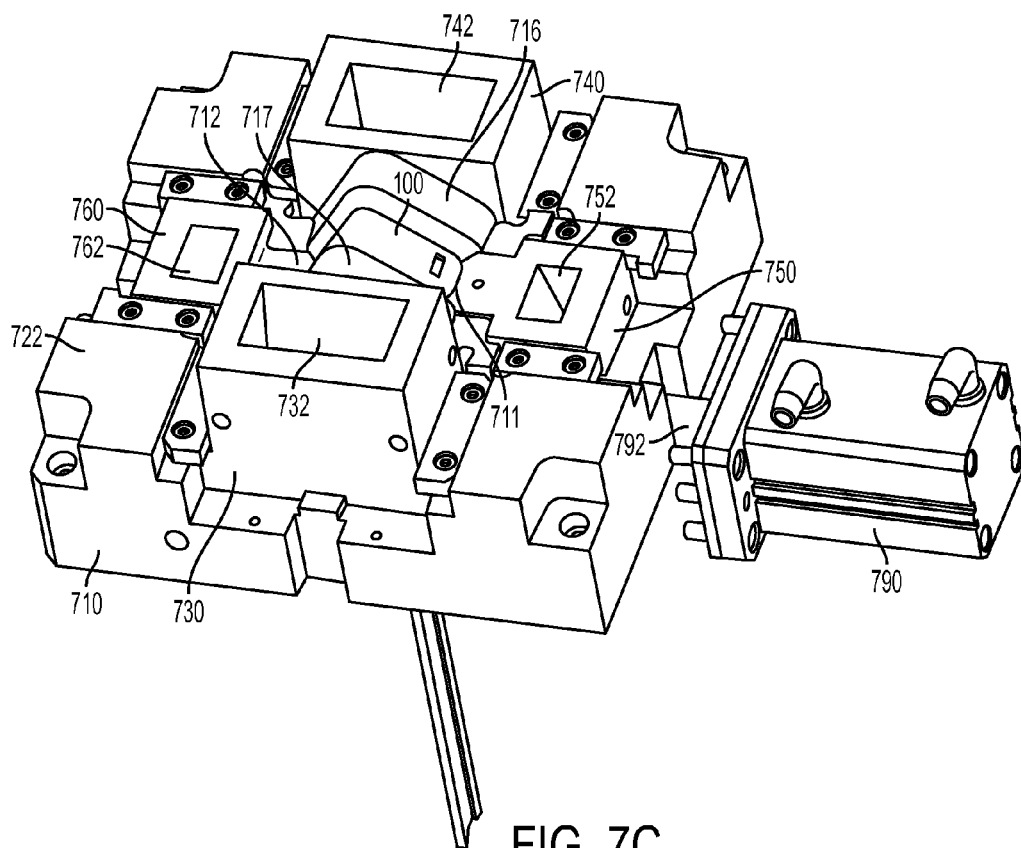
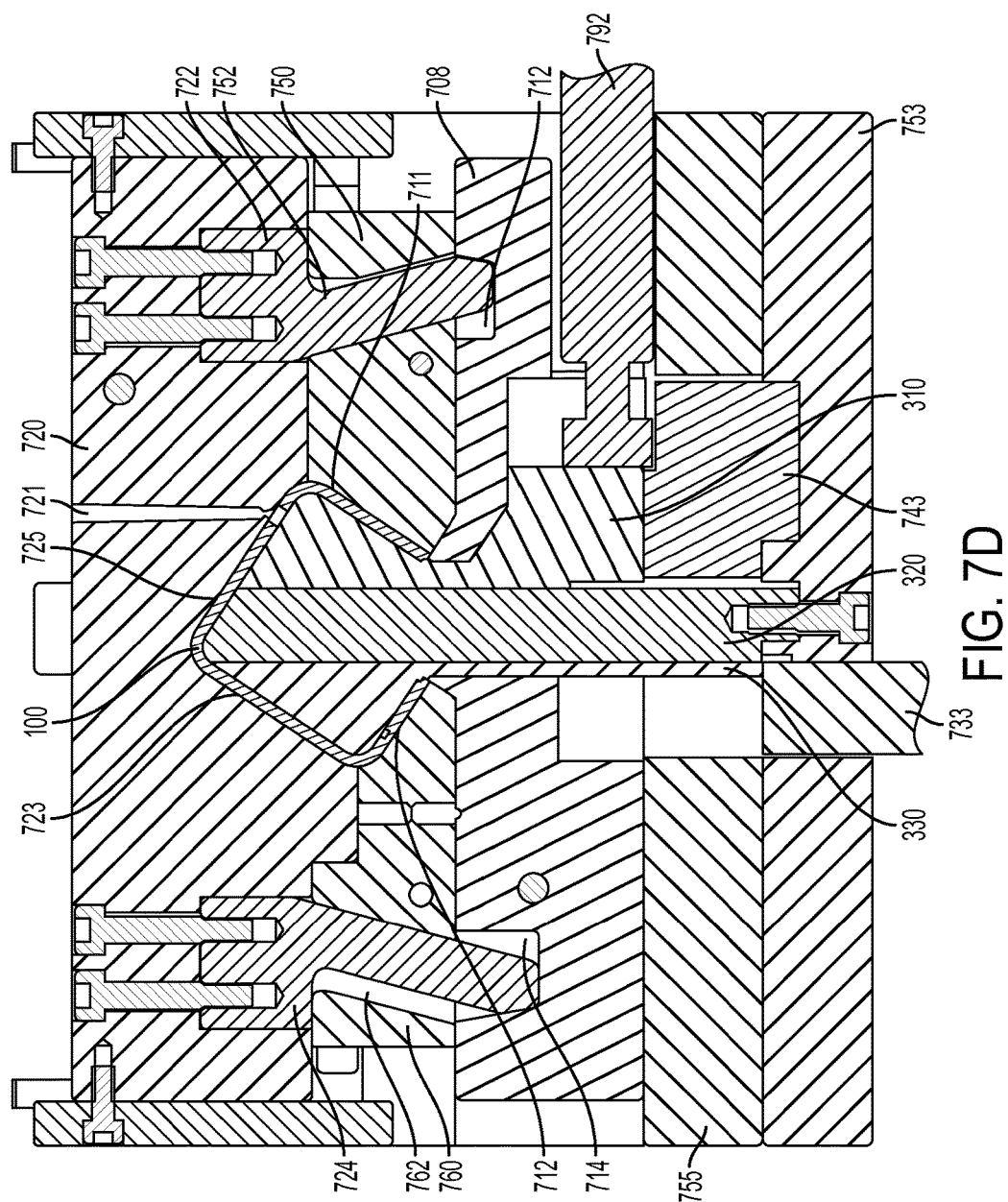


FIG. 7C





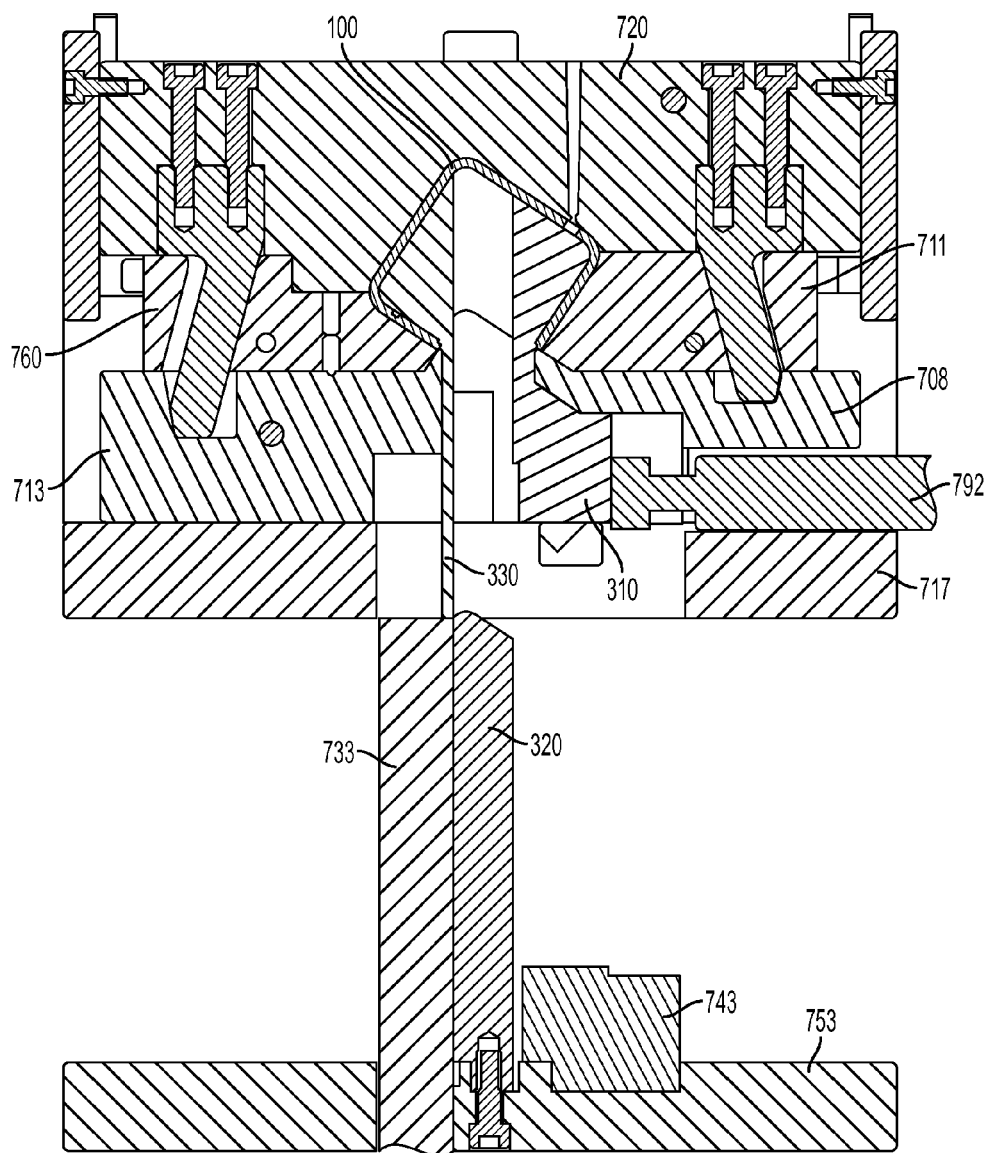


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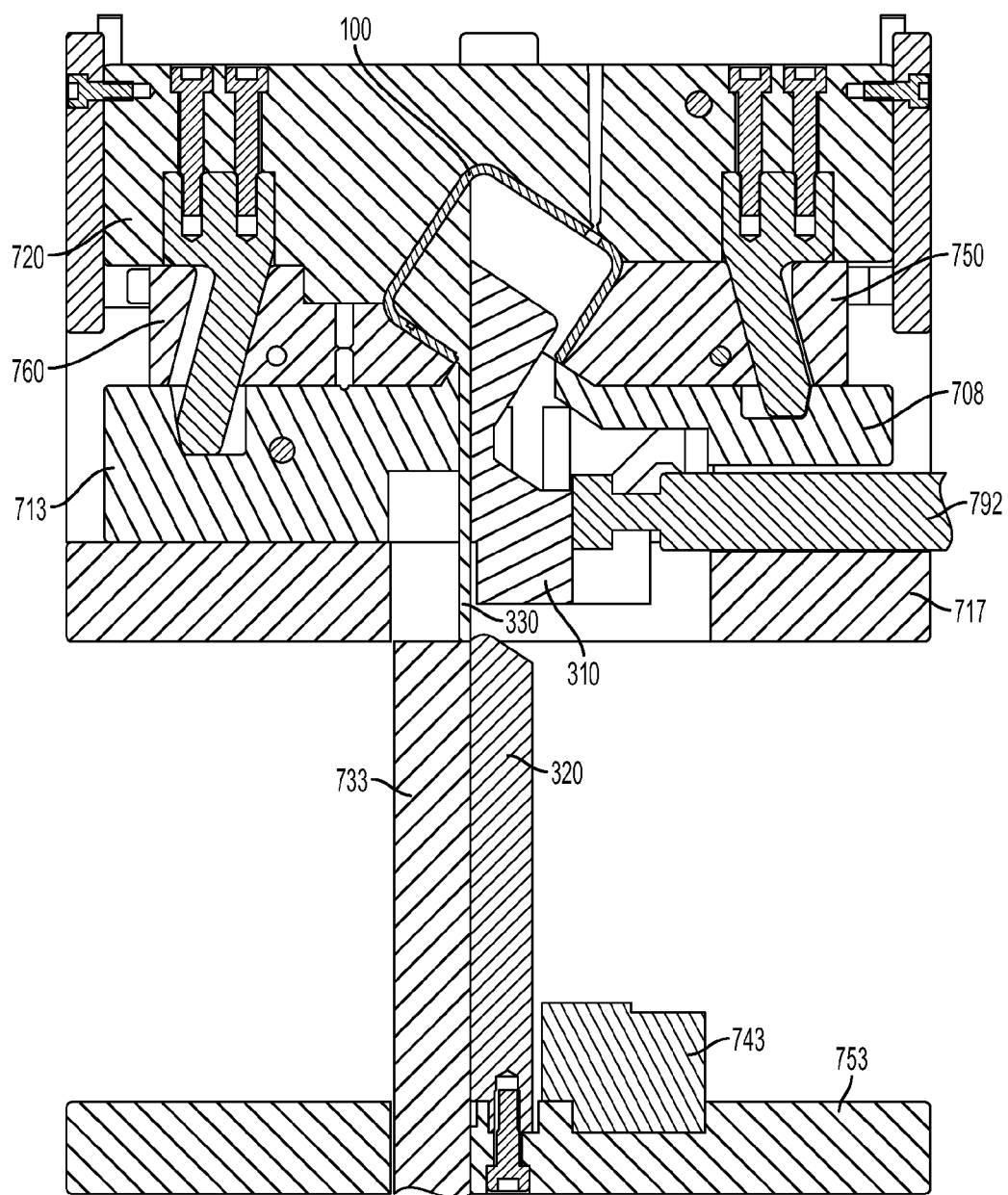


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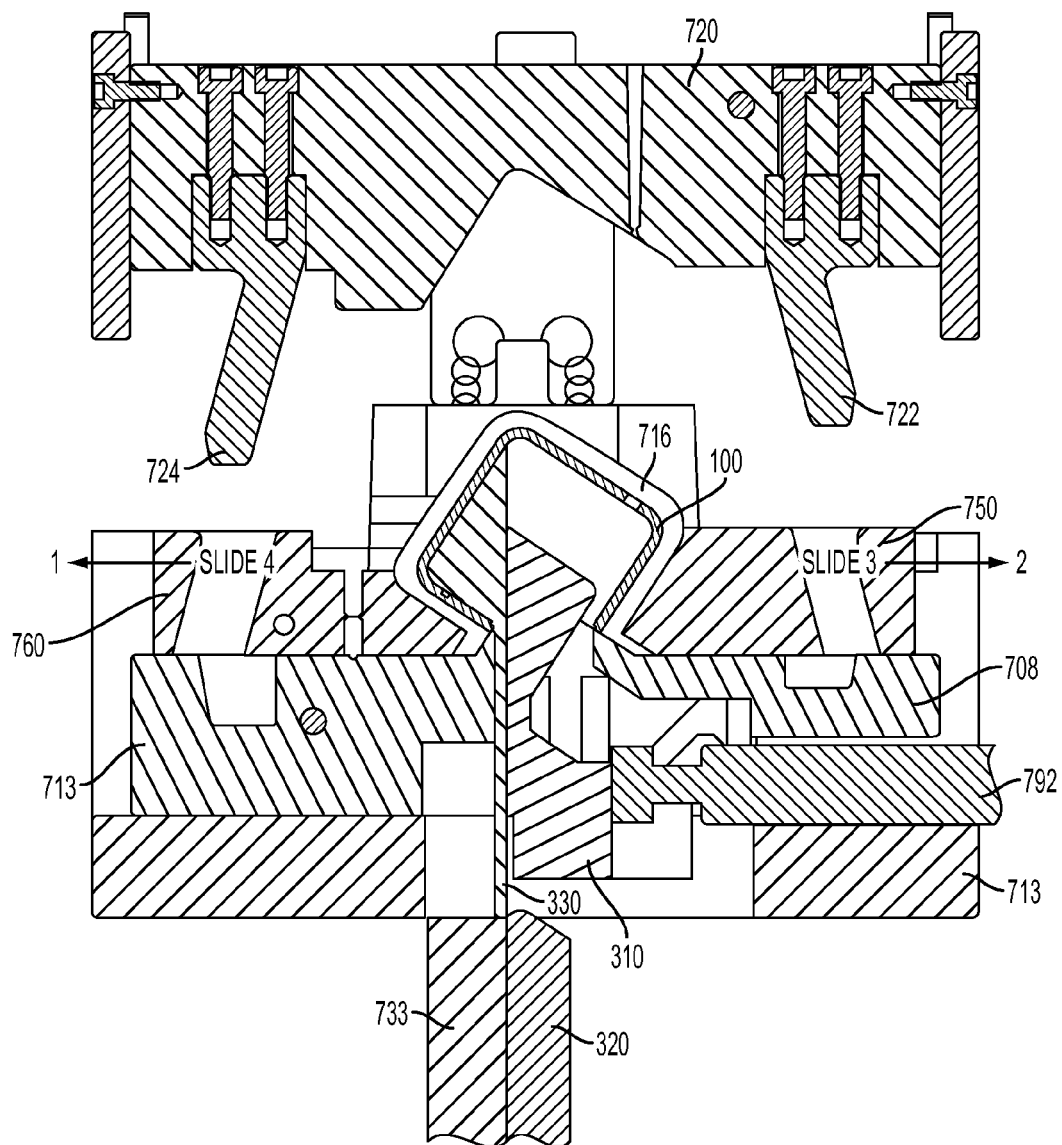


FIG. 7G

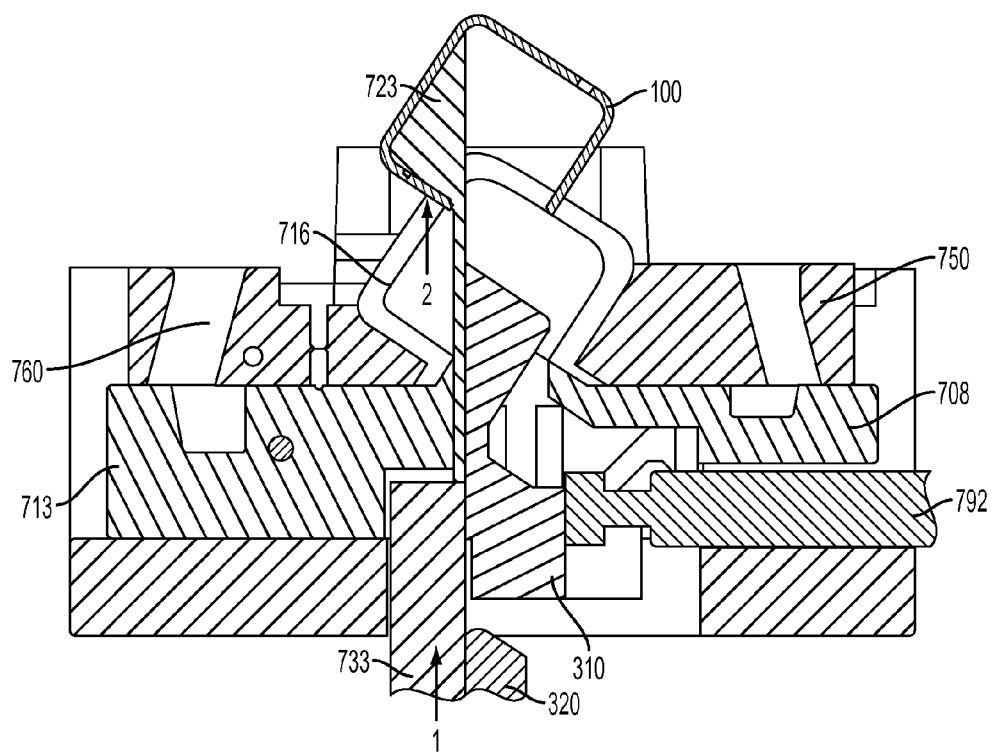


FIG. 7H

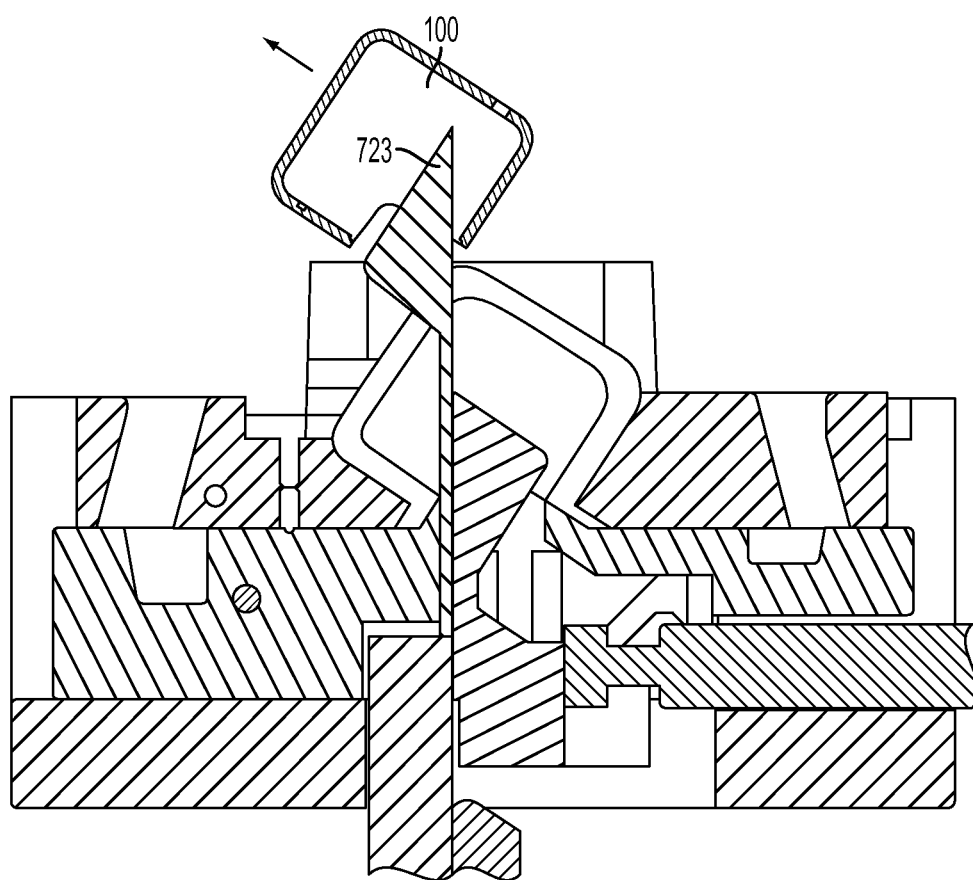


FIG. 71

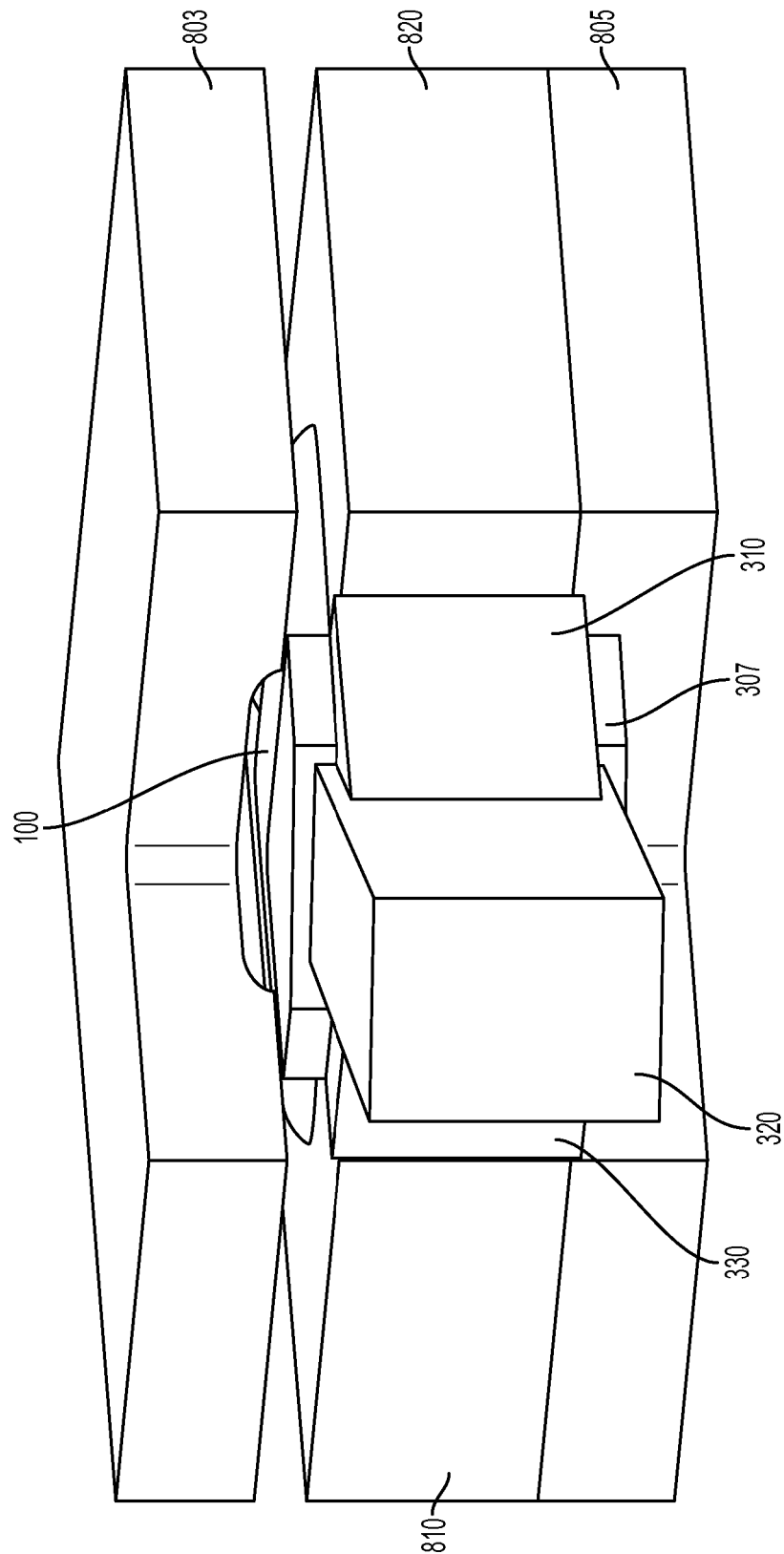


FIG. 8A

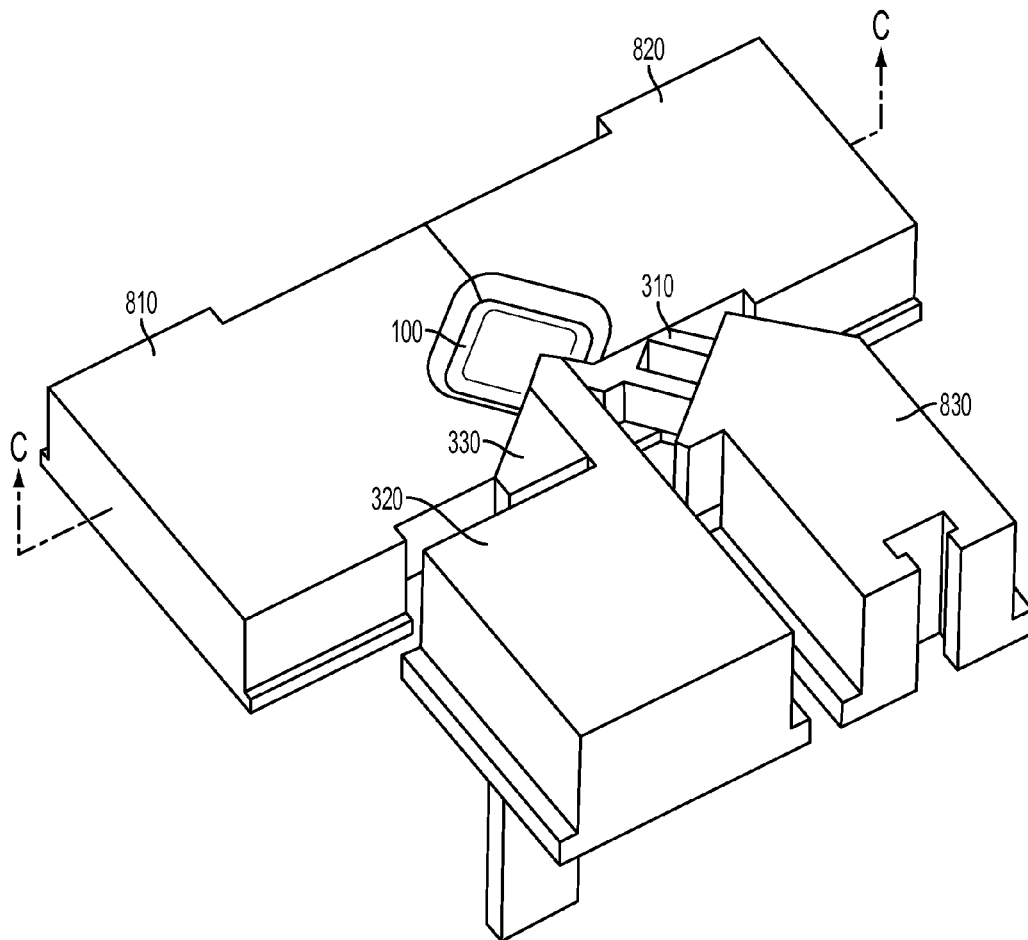


FIG. 8B

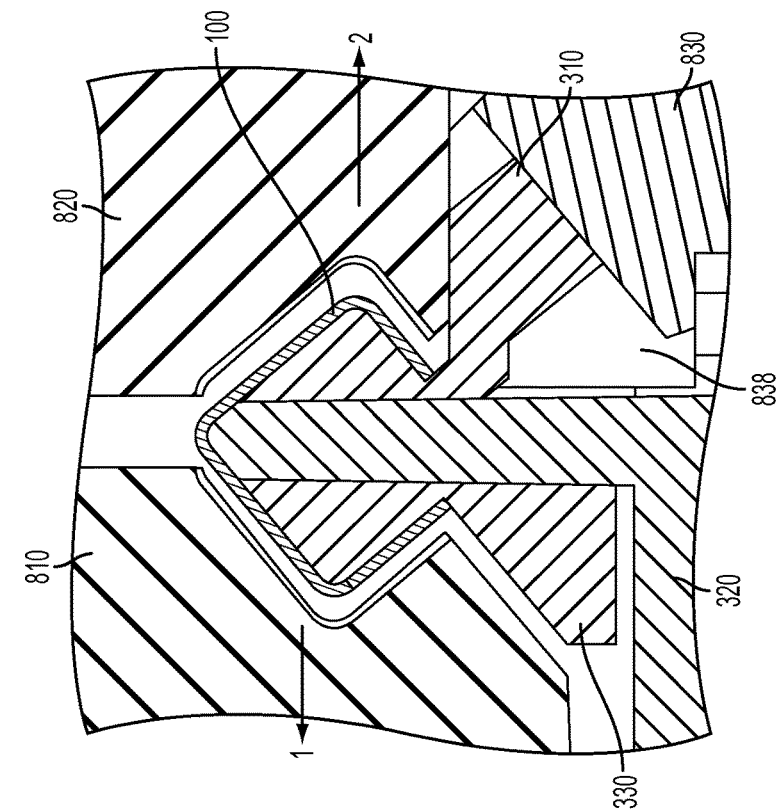


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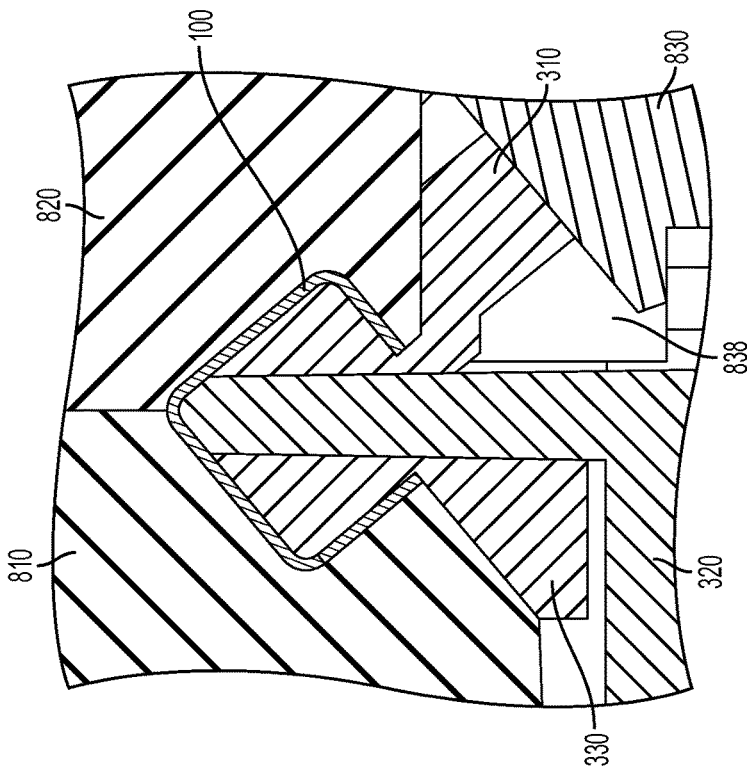


FIG. 8C



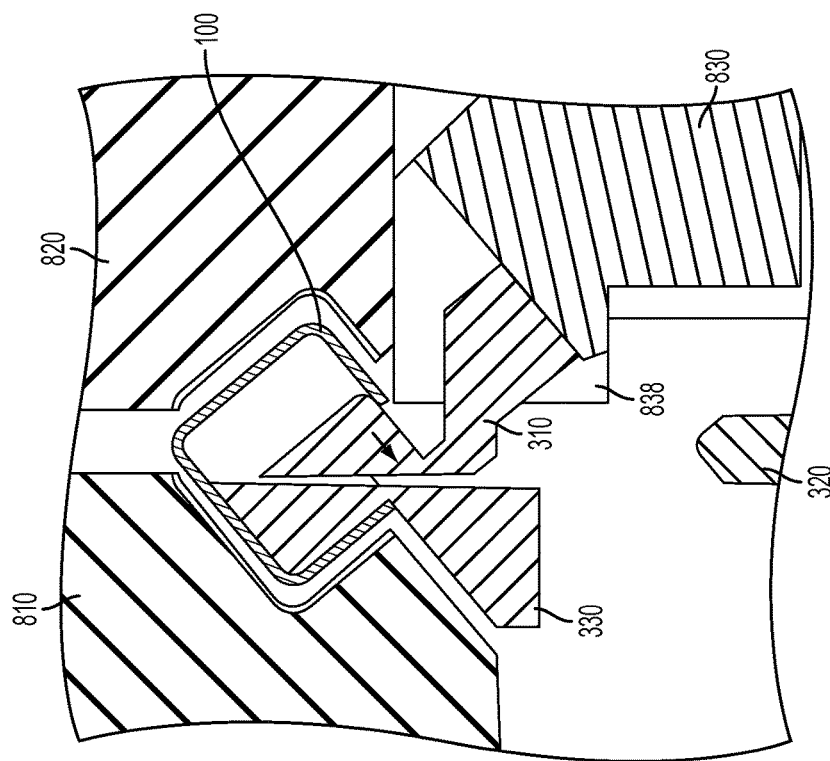


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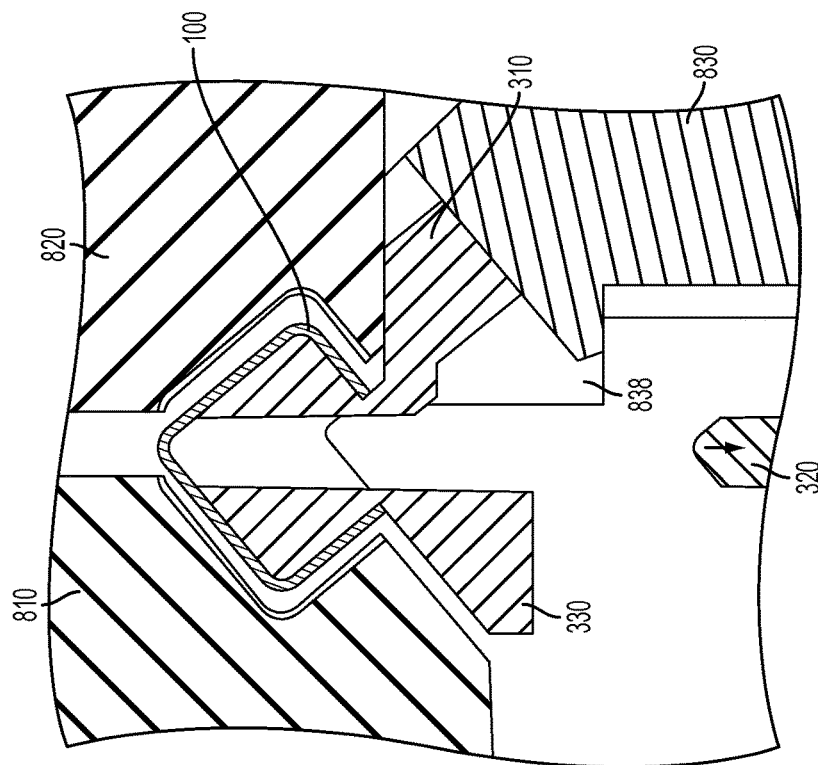


FIG. 8E

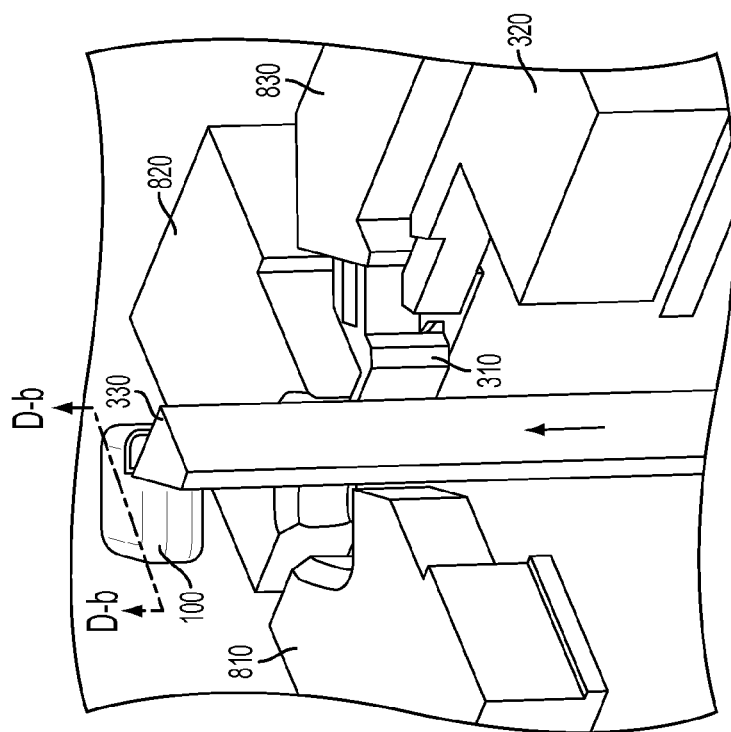


FIG. 8H

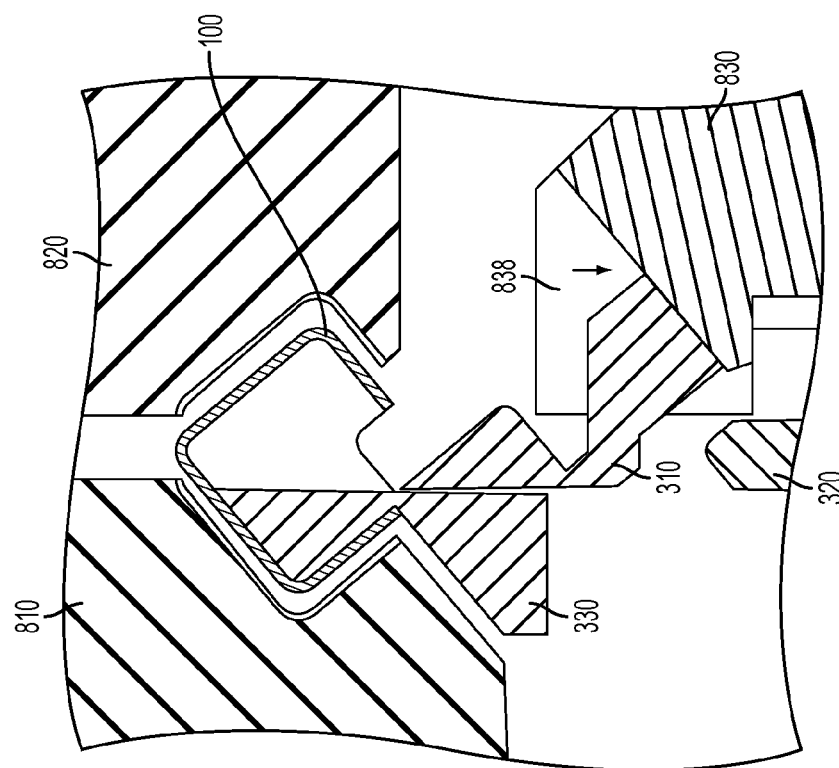


FIG. 8G

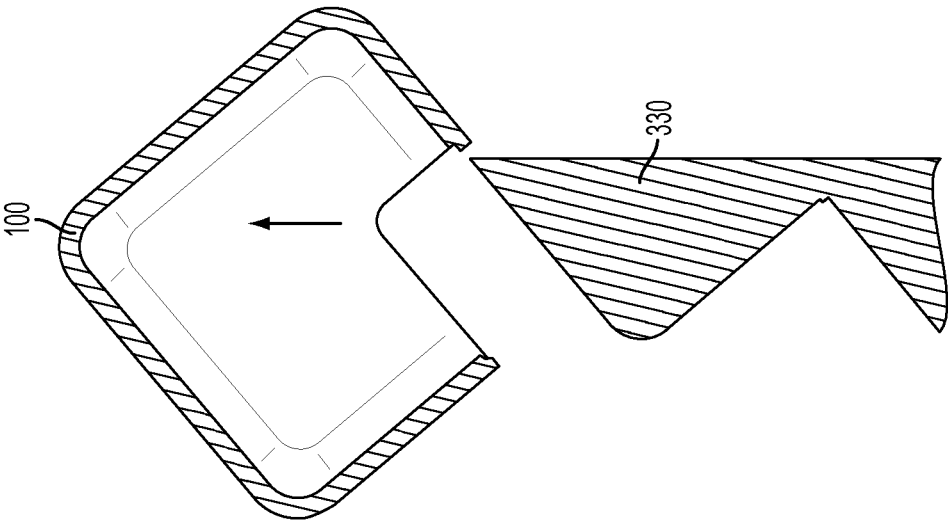


FIG. 8I

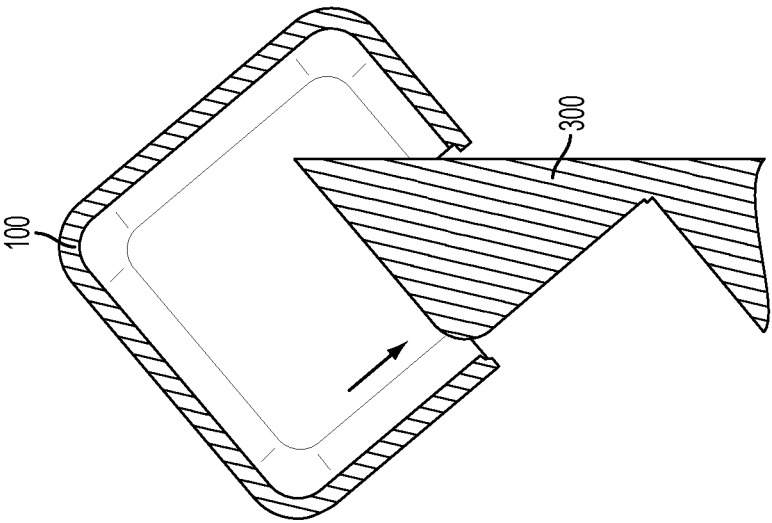


FIG. 8J

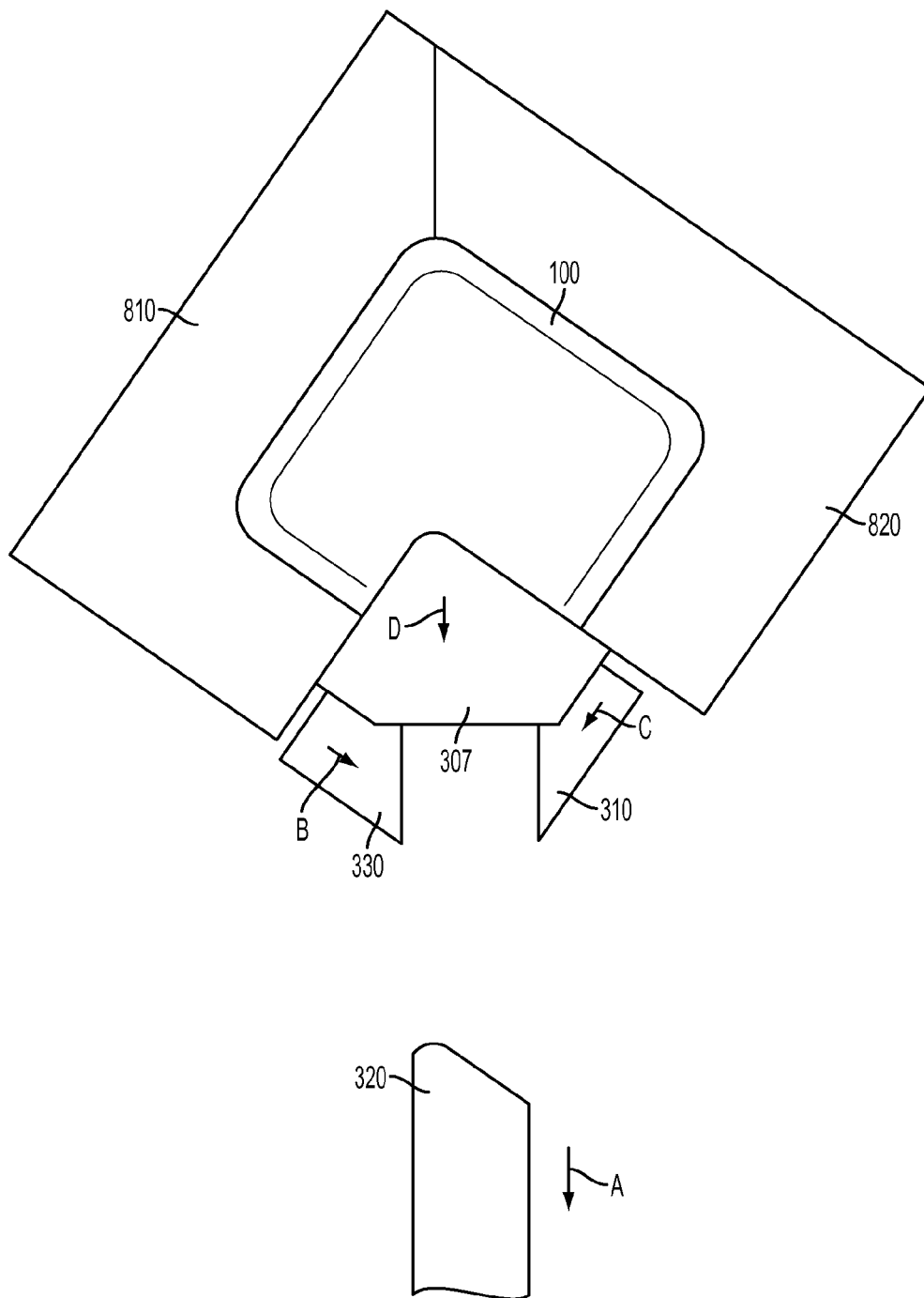


FIG. 8K

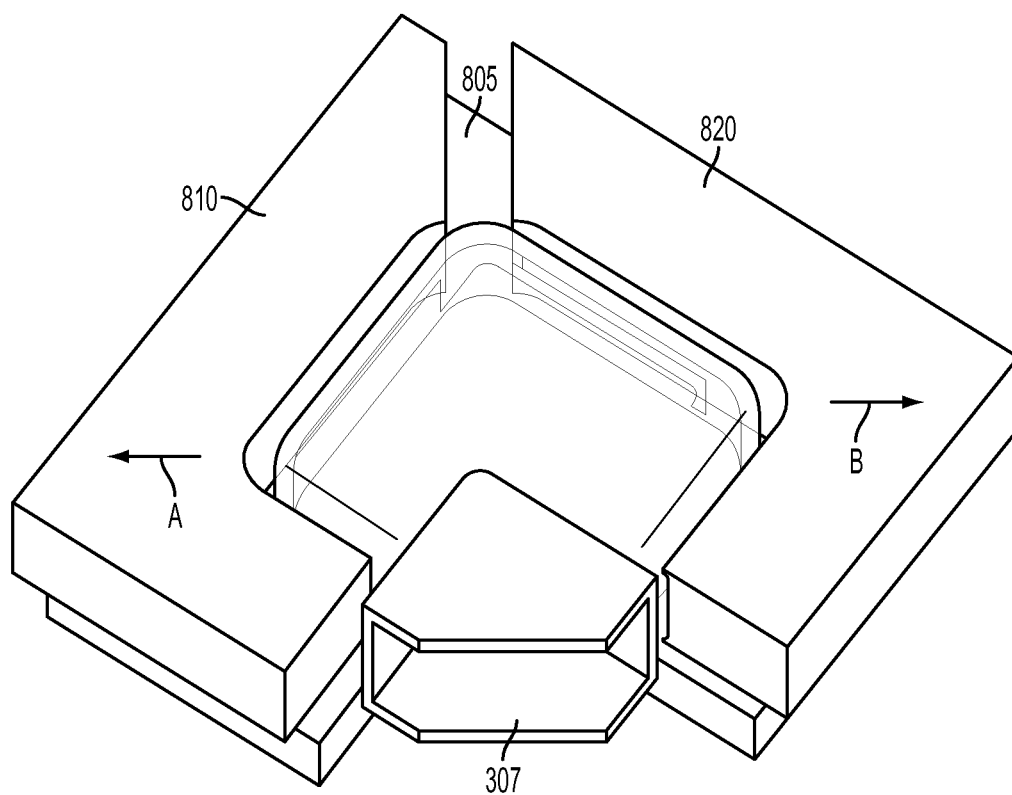


FIG. 8L

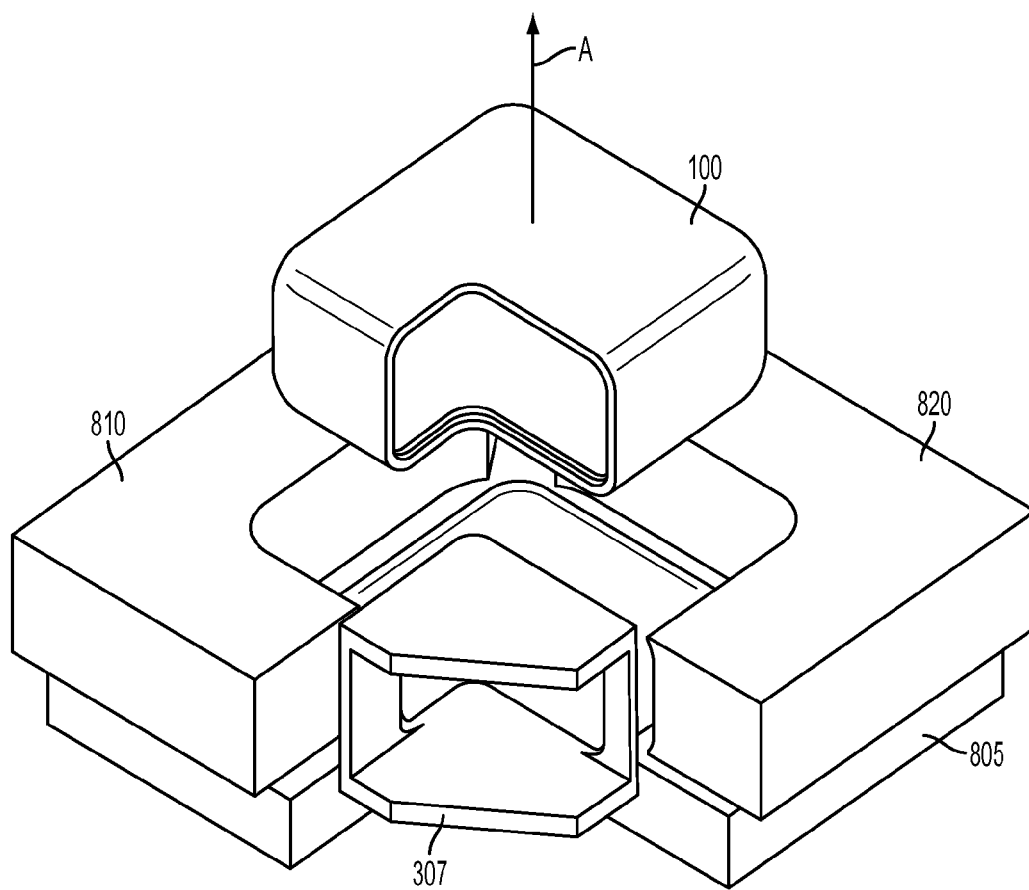


FIG. 8M

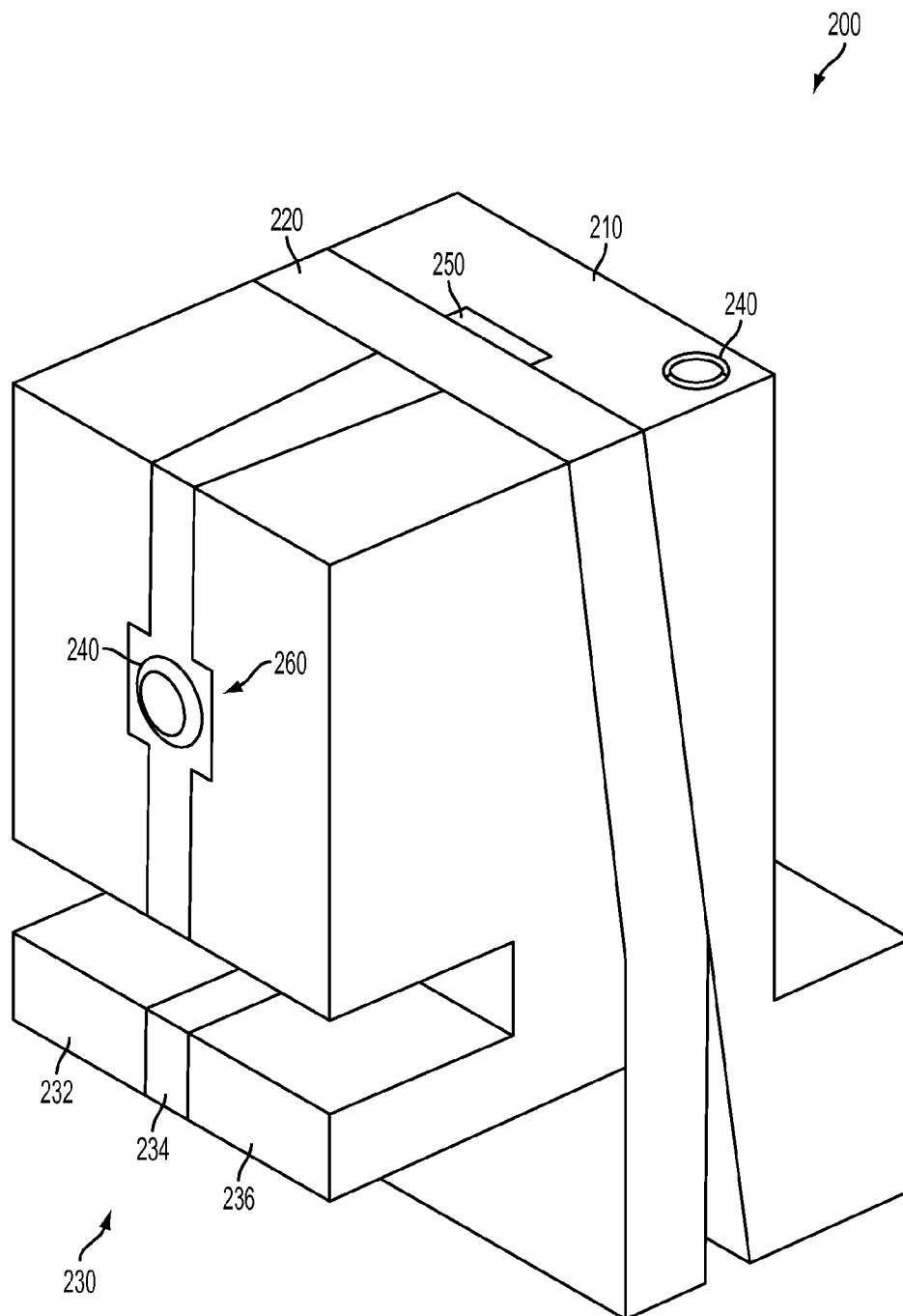


FIG. 9A

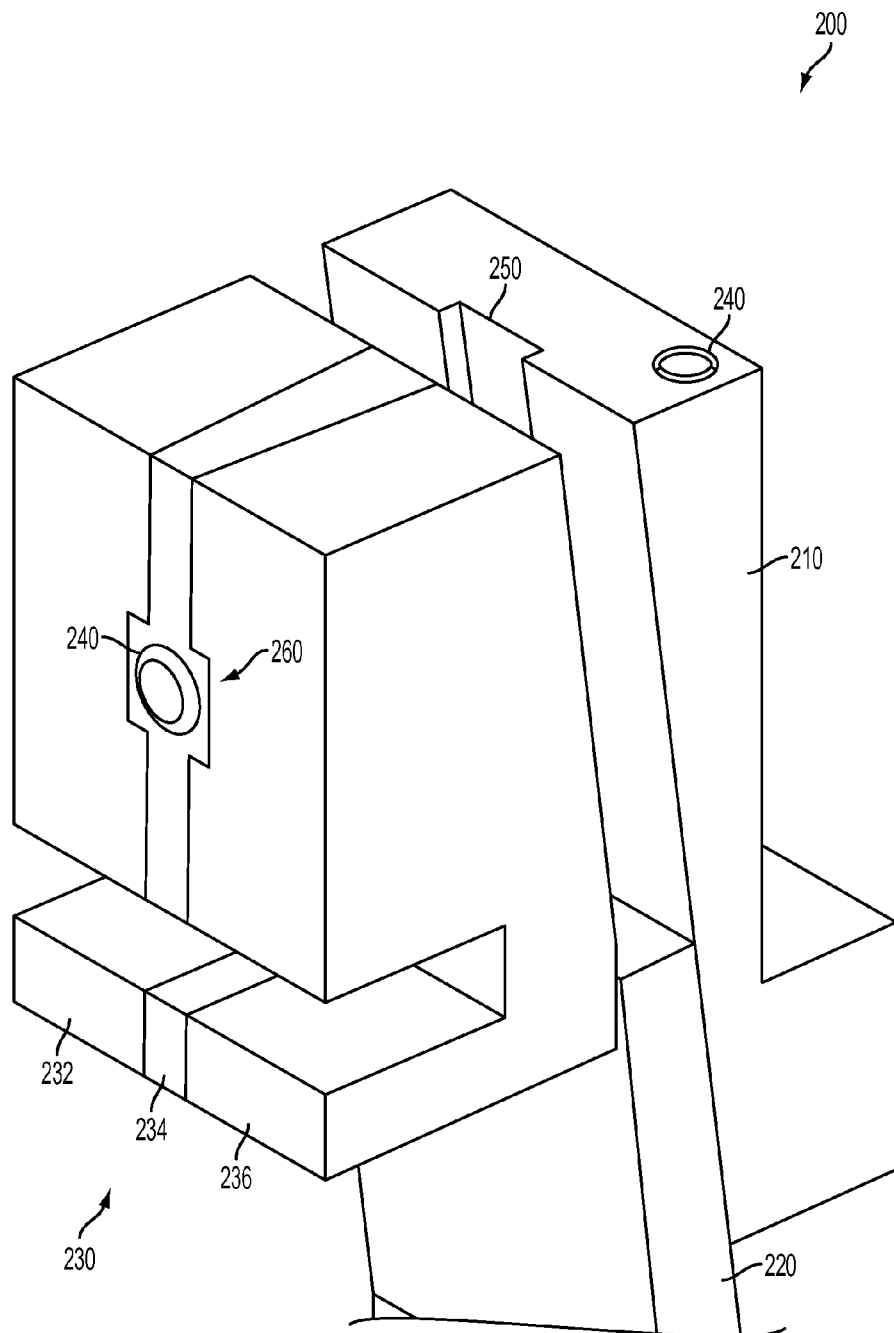


FIG. 9B



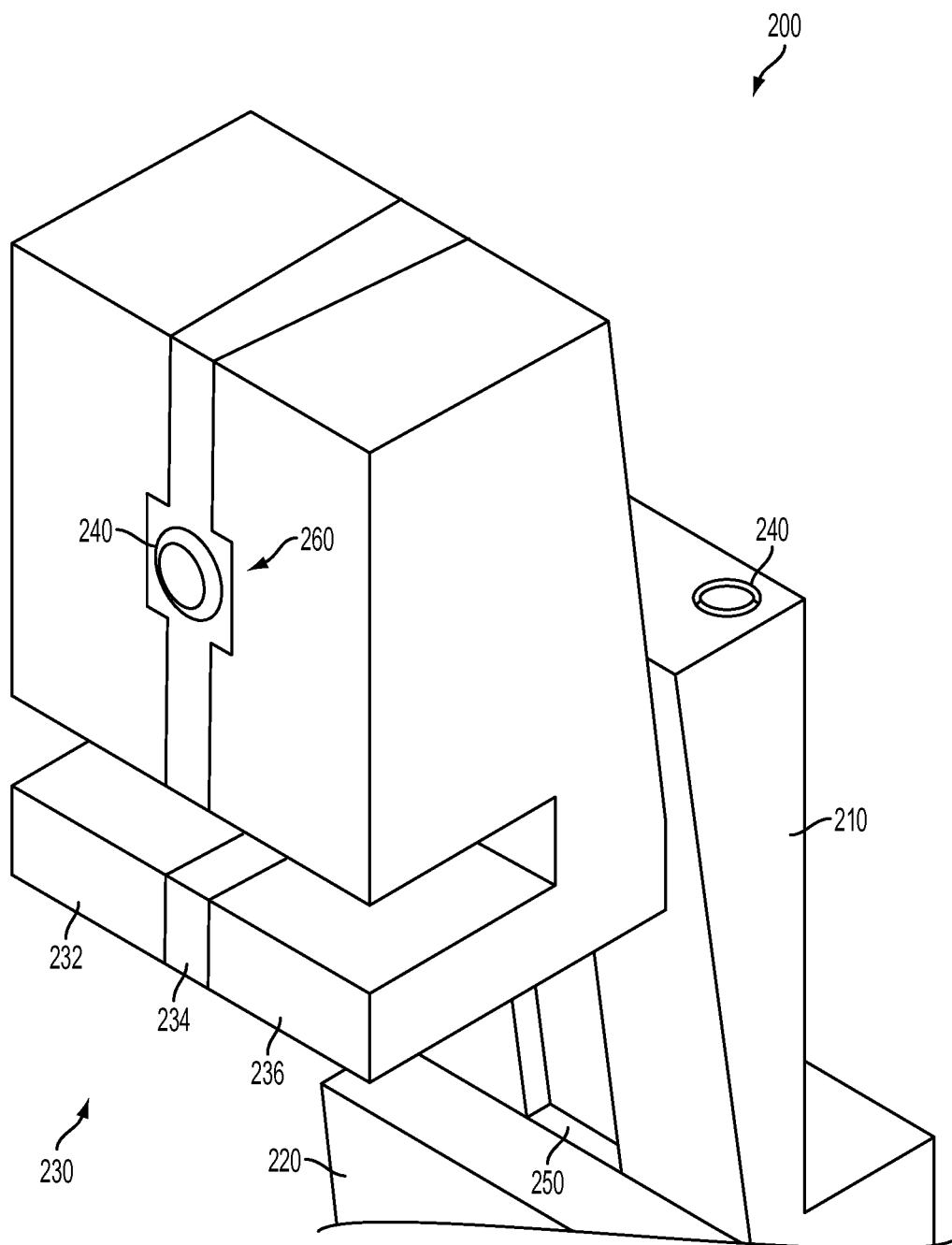


FIG. 9C

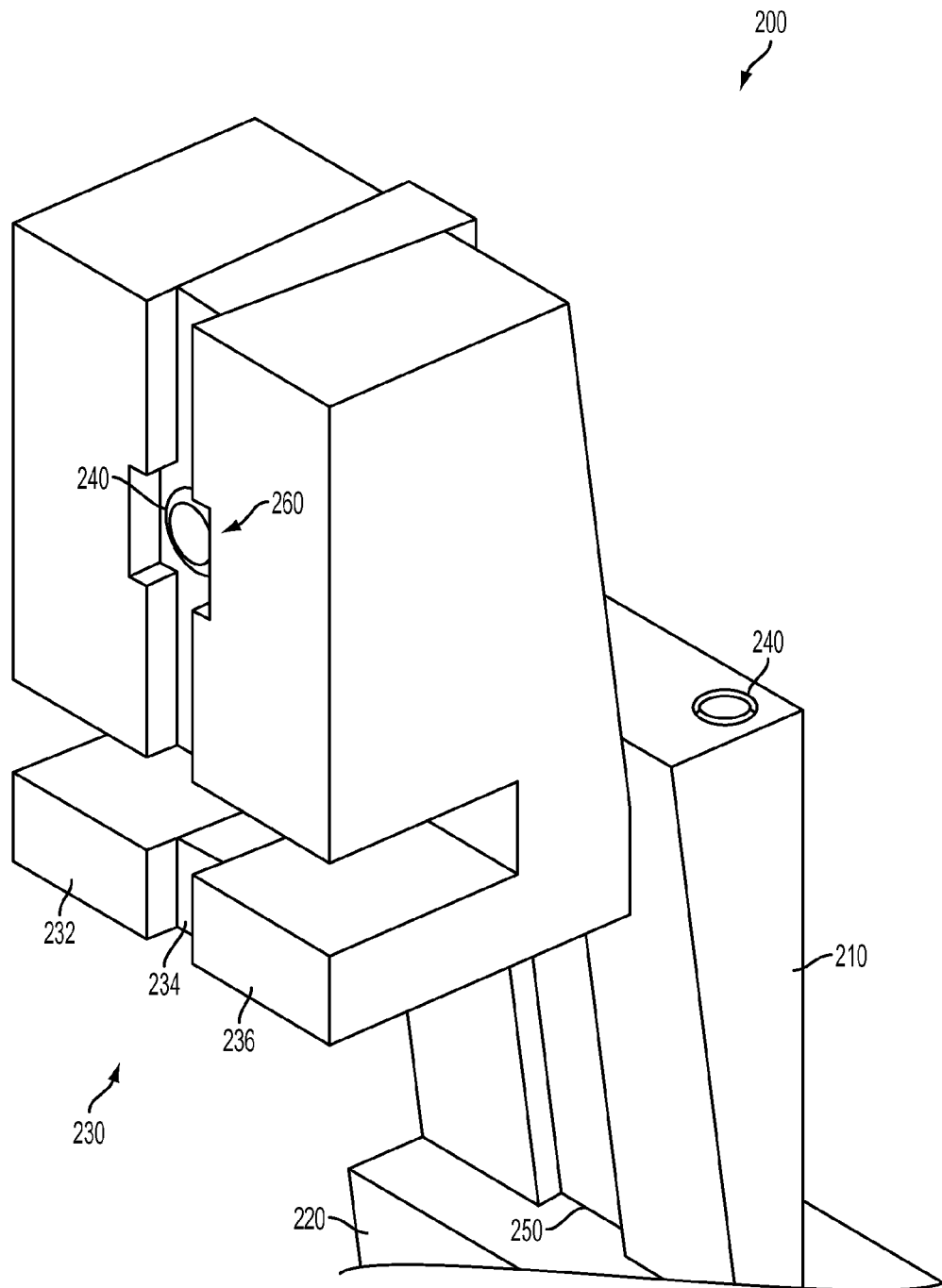


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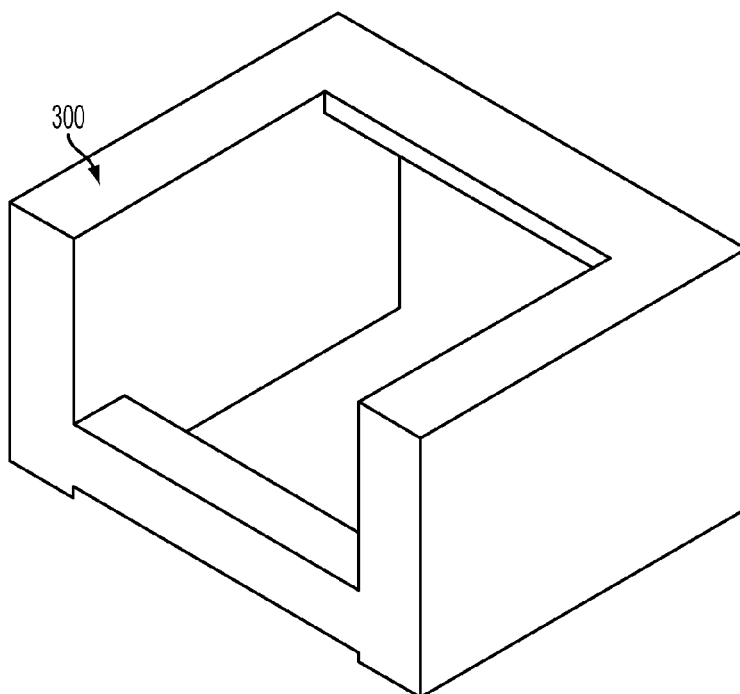


FIG. 9E

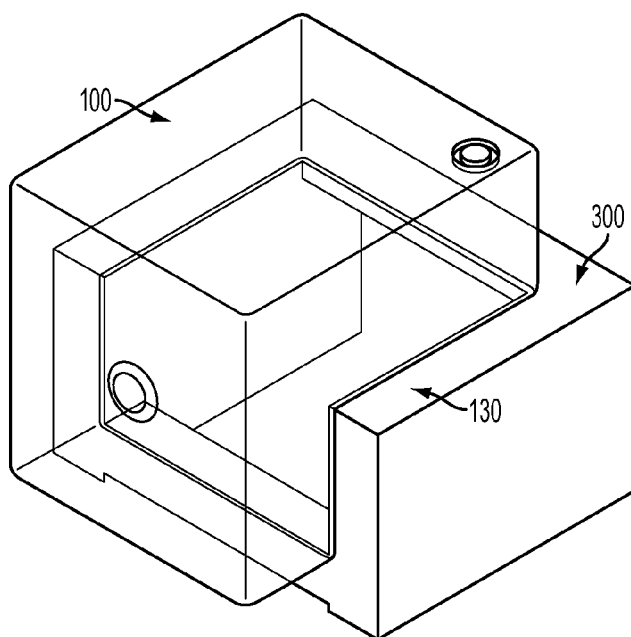


FIG. 9F

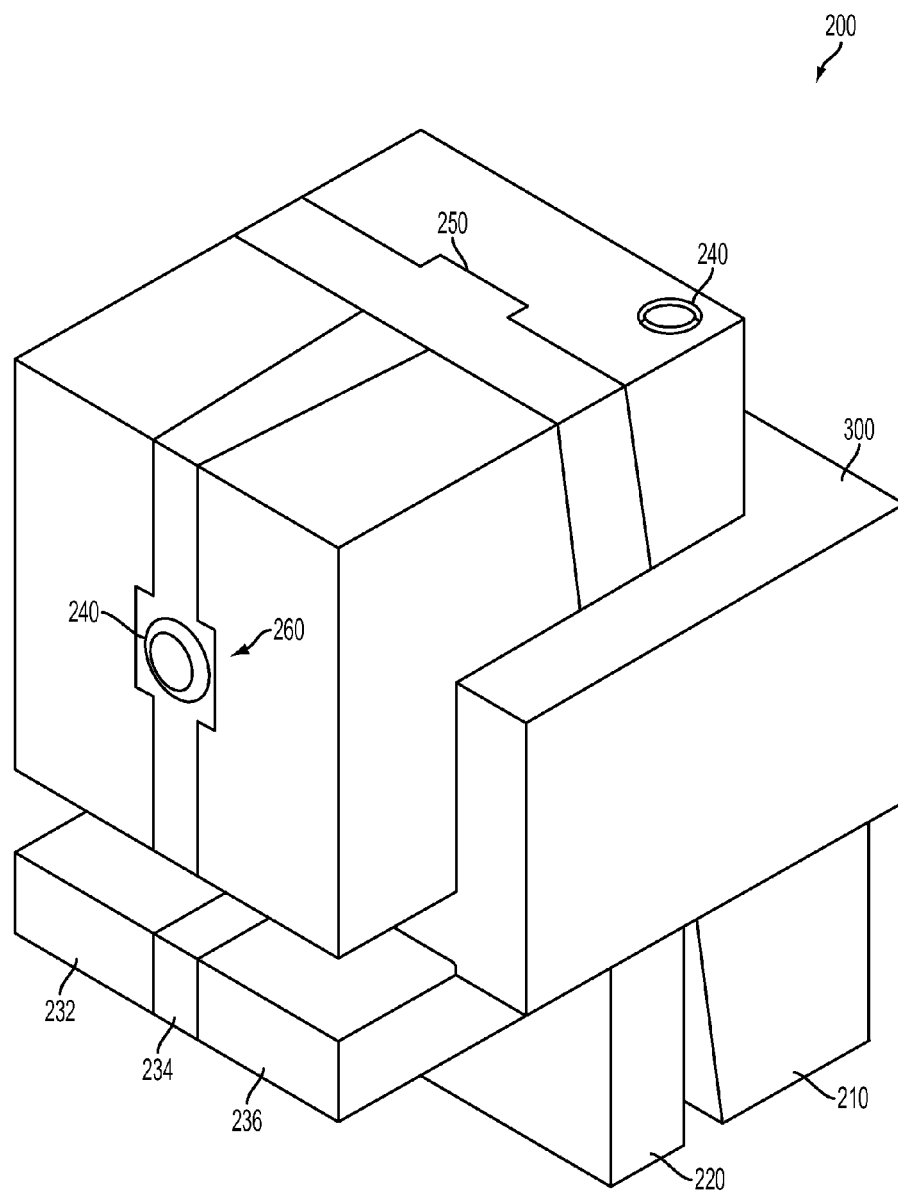


FIG. 9G

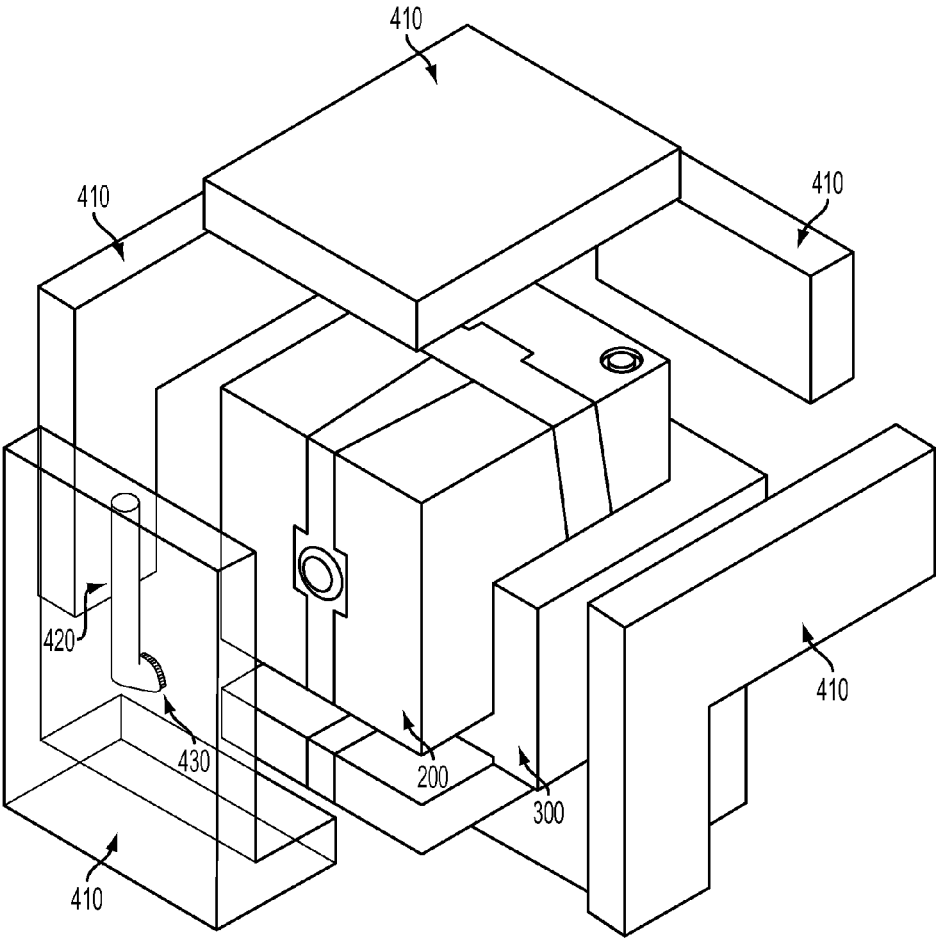


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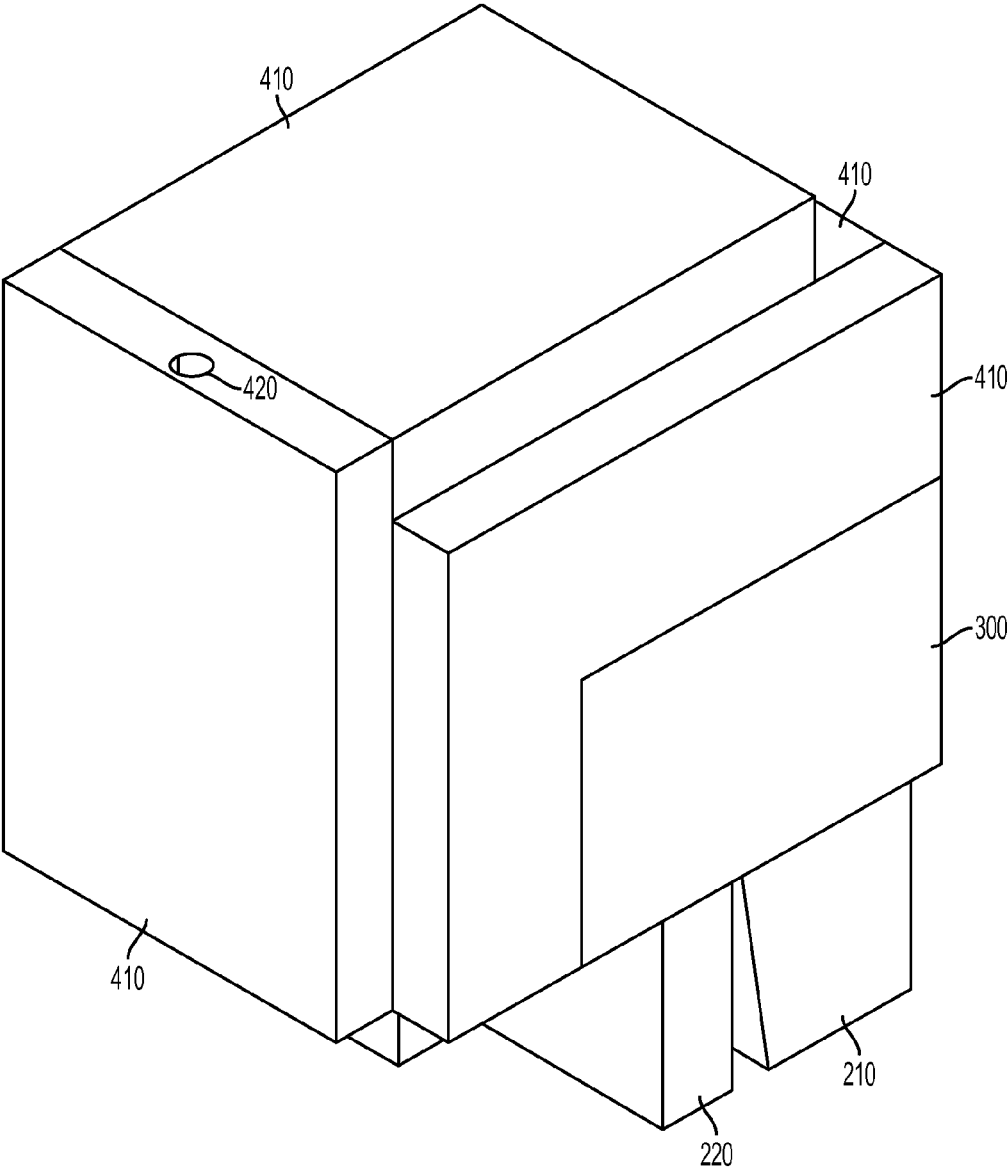


FIG. 9I

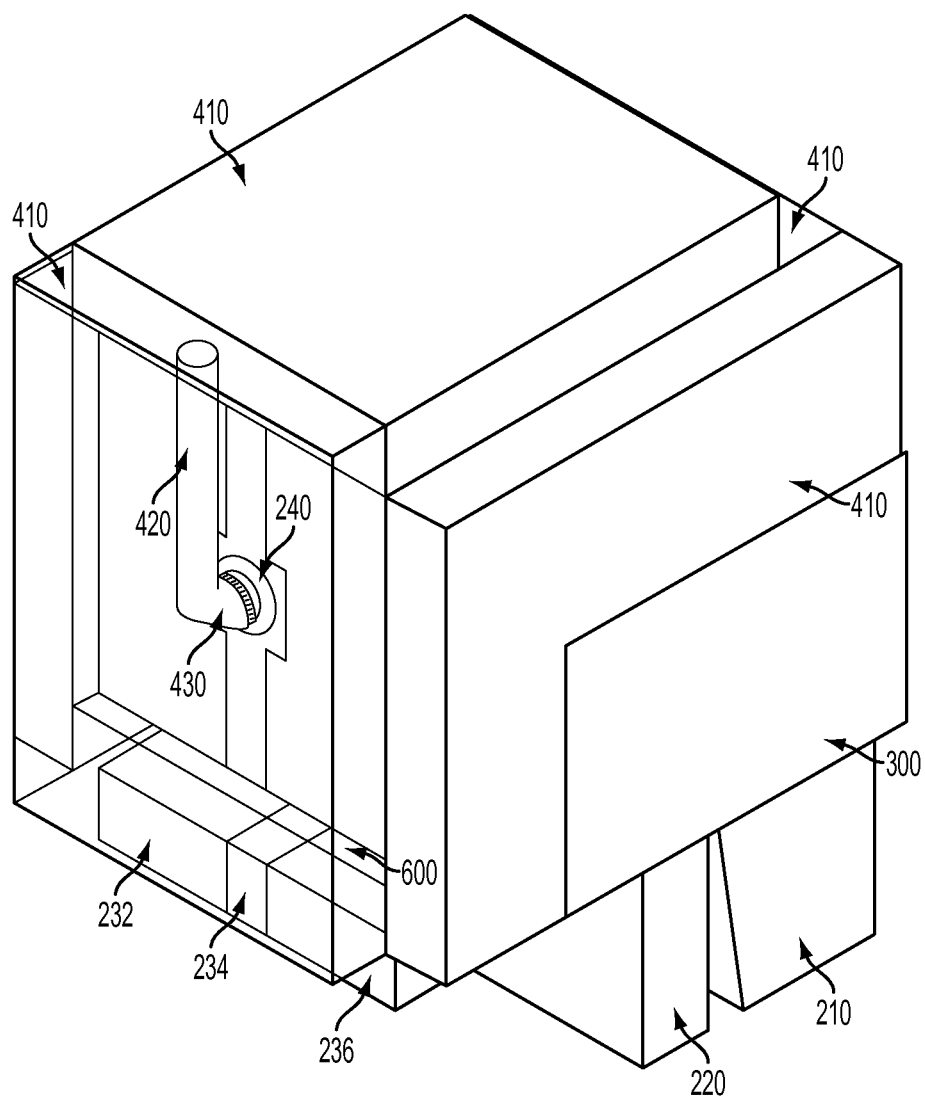


FIG. 9J

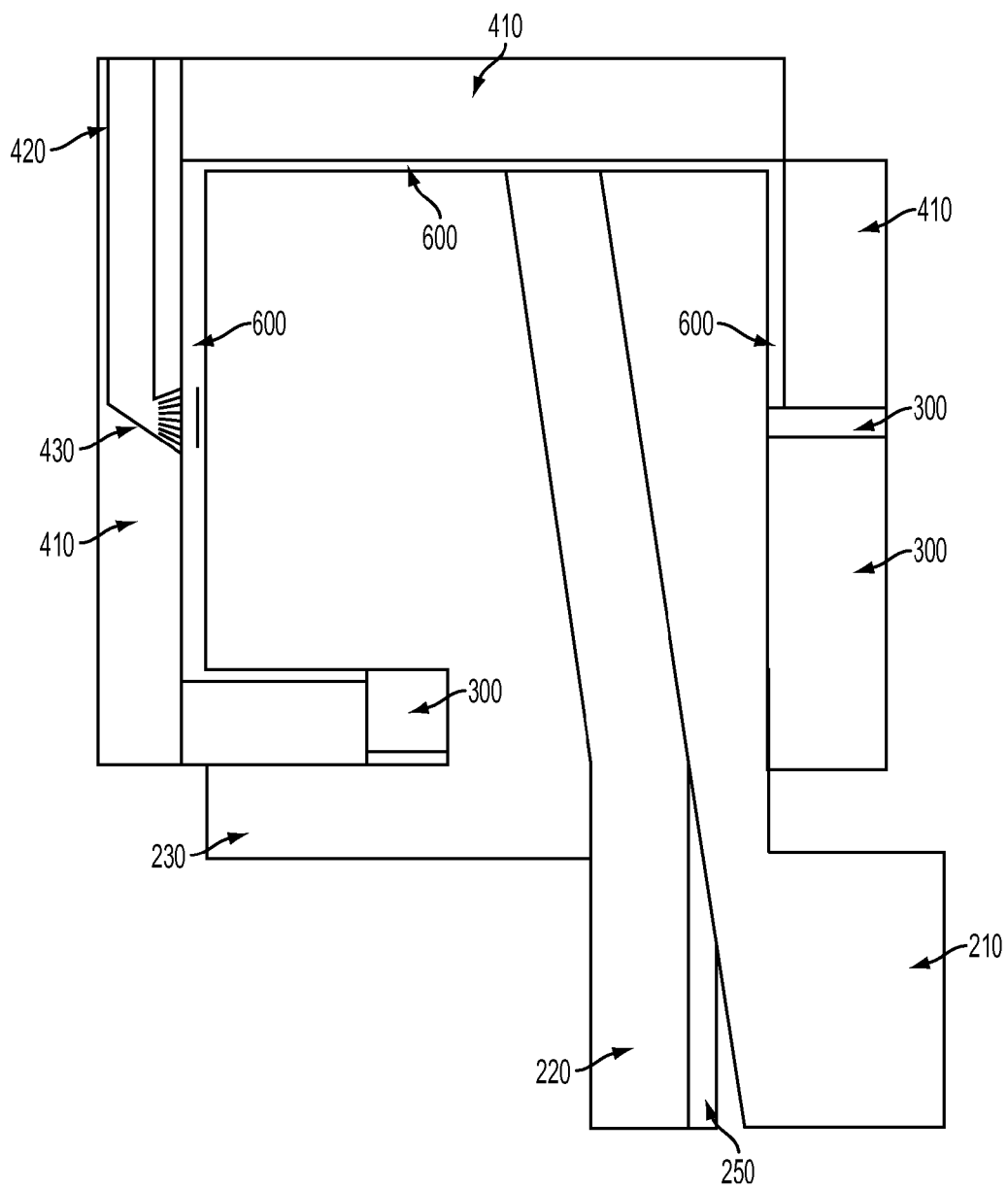


FIG. 9K



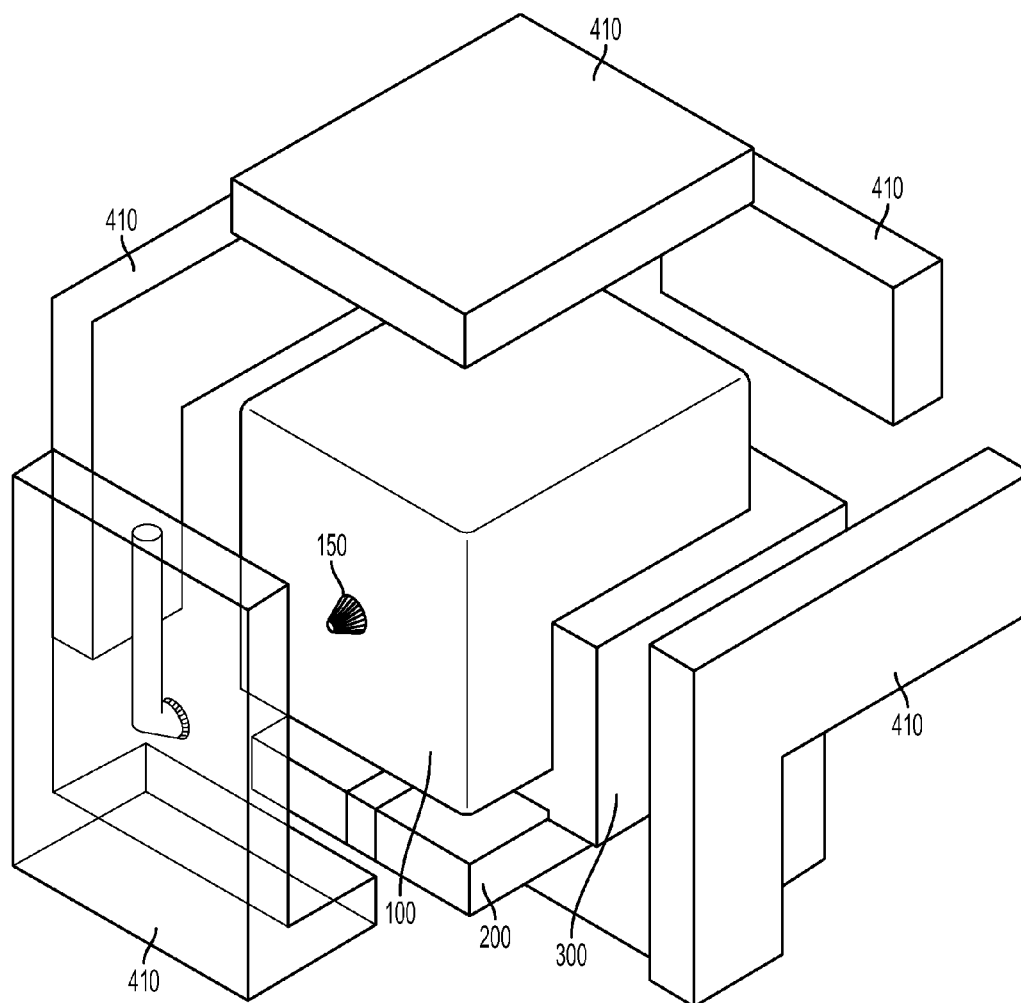


FIG. 9L

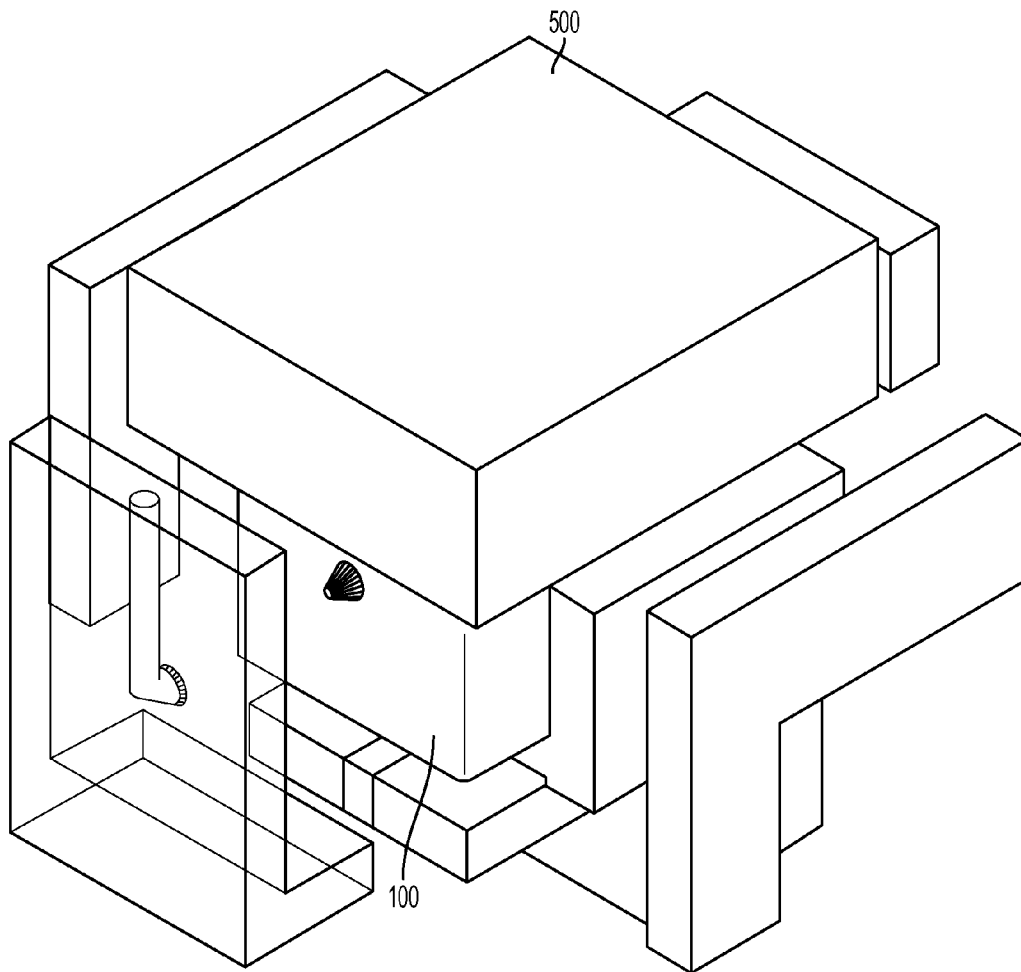


FIG. 9M

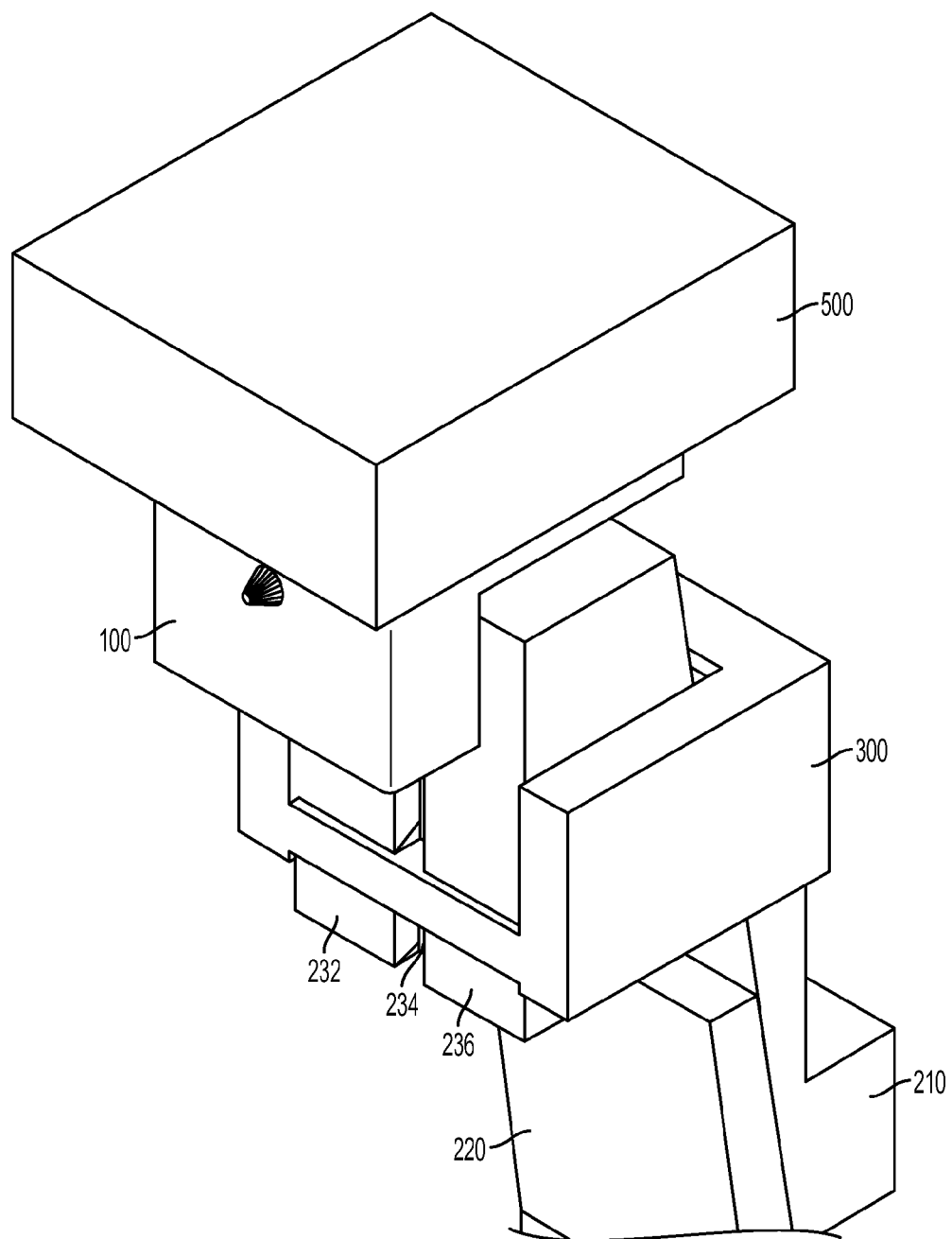


FIG. 9N

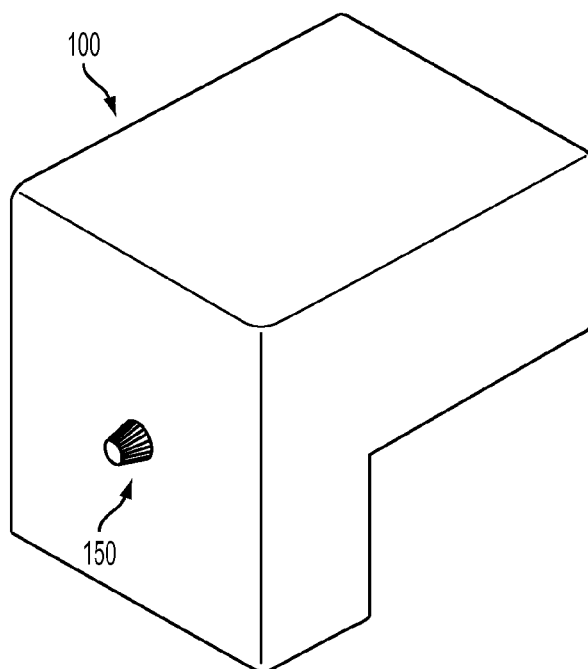


FIG. 90

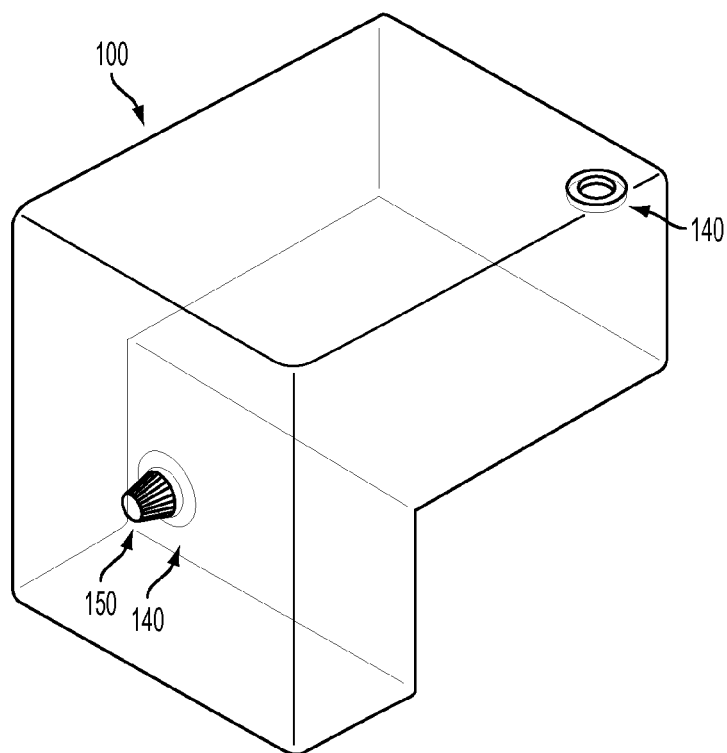


FIG. 9P

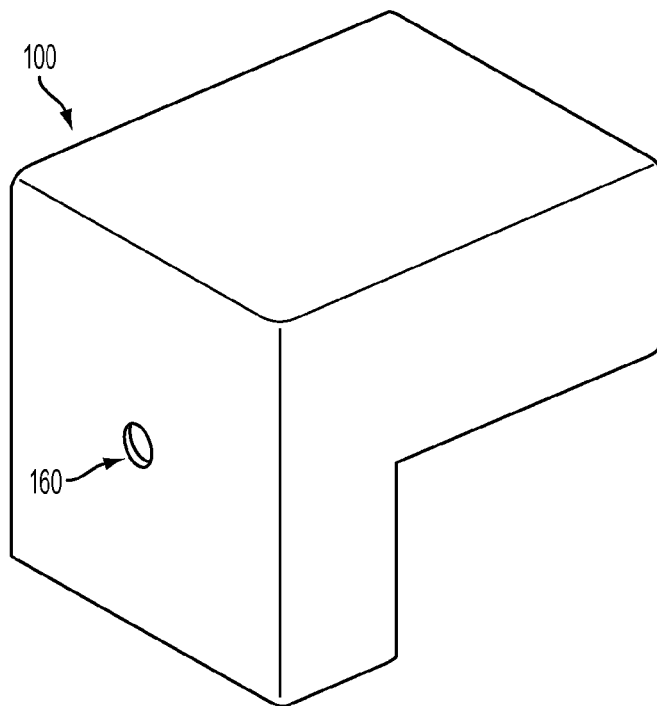


FIG. 9Q

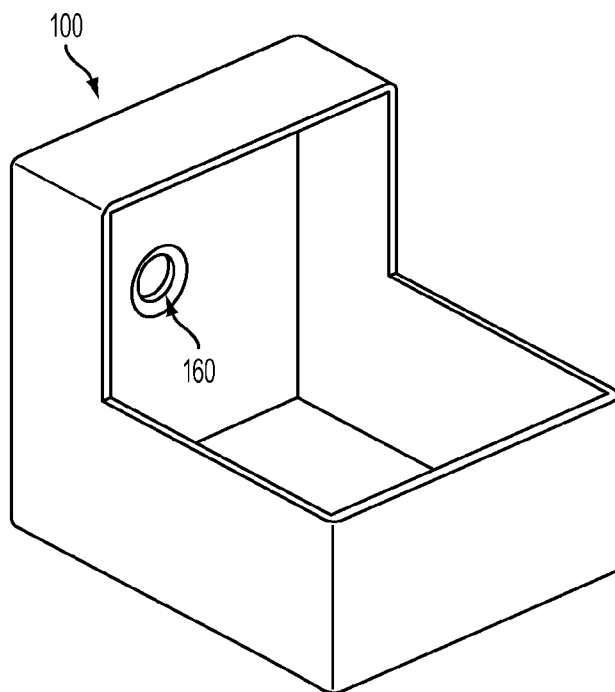


FIG. 9R

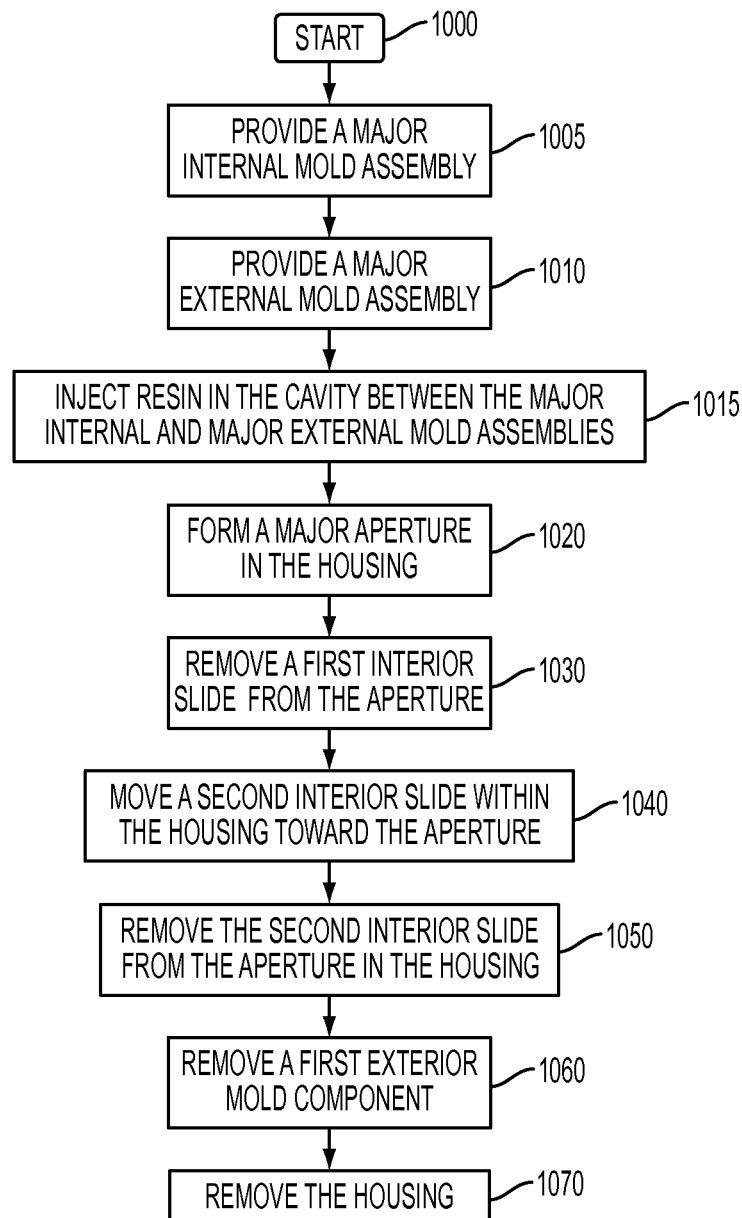


FIG. 10

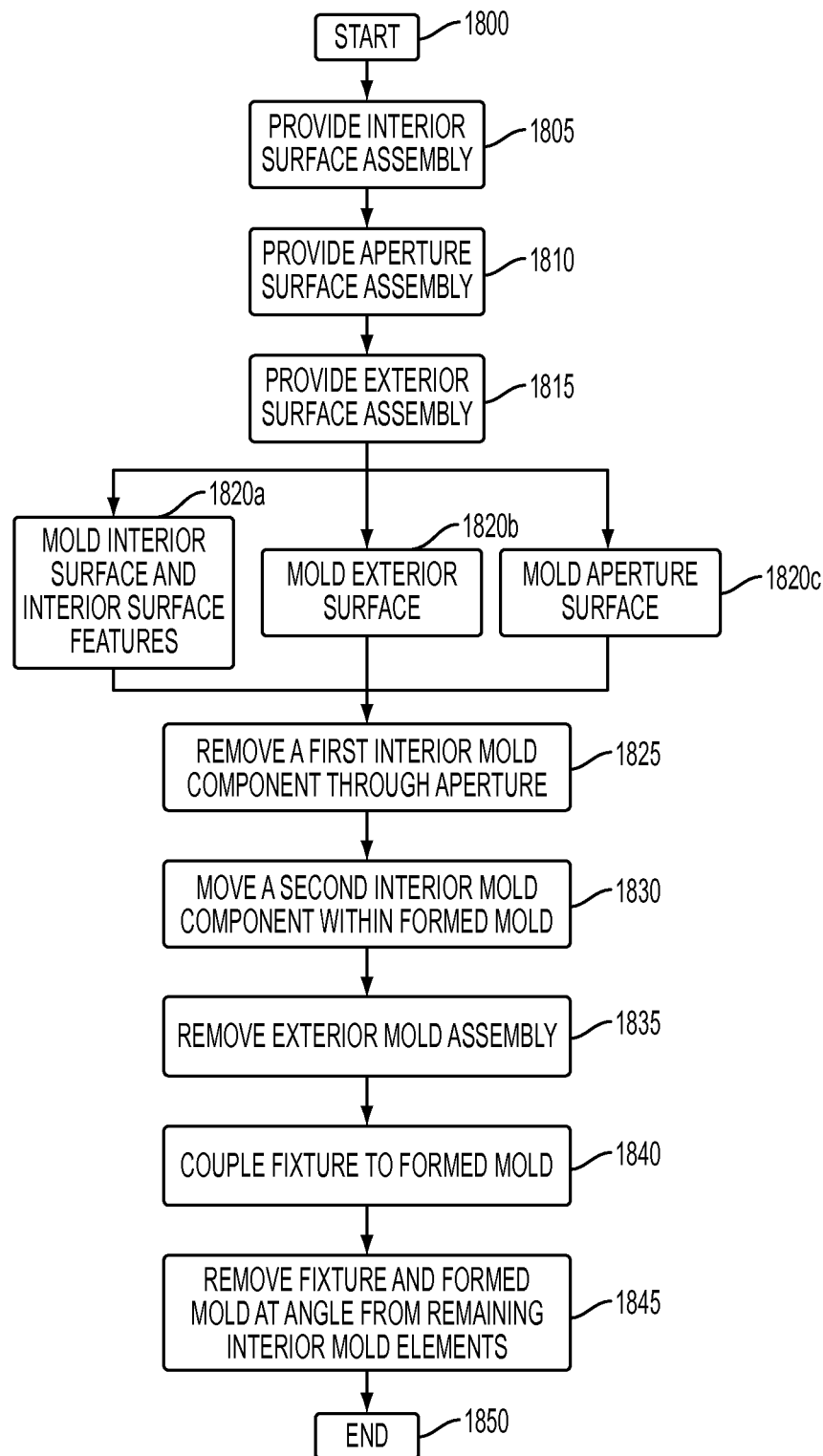


FIG. 11

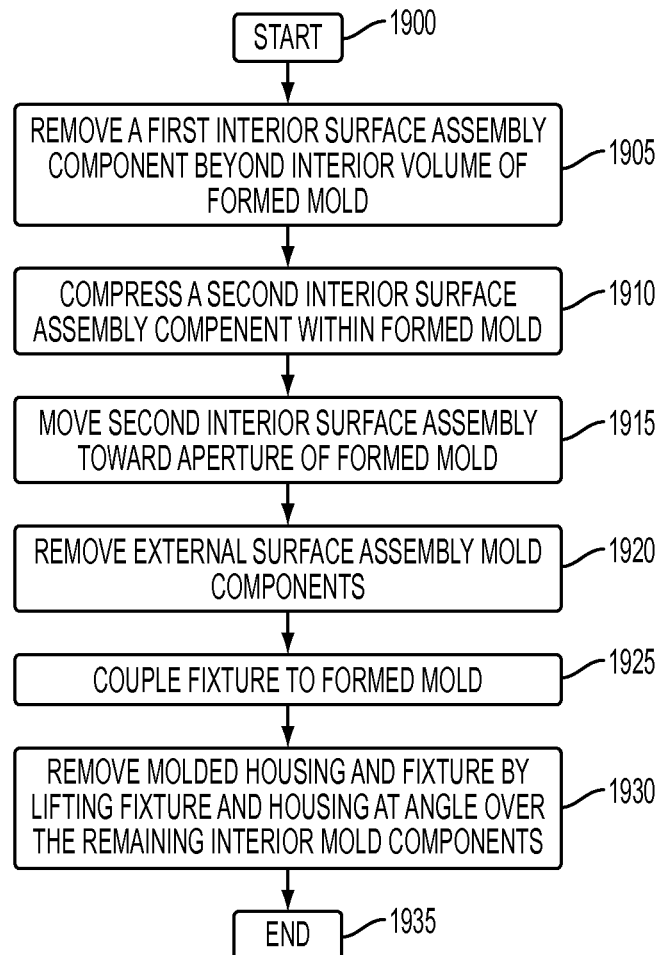


FIG. 12



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## INJECTION MOLD WITH MULTI-AXIAL CORE INSERTS

### CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority under 35 U.S.C. §119(e) to U.S. Provisional Patent Application No. 61/799,065 filed 15 Mar. 2013 and entitled "Injection Mold with Multi-Axial Core Inserts," which is incorporated by reference herein in its entirety.

### TECHNICAL FIELD

This disclosure relates generally to an injection mold for forming a unitary housing, and in particular to methods of assembling and disassembling the same, suitable for injection molding of a housing of unitary construction, the housing having internal surface features suitable for receiving electronic components.

### BACKGROUND

Housings of various forms are used to contain and protect electronic components internal to the housings. Housings may be made lightweight. Reducing the material weight of a housing often reduces strength and durability which increases the likelihood of device failure if dropped on a hard surface. Alternately, selecting lighter materials of equivalent strength may be cost prohibitive to electronic device manufacturers. Furthermore, electronic device housings are often composed of multiple components. During assembly, multiple separate components may be mechanically coupled together to form a singular housing. This process may increase both time and cost of manufacture. In addition, the mechanical coupling often becomes a structural weak point and/or an aesthetic blemish of a fully assembled device.

In one example, housings are formed in a clam shell structure. In such a process, two halves of the housing may be formed separately. After the halves are formed, the two halves of the housing are then assembled using an adhesive or similar mechanical process to hold the two halves together. As indicated above, this may be a costly additional step and the process leaves behind an unattractive seam between the two housing halves.

### SUMMARY

Systems and methods for forming a housing of unitary construction are described herein. One embodiment may take the form of, a housing for electronic components including a major interior surface that defines an interior cavity. The housing may include a major exterior surface comprising at least a first surface and a second surface. The housing may include a major aperture extending from the interior cavity through the major interior surface and major exterior surface. The major aperture may pass through a portion of the first surface and the second surface. The major aperture may extend through a portion of but not the entirety of the at least the first surface and the second surface. The housing may be a single, unitary construction formed of a rigid material of substantially uniform thickness. The housing may be formed in one injection molding step. In further embodiments, the rigid housing for electronic components also includes at least one interior surface feature of the housing member configured to couple to electronic compo-

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nents. The major aperture of the housing may have a substantially L-shaped cross section. The major aperture of the housing may also include a receiving lip around the perimeter of the major aperture. The housing may include a retention cap configured to couple to the receiving lip such that the surface of the retention cap is flush with the at least first and second face of the exterior of the housing member. The retention cap may be flush with the exposed edge of the major aperture. The housing may include a surface feature on the interior surface configured to receive a screw. This surface feature may be molded with a threaded insert member, or in other embodiments, may be molded to receive a self-tapping screw.

In accordance with various embodiments, a method for forming a rigid housing of unitary construction may include providing a major internal mold assembly. Providing the major internal mold assembly may include providing a plurality of movable interior slides in a first position for forming an interior cavity of the housing with each slide having an extraction protrusion. The method may include providing a major external mold assembly. The major external mold assembly may include providing a plurality of movable components in a first position for forming a major external surface of the housing. A cavity may be formed between the major internal mold assembly and the major external mold assembly. The cavity may be configured for injecting resin to form the housing of unitary construction. Resin may be injected in the cavity between the major internal mold assembly and the major external mold assembly. This injection may form a major internal surface and a major external surface, respectively. The formation of the surfaces forms the housing of unitary construction. The major external mold assembly may mate with the extraction protrusion of each of the plurality of movable interior slides. A major aperture may be formed in the housing of unitary construction. The aperture may pass from the interior cavity through the interior surface and the exterior surface of the housing. The major aperture may be formed around the extraction protrusions of each of the movable slides. For example, the aperture formation may be located where the major external mold assembly mates with the extraction protrusion of each of the plurality of movable interior slides. This location may be proximal to the cavity formed between the major internal mold assembly and the major external mold assembly. A first moveable interior slide may be removed through the aperture formed in the housing of unitary construction. A second moveable interior slide may be moved within the formed housing of unitary construction toward the aperture and the second moveable interior slide may be removed through the aperture formed in the housing of unitary construction. The first moveable exterior mold component may be removed. The housing of unitary construction may be removed from the tooling.

In accordance with various embodiments, a system for forming a rigid housing of unitary construction may include a major internal mold assembly comprising a plurality of movable interior slides. Each of the plurality of movable interior slides may have an extraction protrusion. The system may include a major external mold assembly having a plurality of movable components. The major internal mold assembly may be located internally to the major external mold assembly such that a housing cavity is formed between the major internal mold assembly and the major external mold assembly. The cavity may be configured to receive resin to form the housing. In response to the plurality of movable interior slides being assembled to form the major internal mold assembly the plurality of movable interior

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slides occupy at least a portion of an interior cavity within the major external mold assembly. The major external mold assembly may mate with the extraction protrusion of each of the plurality of movable interior slides. The plurality of movable interior slides may be movable within the major external mold assembly and may be configured to move out of the interior cavity. The plurality of movable interior slides may include extraction protrusions that extend out of the interior cavity and mate with an interior of the major external mold assembly. The plurality of movable interior slides may include a first slide, a second slide and a third slide, with the first and second slide engaged and the second and third slide engaged with both engagements being sufficiently tight to prevent resin from flowing between the plurality of movable interior slides. The engagement may allow for the plurality of movable interior slides to move relative to one another. The second slide may be located between the first slide and the third slide. The second slide may be sized and positioned such that it is operable to be moved out from between the first slide and the third slide. The first slide is sized and positioned such that it is operable to be moved out of the interior cavity by utilizing the space occupied by the second slide prior to the second slide's movement, while the third slide is still positioned in the interior cavity. The third slide is sized such that it is operable to be moved out of the interior cavity after the first slide and the second slide are removed.

Another embodiment may take the form of a housing, comprising: an injection-molded body defining a cavity therein; an aperture passing through the injection-molded body; wherein the largest cross-section of the interior cavity is larger than the largest cross-section of the aperture; and the injection-molded body is unitary.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A illustrates a parallel projection view of an example housing of unitary construction.

FIG. 1B illustrates a rear view of an example housing of unitary construction.

FIG. 1C illustrates a side view of an example housing of unitary construction.

FIG. 1D illustrates a parallel projection view of an example housing of unitary construction illustrating an electric component inserted through an aperture in the housing.

FIG. 1E illustrates a parallel projection view of an example housing of unitary construction.

FIG. 1F illustrates a parallel projection view of an example housing of unitary construction.

FIG. 1G illustrates a parallel projection view of an example housing of unitary construction.

FIG. 2 is a parallel projection view of an example housing of unitary construction.

FIG. 3 is a parallel projection view of an example housing of unitary construction, where an interior surface feature can be seen through a major aperture of the housing.

FIG. 4 is a parallel projection view of an example housing of unitary construction, where an interior surface feature can be seen through a major aperture of the housing.

FIG. 5A illustrates a side view of an example housing of unitary construction with an example tooling insert extending therefrom.

FIG. 5B illustrates a bottom view of the example housing of FIG. 5A.

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FIG. 5C illustrates a cross section side view of an example housing of unitary construction with an example tooling insert extending therefrom.

FIG. 5D illustrates a cross section side view of an example housing of unitary construction with an example tooling insert extending therefrom.

FIG. 5E illustrates a cross section side view of an example housing of unitary construction with an example tooling insert extending therefrom.

FIG. 5F illustrates a cross section side view of an example housing of unitary construction with an example tooling insert extending therefrom.

FIG. 5G illustrates a cross section side view of an example housing of unitary construction with an example tooling insert extending therefrom.

FIG. 5H illustrates a parallel projection view of an example housing of unitary construction with an example tooling insert extending therefrom.

FIG. 5I illustrates a cross section side view of an example housing of unitary construction with an example tooling insert extending therefrom.

FIG. 6A illustrates a side view of an example housing of unitary construction with an example tooling insert extending therefrom.

FIG. 6B illustrates a cross section side view of an example housing of unitary construction with an example tooling insert extending therefrom.

FIG. 7A illustrates a parallel projection view of an example injection molding tool for forming a housing of unitary construction.

FIG. 7B illustrates a parallel projection view of an example top section of an injection molding tool for forming a housing of unitary construction.

FIG. 7C illustrates a parallel projection view of an example bottom section of an injection molding tool for forming a housing of unitary construction.

FIG. 7D illustrates a side cross section view of an example injection molding tool for forming a housing of unitary construction as viewed from section B-B in FIG. 7A.

FIG. 7E illustrates a side cross section view of an example injection molding tool for forming a housing of unitary construction as viewed from section B-B in FIG. 7A.

FIG. 7F illustrates a side cross section view of an example injection molding tool for forming a housing of unitary construction as viewed from section B-B in FIG. 7A.

FIG. 7G illustrates a side cross section view of an example injection molding tool for forming a housing of unitary construction as viewed from section B-B in FIG. 7A.

FIG. 7H illustrates a side cross section view of an example injection molding tool for forming a housing of unitary construction as viewed from section B-B in FIG. 7A.

FIG. 7I illustrates a side cross section view of an example injection molding tool for forming a housing of unitary construction as viewed from section B-B in FIG. 7A.

FIG. 8A illustrates parallel projection view of a portion of an example injection molding tool for forming a housing of unitary construction.

FIG. 8B illustrates parallel projection view of a portion of an example injection molding tool for forming a housing of unitary construction in accordance with the cross sections of FIG. 8C-J.

FIG. 8C illustrates a side cross section view of an example injection molding tool for forming a housing of unitary construction as viewed from a section C-C in FIG. 8B.

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FIG. 8D illustrates an alternative side cross section view of an example injection molding tool for forming a housing of unitary construction as viewed from a section C-C in FIG. 8B.

FIG. 8E illustrates an alternative side cross section view of an example injection molding tool for forming a housing of unitary construction as viewed from a section C-C in FIG. 8B.

FIG. 8F illustrates an alternative side cross section view of an example injection molding tool for forming a housing of unitary construction as viewed from a section C-C in FIG. 8B.

FIG. 8G illustrates an alternative side cross section view of an example injection molding tool for forming a housing of unitary construction as viewed from a section C-C in FIG. 8B.

FIG. 8H illustrates a sectional parallel projection view of an example injection molding tool for forming a housing of unitary construction.

FIG. 8I illustrates an alternative side cross section view of an example injection molding tool for forming a housing of unitary construction as viewed from a section D-D in FIG. 8G.

FIG. 8J illustrates an alternative side cross section view of an example injection molding tool for forming a housing of unitary construction as viewed from a section D-D in FIG. 8G.

FIG. 8K illustrates a top view of a portion of an example injection molding tool for forming a housing of unitary construction highlighting the removal of inserts.

FIG. 8L illustrates a parallel projection view of a portion of an example injection molding tool for forming a housing of unitary construction.

FIG. 8M illustrates a parallel projection view of a portion of an example injection molding tool for forming a housing of unitary construction.

FIG. 9A illustrates a parallel projection view of an example of the movable components of an interior mold for a housing of unitary construction.

FIG. 9B illustrates a parallel projection view of an example of the movable components of an interior mold for a housing of unitary construction after a second component has been moved into a second position.

FIG. 9C illustrates a parallel projection view of an example of the movable components of an interior mold for a housing of unitary construction after a first and second component have been moved into a second position.

FIG. 9D illustrates a parallel projection view of an example of the movable components of an interior mold for a housing of unitary construction after a first and second component have been moved into a second position and a second minor component of the third major component has been moved into a second position, causing first and third minor components to compress.

FIG. 9E illustrates parallel projection views of an example of an aperture mold assembly with a semitransparent molded housing overlay.

FIG. 9F illustrates parallel projection views of an example of an aperture mold assembly with a semitransparent molded housing overlay.

FIG. 9G illustrates a parallel projection view of an example of the movable components of an interior mold for a housing of unitary construction when assembled through an aperture mold assembly in a first position.

FIG. 9H illustrates a parallel projection view of an example of the movable components of an interior mold for a housing of unitary construction when assembled through

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an aperture mold assembly in a first position, where movable external mold components are ready to be assembled around the interior mold.

FIG. 9I illustrates a parallel projection view of an example of the movable components of an interior mold for a housing of unitary construction when assembled through an aperture mold assembly in a first position, where movable external mold components are assembled around the interior mold.

FIG. 9J illustrates a parallel projection view of an example of the movable components of an interior mold for a housing of unitary construction when assembled through an aperture mold assembly in a first position, where movable external mold components are assembled around the interior mold and a portion of the external mold is illustratively transparent to reveal both a runner and a gate for an injection molding process.

FIG. 9K illustrates a cross section view of FIG. 12a.

FIG. 9L illustrates a parallel projection view of an example of a completed mold formed around the movable components of an interior mold for a housing of unitary construction when assembled through an aperture mold assembly in a first position, where movable external mold components are separated from the exterior surface of the formed mold.

FIG. 9M illustrates a parallel projection view of an example of a completed mold formed around the movable components of an interior mold for a housing of unitary construction when assembled through an aperture mold assembly in a first position, where movable external mold components are separated from the exterior surface of the formed mold and a fixture has been coupled to the formed mold.

FIG. 9N illustrates a parallel projection view of an example of a fixture coupled to a formed mold being removed at an angle over a third major internal component of the mold, with the first and second internal mold components removed.

FIG. 9O illustrates a parallel projection view of an example of a housing of unitary construction with injection molding gate residue visible.

FIG. 9P illustrates a parallel projection view of an example of a housing of unitary construction with injection molding gate residue visible.

FIG. 9Q illustrates a parallel projection view of an example of a housing of unitary construction after gate residue has been removed and a minor aperture has been opened in the housing.

FIG. 9R illustrates a parallel projection view of an example of a housing of unitary construction after gate residue has been removed and a minor aperture has been opened in the housing.

FIG. 10 illustrates a flow chart of an example process for forming a housing of unitary construction.

FIG. 11 illustrates a flow chart of an example process for forming a housing of unitary construction.

FIG. 12 illustrates a flow chart of an example process for disassembling a mold of unitary construction.

## DETAILED DESCRIPTION

### Introduction

Numerous consumer and non-consumer devices utilize housings to contain electronic components. As discussed herein and in accordance with various embodiments, a tooling system may be utilized in order to form a unitary housing structure that may house these various electronic components or serve similar purposes.

More particularly, an injection molding system may include a cavity that is configured to receive a plurality of internal slides. The cavity may be defined by one or more external tooling sections that cooperate to form the cavity (collectively, a “major exterior mold assembly”). The plurality of internal slides may form a major internal mold assembly and generally cooperate to define a cavity within a finished unitary housing structure, as well as an aperture through the unitary housing structure to provide access to this cavity. In accordance with various embodiments, the housing of unitary construction may be molded with a major internal mold assembly and a major exterior mold assembly meeting in a first position to form a cavity.

A resin may be injected into the cavity to form the unitary housing structure (or “housing”). To facilitate efficient removal of a molded housing, the major internal mold assembly and the major exterior mold assembly may be selectively movable and disassemblable. In various embodiments, a portion of the internal mold assembly may be removed from the interior cavity before the molded part is removed for further manufacturing processing. The major internal mold assembly may form an interior cavity of the unitary housing during the injection molding process. The major internal mold assembly may also form an exterior aperture in the unitary housing. After the molding process, the major internal mold assembly may be removed through the exterior aperture in the unitary housing. As discussed herein, the major internal mold assembly may have a larger cross section than the cross section of the exterior aperture in the housing.

#### Unitary Housings

Additionally, examples and embodiments described herein relate to geometries of housings of unitary construction that are more efficient to manufacture. Housings of unitary construction generally may have internal surface features intentionally placed for coupling to, and securing, electronic components to be inserted therein in a later product assembly process. The later assembly processes often involve the polishing away of undesirable flash, removing by a secondary process (e.g. CNC machining) excess gate or runner material left behind by the injection molding process, and creating minor apertures through the housing by similar or the same secondary processes.

The minor apertures in the housing may be configured to pass light through the housing from, for example, light emitted by the housed electronic components and that is to be viewed external to the housing. In various embodiments, the minor apertures in the housing may be configured to pass audio produced by the housed electronic components through the housing such that it may be better heard outside the housing. In various embodiments, the minor apertures in the housing may be configured to allow access to the housed electronic components, for example, access to a reset or power button is available external to the housing. In various embodiments, the minor apertures in the housing may be configured such that the housing, in a later process, can be coupled to an additional part.

Each of these operations, especially the processing of additional minor apertures, may add cost or delay to the manufacturing of each housing. Accordingly, various benefits may be achieved by co-locating internal surface features of the housing with the gates from the injection molding process such that the gates may be removed in the same process in which the minor apertures are later opened. In other embodiments, some internal surface features may be co-located with gates from the injection molding process in

order to provide additional structural integrity around locations where apertures will be later opened.

A “unitary structure,” as described herein, refers to a housing in which the exterior surfaces are contiguous (e.g., are not separate but mechanically attached to one another to form a surface or component). A unitary structure may also be formed in a single manufacturing process. The housing of unitary construction may be formed, in certain embodiments, in a single injection molding process. In one example, the formation of the exterior surfaces may include the formation of the entire exterior surfaces of the molded housing. The entire exterior surface of a housing may not include caps or other features utilized to fill various apertures. The caps or other features may however constitute additional surfaces and not mechanical extensions or seams in the same surface. In another example, the formation of the exterior surfaces may include the formation of at least a portion of all of the exterior surfaces of the housing. For example, a box may have six sides. The box may have an aperture through one or more of the sides. The aperture may make one or more of the sides incomplete preventing the box from being enclosed. The six sides may be formed in the injection molding process. In various embodiments, the six sides may be seamless. The six sides may be contiguous with no mechanical attachments utilized to form the six sides. The six sides may all be formed at the same time in the same tool in a contiguous manner.

For example, FIGS. 1-4 illustrate an example housing of unitary construction. In accordance with various embodiments and as illustrated in FIGS. 1a-c, the housing may include a top surface **115a**, a front surface **115b**, a bottom surface **115c**, a back surface **115d**, a left surface **115e**, or a right surface **115f**. In accordance with various embodiments, as illustrated in FIG. 2, the housing **100** may include a major exterior surface **110** and a major aperture **130** which provides a location through which major internal mold assemblies may be inserted and removed during molding. The interior volume of the housing **100** may be visible through aperture **130**. The interior volume may be defined by the walls defined by a major internal surface **120** and the major exterior surface **110**. The housing **100** may be constructed of any material suitable for injection molding. For example, the housing may be made of a rigid material not subject to substantial deformation.

In accordance with various embodiments, as discussed above and illustrated in FIGS. 1-4, the housing may include one or more apertures. For example, a minor aperture **160** may pass through at least one surface such as left surface **115e**. In various embodiments, at least one aperture may pass through more than one surface. A major aperture **130** may pass through **115a**, **115b**, **115f** and **115d** forming an aperture surface **117**. By having the aperture in several surfaces but by leaving at least a portion of each of those surfaces, the housing may have a unitary construction. In accordance with various embodiments, as illustrated in FIGS. 1-4, the housing does not have seams where multiple portions of the housing are assembled to create the completed housing with surfaces **115a-g**. The housing may be a contiguous structure without the use of adhesives or mechanical attachments to connect portions of any of the walls **115a-g**.

The major aperture **130** may extend from a major interior surface **120** through the housing **100** to the exterior surface **110** through at least two faces **115a** and **115b** of the exterior surface. By extending through at least more than one face of the exterior surface, the perimeter of the major aperture may be defined by an area parallel to the first face **115a** and an

area parallel to the second face **115b**. The cross sectional opening of the major aperture **130** may be larger than the cross sectional of the largest slide utilized to form a portion of the interior cavity. The cross sectional opening may be smaller than the cross sectional of the largest slide combined with the cross section of the narrowest portion of any other additional slide utilized to form at least a portion of the interior cavity.

As illustrated in FIGS. **1d-g**, the housing **100** may be configured to receive and contain electronic components **180**. In various embodiments, electronic components **180** may be inserted through the major aperture **130** into the housing **100**. As such, the major aperture **130** may have a suitable cross section entrance to receive the electronic components **180**. The electronic components **180** may be inserted into the housing **100** in one or more sections. For example, a first electronic component may be inserted and then a second electronic component may be inserted connecting to the first electronic component.

As illustrated in FIGS. **1A**, **1E**, and **1G**, the housing **100** may include a retention cap **170**. The retention cap **170** having first and second exterior cap surfaces **172a** and **172b** that intersect at an elbow **174**. The retention cap **170** may mate with a receiving lip **119** formed around major aperture **130**. In this structure; the retention cap **170** may mount flush with the aperture surface **117**. Once mounted, the retention cap **170** may close the major aperture **130** and contain the electronic components **180** inside of the housing **100**. Thus, the retention cap **170** may be configured as an electronics retention cap. The retention cap **170** includes a protrusion **176** that extends outward from the first exterior cap surface **172a** and a minor aperture **178** that extends through the second exterior cap surface **172b** to the interior cavity. The housing is illustrated as being transparent in FIGS. **1D**, **1F** and **1G** for purposes of clarity, although the housing is not necessarily transparent in any embodiment.

As illustrated in FIG. **3**, the housing may have an interior surface **120**. Interior surface **120** may include interior surfaces which correspond to the opposing wall surfaces of **115a-f**. For example, interior surface **120** may comprise interior back surface **125d** (corresponding to back surface **115d**) and interior bottom surface **125c** (corresponding to bottom surface **115c**). Interior surface **120** may also comprise interior feature **140**. Interior surface feature **140** may be located on or through the bottom surface **125c**, as can be seen through the major aperture **130** of the housing in FIG. **3**. As illustrated in FIG. **4**, the housing **100** may comprise an additional interior surface feature **140**. For example, the additional interior surface feature can be seen through a major aperture **130** of the housing **100**.

In accordance with one embodiment, as illustrated in FIGS. **5-8** a tooling apparatus may be operable to assemble and separate inside of a molded part allowing the tool to form an internal cavity that is larger than the aperture through which the internal mold assembly is inserted. This internal mold assembly may include a relatively small number of moving parts, for example three. The system may include a major external mold assembly and a major internal mold assembly that are assembled together in a first position to form the cavity with the geometric features of the housing **100**.

#### Mold Assembly with Internal Slides

As illustrated in FIGS. **5A-5D**, a major internal mold assembly may include a plurality of tooling slides for the formation of the interior cavity of the housing **100**. The plurality of tooling slides may be independently and selectively movable relative to one another. The major internal

mold assembly may include a first major interior slide **310**, a second major interior slide **320**, and a third major interior slide **330**. The major internal mold assembly may extend from major aperture **130** after forming the housing **100**.

As illustrated in FIG. **5B**, the first major interior slide **310**, the second major interior slide **320**, and the third major interior slide **330** may extend through the aperture at the same time and engage one another, although they may enter or exit the aperture at different times. In accordance with various embodiments, the second major interior slide **320** may engage the first major interior slide **310** through a first engagement feature **327**. The second major interior slide **320** may engage the third major interior slide **330** through a second engagement feature **329**. The engagement may be any process or feature for engaging two movable tooling slides. For example, as illustrated in FIG. **5B** the engagement features may include dovetail connections with an engagement groove and an engagement protrusion. It may be noted that each of the first major interior slide **310**, the second major interior slide **320**, and the third major interior slide **330** may include a receiving feature, a protruding feature or any combination of the same, and so are not limited to dovetail connections.

In accordance with various embodiments, the major internal mold assembly may be configured to be removed from the interior of the housing **100** after the housing **100** has been molded. This may be accomplished by removing each interior slide that make up the major internal mold assembly one at a time (or substantially removing them one at a time). For example, as illustrated in FIG. **5C** and discussed above, the first major interior slide **310**, the second major interior slide **320** and the third major interior slide **330** may be independently movable. The second major interior slide **320** may be moved relative to the first major interior slide **310** and the third major interior slide **330** laterally. For example, FIG. **5C** illustrates arrow **1** which may represent the order and path of travel of the second major interior slide **320** relative to the first major interior slide **310** and the third major interior slide **330**. Arrow **1** of FIG. **5C** may represent a second position of the major internal mold assembly. Arrow **2** may represent the order and path of travel of the third major interior slide **330** relative to the first major interior slide **310** and the second major interior slide **320**. Arrow **2** of FIG. **5C** may represent a third position of the major internal mold assembly. Arrow **3** may represent the order and path of travel of the first major interior slide **310** relative to the second major interior slide **320** and the third major interior slide **330**. Arrow **3** of FIG. **5C** may represent a fourth position of the major internal mold assembly.

As illustrated in FIG. **5D**, the major internal mold assembly may be positioned within the housing **100** after the housing **100** has been molded. Portions of the major internal mold assembly may protrude from the housing **100** through the major aperture **130**. The portions of the major internal mold assembly that may protrude from the housing **100** may be utilized to extract each of the plurality of tooling slides from the housing **100** after molding is complete. For example, the first major interior slide **310** may include a first extraction protrusion **315**. The first extraction protrusion **315** may be located outside of the molded housing **100** and within the injection tooling system. The first extraction protrusion **315** may be configured to receive a mechanical force to extract the first major interior slide **310** from within the molded housing **100**. The second major interior slide **320** may include a second extraction protrusion **325**. The second extraction protrusion **325** may be located outside of the molded housing **100** and within the injection tooling system.

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The second extraction protrusion **325** may be configured to receive a mechanical force to extract the second major interior slide **320** from within the molded housing **100**. The third major interior slide **330** may include a third major extraction protrusion **335**. The third extraction protrusion **335** may be located outside of the molded housing **100** and within the injection tooling system. The third extraction protrusion **335** may be configured to receive a mechanical force to extract the third major interior slide **330** from within the molded housing **100**.

As illustrated in FIG. 5E, the second major interior slide **320** may be configured to move relative to the first major interior slide **310** and the third major interior slide **330** opening a space within housing **100** between the first major interior slide **310** and the third major interior slide **330**. The second major interior slide **320** may include various features that allows it to form a portion of the housing **100**. For example, the second major interior slide **320** may include a front surface and a back surface. For example, a front surface **321** may form the front interior wall of housing **100**. The back surface (on the opposite side of front surface **321** on the second major interior slide **320**) may form a portion of the back interior wall **125d** of housing **100**. Additionally, a first surface **134** may form a portion of an interior wall of housing **100**, a second surface **138** may form a portion of a second interior wall of housing **100**, and a transition point **136** may form a transition between the first surface **134** and the second surface **138** to form a transition within housing **100**. The second major interior slide **320** may include various features that allow it to engage with and move relative to the first major interior slide **310** and the third major interior slide **330**. For example, the second major interior slide **320** may include engagement groove **132**, (this engagement feature may also be an engagement protrusion in accordance with various embodiments). For example, the second major interior slide **320** may include engagement protrusion **139** (this engagement feature may also be an engagement groove in accordance with various embodiments).

As illustrated in FIG. 5F, the first major interior slide **310** may be configured to move relative to the third major interior slide **330** opening additional space within housing **100**. The first major interior slide **310** may include various features that allow it to form a portion of the housing **100**. For example, a front surface **311** may form the front interior wall of housing **100**. The back surface (on the opposite side of front surface **311** on the first major interior slide **310**) may form a portion of the back interior wall **125d** of housing **100**. Additionally, a first surface **312** may form a portion of an interior wall of housing **100**, a second surface **316** may form a portion of a second interior wall of housing **100**, and a transition point **314** may form a transition between the first surface **312** and the second surface **316** to form a corresponding transition within housing **100**. The first major interior slide **310** may include various features that allow it to engage with and move relative to the second major interior slide **320**. For example, the first major interior slide **310** may include engagement protrusion **318** (this engagement feature may also be an engagement groove in accordance with various embodiments).

As illustrated in FIG. 5G, the third major interior slide **330** may be configured to move out of the housing **100** major aperture **130**. The third major interior slide **330** may occupy the entirety of the cross section of the major aperture **130** indicated by arrows W in FIG. 5G. This geometry of the third major interior slide **330** may be greater than either of the second major interior slide **320** or the first major interior

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slide **310**. The first major interior slide **310** may have a maximum width illustrated by arrow Y (as illustrated in FIG. 5G). This width may be less than the width W minus the width of the portion of the third interior slide **330** that occupies the major aperture **130** while the third interior slide **330** is seated in the cavity as it would be during the injection molding process. (i.e. the first position discussed above) The second major interior slide **320** may have a maximum width illustrated by arrow Z (as illustrated in FIG. 5G). This width may be approximately the width of W minus the width of the portions of the third interior slide **330** and the first interior slide **310** that occupy the major aperture **130** while the third interior slide **330** and the first interior slide **310** is seated in the cavity as they would be during the injection molding process. (i.e. the first position discussed above) Stated another way, the first major interior slide **310** is sized and positioned such that it is operable to be moved out of the interior cavity while the third major interior slide **330** is still positioned in the interior cavity, wherein the third major interior slide **330** is sized such that it is operable to be moved out of the interior cavity after the first major interior slide **310** and the second major interior slide **320** are removed. In various embodiments, the procedure of removing the first major interior slide **310** and the third slide may be interchangeable. For example, the size of the third major interior slide **330** could not be maximized (reducing the resulting size of the cavity it can form in the injection molding process) but instead having the first major interior slide **310** and the third major interior slide **330** the same size such that after the second major interior slide **320** is removed either the first major interior slide **310** or the third major interior slide **330** can be removed next.

In accordance with various embodiments, the first major interior slide **310**, the second major interior slide **320** and the third major interior slide **330** together form the interior cavity of housing **100**. The first major interior slide **310** and the third major interior slide **330** may form the corners of the housing where the exterior surfaces **115a/e c/f** meet. The width of the first major interior slide **310** (expressed by X) and the third major interior slide **330** may be less than distance W. As such the distance from the aperture to the corners formed by the intersection of the bottom surface **115c** and right surface **115f** (shown as line X in FIG. 5G) and the corner formed by intersection of the top surface **115a** and the left surface **115e** may be less than the major aperture opening. In various embodiments, one of the corners formed (e.g. either **115a** and **115e** or **115c** and **115f**) may be approximately the same as the cross section distance of major aperture **130** (i.e. width was illustrated in FIG. 5G).

In accordance with various embodiments, the third major interior slide **330** may include various features that allow it to form a portion of the housing **100**. For example, a front surface **331** may form the front interior wall of housing **100**. The back surface (on the opposite side of front surface **331** on the third major interior slide **330**) may form a portion of the back interior wall **125d** of housing **100**. Additionally, a first surface **332** may form a portion of an interior wall of housing **100**, a second surface **336** may form a portion of a second interior wall of housing **100**, and a transition point **334** may form a transition between the first surface **332** and the second surface **336** to form a corresponding transition within housing **100**. The third major interior slide **330** may include various features that allow it to engage with and move relative to the second major interior slide **320**. For example, the third major interior slide **330** may include

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engagement groove 338 (this engagement feature may also be an engagement protrusion in accordance with various embodiments).

In accordance with various embodiments, the major interior slides 310, 320, and 330 may be retained by a ring 307 as illustrated in FIG. 5H and FIG. 5I. Ring 302 may be located in a position suitable to form 117 in the housing. A first ring surface 308 may form a portion of the aperture surface 117 and a second ring surface 309 may form another portion of the aperture surface 117. The ring 307 may also be sized sufficient to compress the major interior slides 310, 320, and 330 together as illustrated in the cross section of FIG. 5I. The ring 307 may aid in maintaining close tolerance between the major interior slides 310, 320, and 330 to limit any housing material from seeping between the major interior slides 310, 320, and 330 during the injection molding process. The opening in the ring 307 may correspond to the major aperture 130.

In accordance with various embodiments, the major internal mold assembly may be removable from the major aperture 130 in a variety of directions. For example FIGS. 5A-I illustrate the various slides (e.g. first major interior slide 310, second major interior slide 320, and third major interior slide 330) extracted in a direction that is not parallel to any of the walls housing walls. In another example, as illustrated in FIGS. 6A-B, one or more of the various slides (e.g. a first major interior slide 610, a second major interior slide 620, and a third major interior slide 630) may be removed parallel to at least one of the walls of the housing 100. The second major interior slide 620 may be removed at an angle to the housing 100 walls according to arrow 1. The first major interior slide 610 may be removed from housing 100 parallel with at least one wall according to arrow 2. The third major interior slide 630 may be removed from housing 100 parallel with at least one wall according to arrow 2.

In accordance with various embodiments, the various slides (e.g. a first major interior slide 610, a second major interior slide 620, and a third major interior slide 630) may be sized and configured in any way to fill the interior volume of housing 100. For example, the first major interior slide 610 may be larger or smaller than either of the other interior slides. The second major interior slide 620 may be larger or smaller than either of the other interior slides. The third major interior slide 630 may be larger or small than either of the other interior slides. Any combination of size and shape may be used to obtain the sought after size and shape of the housing 100. Aperture 130 and the various slide shapes and sizes may be varied in order to allow the various slides to be extracted through aperture 130 while forming an interior cavity for the housing 100.

In accordance with various embodiments, the various slides (e.g. the first major interior slide 610, and the third major interior slide 630) may include additional features for forming other aspects of the housing 100. For example, the first major interior slide 610 may include a lip feature 613 that corresponds to the retention lip 119. As such, the first major interior slide 610 may be configured to form the retention lip 119. The third major interior slide 630 may include a lip feature 633 that also corresponds to the retention lip 119. As such, the third major interior slide 630 may be configured to form the retention lip 119.

#### Injection Molding Tool with Simple Interior Slides

In accordance with the various embodiments, as discussed herein, the major internal mold assembly may be a portion of an injection molding tool. As illustrated in FIGS. 7A-I, an injection molding tool may include a lower exterior mold assembly 710 and an upper exterior mold assembly 720. In

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various embodiments, the injection molding tool may include external mechanical actuators. For example, the injection molding tool may include a hydraulic actuator 790 and hydraulic cylinder 792. The injection molding tool may receive a resin from an injection gate 721 which may be delivered by injection pump to an internal cavity in which the housing 100 is formed. The injection gate 721 may be configured for filling the housing cavity with the resin.

As illustrated in FIG. 7B, an upper exterior mold assembly 720 may include a molding surface 723, and a molding surface 725. The molding surfaces 723 and 725 may be configured to form outer surfaces of the housing 100. For example, molding surface 723 may form the bottom surface 115c. Molding surface 725 may form the left surface 115e.

In various embodiments, the upper exterior mold assembly 720 may include a plurality of lances for engaging the lower exterior mold assembly 710. For example, the upper exterior mold assembly 720 may include one or more of a first lance 726, a second lance 728, a third lance 722, or a fourth lance 724. The lances may be configured to engage exterior slides in the lower exterior mold assembly 710. As the first lance 726, the second lance 728, the third lance 722, or the fourth lance 724 engage the lower exterior mold assembly the lances may compress exterior slides together to aid in forming the cavity that forms the housing 100.

As illustrated in FIGS. 7C and 7D, a lower exterior mold assembly 710 may include a lower core plate 753, an inner core plate 755, a first secondary slide 708, a second secondary slide 713 or a plurality of lance receptacles for engaging the upper exterior mold assembly 720. For example, the lower exterior mold assembly 710 may include one or more of a first lance receptacle 732, a second lance receptacle 742, a third lance receptacle 752, or a fourth lance receptacle 762. The first lance receptacle 732 may be an aperture in a first external slide 730. The first external slide 730 may have a molding surface 717 which forms an exterior surface of the housing 100. For example, the molding surface 717 may form the front surface 115b of the housing 100. The second lance receptacle 742 may be an aperture in a second external slide 740. The second external slide 740 may have a molding surface 716 which forms an exterior surface of the housing 100. For example, the molding surface 716 may form the back surface 115d of the housing 100. The third lance receptacle 752 may be an aperture in a third external slide 750. The third external slide 750 may have a molding surface 711 which may form an exterior surface of the housing 100. For example, the molding surface 711 may form the top surface 115a of the housing 100. The fourth lance receptacle 762 may be an aperture in a fourth external slide 760. The fourth external slide 760 may have a molding surface 712 which forms an exterior surface of the housing 100. For example, the molding surface 712 may form the left surface 115e of the housing 100. As discussed above, each of the lances may be configured to engage their respective receptacles forcing the respective slides to compress toward the center of the tool.

In accordance with various embodiments, the cavity for the housing 100 may nested in the injection molding tool in a variety of ways. For example, as illustrated in FIG. 7D, the upper exterior mold assembly 720 the exterior surface slide 750 and the exterior surface slide 760 are utilized to form the exterior surfaces 115e, 115c and 115f (see e.g. FIGS. 1A-C). It may be noted, as seen in FIG. 7D, that the upper exterior molds assembly 720 forms a plurality of the sides (e.g. left side 115e and right side 115c FIGS. 1A-C) of housing 100 and the exterior surface slide 750 and the exterior surface slide 760 form a single side of housing 100 each.

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As illustrated in FIG. 7D, as indicated above, the lower exterior mold assembly 710 may include the first secondary slide 708 or the second secondary slide 713. The first secondary slide 708 may be positioned to mate with the first major interior slide 310. The first secondary slide 708 may also support the third external slide 750 when the upper injection assembly 720 and the lower exterior mold assembly 710 are mated together during the injection molding process. The first secondary slide 708 may also receive the third lance 722 into a secondary slide receptacle 715 which is an aperture within the upper portion of the body of the first secondary slide 708. The second secondary slide 713 may be positioned to mate with the third major interior slide 330. The second secondary slide 713 may also support the fourth external slide 760 when the upper injection assembly 720 and the lower exterior mold assembly 710 are mated together during the injection molding process. The second secondary slide 718 may also receive the fourth lance 724 into a secondary slide receptacle 714 which is an aperture within the upper portion of the body of the second secondary slide 713.

As illustrated in FIG. 7D, as indicated above, the lower exterior mold assembly 710 may include the lower core plate 753, the lower exterior mold assembly 710 may also include the inner core plate 755. The inner core plate 755 may be positioned between the lower core plate 753 and the second secondary slide 713. The inner core plate 755 may provide support to second secondary slide 713 or hydraulic cylinder 792. The lower core plate 753 may be positioned below the inner core plate 755. The lower core plate 753 may provide support to a core block 743. The lower core plate 753 may be in communication with the second major interior slide 320. The core plate 753 may be directly fixed to the second major interior slide 320. Alternatively, the core plate 753 may be attached to the second major interior slide through an intermediary slide. The core plate 753 may have an aperture extending through the core plate 753 such that an ejector block 733 may extend through the lower core plate 753 and contact the third major interior slide 330.

As illustrated in FIG. 7E, the lower core plate 753 may be configured to be removable from the rest of the injection molding tool. Being attached to the second major interior slide 320, removal of the core plate may additionally with draw the second major interior slide 320 from the interior of the injection molding cavity and the interior of housing 100. The lower core plate 753 may be configured to slide down the ejector block 733 which stays in place during the removal of the lower core plate 753.

As illustrated in FIG. 7E, the hydraulic cylinder 792 may be configured to extend in the direction of arrow 1 illustrated in FIG. 7E. An engagement between the first major interior slide 310 and the hydraulic cylinder 792 may cause the first major interior slide 310 to slide toward the third major interior slide 330. The first major interior slide 310 may be able to contact the third major interior slide 330. In this position the first major interior slide 310 may be operable to be pulled down and extracted from housing 100.

As illustrated in FIG. 7G, the third external slide 750 and the fourth external slide 760 may be translated laterally away from the housing 100 along arrows 1 and 2 respectively. This movement of the third external slide 750 and the fourth external slide 760 may remove the mold from the top surface 115a and the right surface 115f exposing them to the environment outside of the injection molding tool. The upper injection assembly 720 may be translated up and away from the housing 100. This movement of upper injection

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assembly 720 may remove the mold from the left surface 115e and the bottom surface 115c exposing them to the environment outside.

As illustrated in FIG. 7H, the ejector block 733 may be inserted into the mold assembly toward housing 100. The ejector block 733 may be inserted in the direction of arrow 1 as illustrated in FIG. 7H. As the ejector block 733 may contact the third major interior slide 330, the third major interior slide 330 may also be forced up through the lower external mold assembly. With the third major interior slide 330 still located in the housing 100, the housing 100 may be lifted up out of the lower external mold assembly along arrow 2 as illustrated in FIG. 7H. Once the housing is lifted up and out of the lower external mold assembly the housing 100 may be removed off of the third major interior slide 330 in the direction of arrow 1 as illustrated in FIG. 7I.

Alternatively, the injection tool may have the various components arranged to form housing 100 utilizing different injection molding plates and potentially limiting the parts of the tool used to form the exterior surfaces of housing 100. For example, as illustrated in FIG. 8A, the injection tooling may include an upper plate 803, a lower plate 805, a first exterior plate 810, and a second exterior plate 820. The upper plate 803 and the lower plate 805 may form the front surface 115b and the back surface 115d (the front and back surfaces as shown in FIGS. 1-4). The injection tool may also include the first major interior slide 310, the second major interior slide 320, and third major interior slide 330. Similar to the embodiments discussed above in relationship to FIGS. 5H and 5I, the tool may comprise ring 307 which may form the aperture of housing 100 or retain the major interior slides 310, 320, and 330. However it may be noted that the inclusion is merely one embodiment that may variously be combined with or separated from any of the other embodiments as discussed herein. For example, FIGS. 8B-8J do not specifically mention the ring but instead the major interior slides 310, 320, and 330 form the aperture of housing 100 and engage one another without the added support of ring 100. However, the ring 100 may still be included as shown in FIGS. 8K-8M.

FIG. 8B illustrates the first exterior plate 810 and the second exterior plate 820 in the absence of the upper plate 803 and the lower plate 805. The first exterior plate 810 and the second exterior plate 820 may each form a plurality of the sides of housing 100. In this example, the first exterior plate 810 and the second exterior plate 820 are each configured to be separable from housing 100. The second exterior plate 820 may form bottom surface 115c and right surface 115f. The first exterior plate 810 may form left surface 115e and top surface 115a.

In accordance with various embodiments, as discussed above and illustrated in FIG. 8C the injection molding tool may also include a plurality of interior surface slides such as the third major interior slide 330, the second major interior slide 320, and the first major interior slide 310 which form the major interior mold assembly. As discussed above, the third major interior slide 330 and the second major interior slide 320 may be engaged with one another. The second major interior slide 320 and the first major interior slide 310 may be engaged with one another. Both engagements may be sufficiently tight to prevent resin from flowing between each of the slides but still allowing for each of the slides to move relative to one another. The tool may also include slide areas which may be utilized to move slides within the injection tool. For example, a slide area 838 may be located on one or more sides of the first major interior slide 310. The slide area 838 may allow the first major interior slide 310 to



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move relative to a third major exterior slide **830** within the injection molding tool. This movement may enable the first major interior slide **310** to exit the housing **100** after the housing is formed.

As illustrated in FIG. **8D** the first exterior plate **810** and the second exterior plate **820** may be separable exposing the housing **100** after molding is completed. The separation may occur along the directions of arrows **1** and **2** as shown in FIG. **8D**. The second major interior slide **320** may be pulled out of the housing **100** along the direction of the arrow illustrated in FIG. **8E**. The first major interior slide **310** may be pulled out of the housing **100** along the direction of the arrow illustrated in FIG. **8F**. In this movement, the first major interior slide **310** may occupy the slide area **838** set aside for this translation of the first major interior slide **310**. The third major exterior slide **830** may be moved along the direction of the arrow illustrated in FIG. **8G**. The movement of the third major exterior slide **830** may pull the first major interior slide **310** out of the housing **100** in the direction of the arrow illustrated in FIG. **8G**. The third major interior slide **330** may push (or pull) the housing **100** away from the other injection molding tool portions already separated. The movement of the housing **100** may be along the arrow illustrated in FIG. **8H**. In this motion, the housing **100** may be suspended and/or touching the third major interior slide **330**. The housing **100** may be removed from the third major interior slide **330** by translating the housing **100** in the direction of the arrow in FIG. **8I** and then in the direction of the arrow in FIG. **8J**.

As discussed above and illustrated in FIGS. **8K-8M**, the injection molding tool may include ring **307**. By utilizing ring **307** the major interior slides **310**, **320**, and **330** may be maintained together in tighter tolerances. After injection molding housing **100**, the ring may be separated from the housing and other portions of the tool. Until major interior slides **310**, **320**, and **330** are entirely removed from the interior of the ring **307** the ring **307** may not be entirely separated from the injection molding tool. However, in accordance with various embodiments, once major interior slide **320** is removed from the interior of the housing **100** (along arrow A as shown in FIG. **8K**) and out of ring **307**, the ring **307** may be separated from the injection molding tool. In separating the ring **307** from the injection molding tool major interior slides **320** and **330** may be moved towards the interior of ring **307**. In various examples, the ring **307** may be separated from the aperture of housing **100** along arrow D by 1 mm. Major interior slide **330** may move along arrow B (in one example arrow B may be 57 degrees off a line which can be depicted by direction of arrow A) and be removed from ring **307**. Major interior slide **310** may move along arrow C (in one example arrow C may be 37 degrees off a line which can be depicted by direction of arrow A) and be removed from ring **307**. After the major interior slides **310**, **320**, and **330** are removed, the **810** and the second exterior plate **820** may be separated as shown in FIG. **8L**. Specifically **810** may be moved along arrow A and **820** may be moved along arrow B as shown in FIG. **8L**. Subsequently the housing **100** may be separated from the lower plate **805**, ring **307**, the first exterior plate **810**, and second exterior plate **820** along arrow A, as shown in FIG. **8M**.

#### Injection Molding Tool with Compound Interior Slides

In accordance with another embodiment, as illustrated in FIGS. **9A-R**, a major internal mold assembly operable to compress in on itself by utilizing compound interior slides. The additional compression operation of a major internal mold assembly may allow for larger internal features in a

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housing to be formed using a smaller aperture. Tooling utilizing a major internal mold assembly may operate or have similar features as tooling discussed above. Some of these similar feature and additional features may be discussed below with respect to embodiments directed to compressible internal mold assemblies.

FIG. **9A** illustrates an example of a first position of an embodiment of a major internal mold assembly. The major interior surface mold assembly **200** may be comprised of a plurality of movable components. As indicated the plurality of movable components may be selectively movable. The interior surface assembly **200** may comprise three major independently moveable slides. A first major independently movable interior surface slide **210** contours the interior surface of at least a first interior face of the first housing member, but may contour a portion of interior faces adjacent to the first interior face. The first major slide **210** may also form at least one interior surface feature **240** suitable for coupling electronic devices to the interior geometry of the faces the first major slide **210** contours. A second major independently movable interior surface slide **220** may include a dovetail **250** which may engage with the first major slide **210**. This may configure the second slide **220** to freely slide along the face of the first major slide **210**. The second major slide **220** may contour additional area of the interior faces adjacent to the first face.

Each of the major slides **210**, **220**, and **230** may be considered compound slides as they may have movable subcomponents. The inclusion of these movable subcomponents as discussed herein may allow the major slides **210**, **220**, and **230** to exit through a smaller aperture in the completed housing of unitary construction while being able to form a larger interior volume in the housing of unitary construction.

A first minor slide **234**, second minor slide **232** and third minor slide **236** may couple together to form a third major independently movable interior surface slide **230**. The first minor slide **234** may connect with a dovetail coupling **260** to the second minor slide **232** or third minor slide **236**. The width of the first slide **234** may taper parallel to the dovetail coupling **260** such that when the first minor slide **234** slides along the dovetail coupling **260** the second **232** and third minor **236** slides may compress together. When the three minor slides (**232**, **234**, **236**) are in a first position (e.g. FIG. **9A**), the third major slide **230** forms at least a second interior face of the first housing member **100** (not show in FIG. **9A**), and may also contour a portion of interior faces adjacent to the first interior face. The third major slide **230** may also form at least one interior surface feature **240** suitable for coupling electronic devices to the interior geometry of the faces the third major slide **230** contours.

FIG. **9B** illustrates an example of a second position companion to the embodiment of FIG. **9A**. In the embodiment as illustrated, the first major interior surface slide **210** is angled at the interface with the second major interior surface slide **220**. The second major independently movable slide **220** may slide down the dovetail coupling **250** along the angled faces between the first major interior surface slide **210** and second major interior surface slide **220**.

FIG. **9C** illustrates a third position. Which illustrates that the first major interior surface slide **210** and second major interior surface slide **220** may slide at the same time at an angle parallel to the outward facing major face of the first major slide **210**, or at such an angle as to remove the mold of interior surface feature **240** without exerting stress on a molded interior surface feature **140** (see e.g. FIG. **3**).

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FIG. 9D illustrates an example of a fourth position. For example, the first major interior surface slide **210** and second major interior surface slide **220** may slide at the same time at an angle parallel to the outward facing major face of the first major slide **210**, or at such an angle as to remove the mold of interior surface feature **240** without exerting stress on the molded interior surface feature **140** (see e.g. FIG. 3). In addition, the first minor slide **234** may be slid along the tapered dovetail coupling **260** toward the vacancy created by the removal of the first major slide **210** and second major slide **220**. As a result of the tapered coupling **260**, the first minor slide **232** and third minor slide **236** are compressed toward one another. The compression of minor slides **232** and **236** and the movement of minor slide **234** may cause the third major slide **230** to compress along its width. The movement and compression of the third major slide **230** also permits any surface feature molds (e.g. surface feature mold **240**) to be removed without exerting stress on a molded interior surface feature **140** (see e.g. FIG. 4).

One of ordinary skill in the art will appreciate that FIGS. 9A-D are presented as showing a progression of positions of an interior mold as it is being removed from an already molded housing **100** as shown in FIGS. 2-4. I may be appreciated that additional mold components may be utilized for a complete mold cavity but are not shown in FIGS. 9A-D so that the interior mold component movements may be more clearly understood. One of ordinary skill in the art will understand how to utilize the tooling discussed herein and apply the subject matter.

As illustrated in FIGS. 9E-F, a major aperture mold assembly **300** may be used to contour the geometry of major aperture **130** of the housing **100**. The aperture mold has a rotated L-shaped profile, but those skilled in the art will recognize that the aperture may be of an arbitrary shape. The major aperture assembly **300** is sized such that when in the first position as shown in FIG. 9A, major interior mold slides **210**, **220** and **230** fit within and through the major aperture **300** to form the inverse of the interior surface **120** (see e.g. FIGS. 3-4). The housing is shown as transparent in FIG. 9F to facilitate the view of the major aperture.

As illustrated in FIG. 9G, the interior mold slides **210**, **220** and **230** may be assembled through the aperture mold assembly **300** in the first position as shown in FIG. 9A. The aperture mold assembly may be exactly the width of the interior mold assembly **200** to provide as tight a fit as possible between the parts. As illustrated in FIG. 9H, a number of movable external mold components **410** may be positioned around the other mold components (**200** and **300**) in order to complete the interior and exterior geometry of the mold cavity. Together, external mold components **410** join together to contour the exterior surface of the mold cavity as exterior mold **400**. As further illustrated in FIG. 9H, the foremost external mold component **410** has been made slightly transparent so that the injection molding runner **420** and gate **430** are also visible. Both runner **420** and gate **430** are hollow paths through which mold material may be injected. During the molding process, a certain amount of mold material is injected through runner **420** and gate **430** into the cavity created by the complete assembly of the mold. In various embodiments, the injection molding tool may include five external mold components as illustrated in FIG. 9H, four of which contour a single external face, the foremost contouring two external faces. One skilled in the art will recognize that fewer than five external mold components may be utilized or more than five external mold components may be utilized. For example, some of the mold components may be combined into a single part in order to

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contour more than one face or edge. Although FIG. 9H illustrates the exterior mold components **410** contouring substantially flat faces and corners, one of ordinary skill can further appreciate that arbitrarily shaped exteriors or corners may be molded as well.

In various embodiments, exterior mold components **410** may be set in place along a path perpendicular to the face each component contours. In other embodiments, exterior mold components **410** may be angled into place or, in other embodiments, slid into position parallel the face each component contours. In further embodiments, exterior mold components **410** may also be rotated into place. One of skill in the art will appreciate that the path the exterior mold components **410** take while being set is arbitrary and may be changed. One of skill will further appreciate that independent external mold components may be set in different ways.

FIG. 9I illustrates an example of a closed mold ready for injection. As the mold is closed, the cavity created by all three mold components (interior mold **200**, aperture mold **300**, exterior mold **400**) is not visible. FIG. 9J is a companion figure to FIG. 9I, with exception that the foremost external mold component **410** is illustrated transparently. In this way, the mold cavity **600** is visible. As illustrated in FIG. 9K, the wall thickness of the mold cavity **600** may be determined by the position of the exterior mold components **410**. As demonstrated, the wall thickness of mold cavity **600** is not necessarily uniform. In various embodiments wall thickness may be uniform. One of ordinary skill can appreciate that wall thickness for the mold cavity may arbitrarily differ throughout the geometry of the mold.

Once mold material is injected through runner **420** and gate **430** into the mold cavity **600**, the housing of unitary construction **100** has been formed as is ready to be removed for further processing. As illustrated in FIG. 9L, the external mold components **410** may be removed in the order they were set. In other embodiments, external mold components **410** may be removed in a different order. One of ordinary skill will appreciate that as with setting the external mold components, removal path and order of external mold components may be accomplished in a variety of orders. As further illustrated in FIG. 9L, the gate residue **150** may be present if a cold runner injection molding process is used. As the gate residue may not provide an aesthetically or functionally pleasing external geometry, it may be removed in a later process. As shown in FIG. 9L, the interior mold assembly **200** may still be assembled within the molded housing **100**.

After the housing **100** has been molded and is prepared to be removed for further processing both the external and internal mold components may be positioned such that the newly molded housing may be separated without damage. In accordance with various embodiments, after external mold components are removed as illustrated in FIG. 9L, a fixture **500** is coupled to the housing **100** (FIG. 9M). The fixture **500** provides stability to the housing **100** as internal mold slides **210** and **220** are removed and component **230** is compressed in the sequence shown in FIGS. 9A-D. In certain other embodiments, stability for the housing **100** is provided by the external mold assembly **400** during the removal and compression sequence of the internal mold components in FIGS. 9A-D. In various embodiments, the fixture **500** may be coupled to the housing **100** before all external mold components **410** are removed.

As illustrated in FIG. 9N, the injection molding tool may have a final position for the slides **210**, **220** and **230** (**232**, **234**, and **236**) after the independent movements shown in FIGS. 9A-D. As a result, there may be sufficient space

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provided by the molded aperture 130 (see e.g. FIGS. 2-4) that the housing 100 may be separated from internal mold 230. In this way, the internal mold component 230 is not removed from the aperture assembly 300 during the separation of housing 100 by fixture 500. FIGS. 9O-9P illustrate examples of the molded housing 100 after molding but before final processing if, as an effect of cold runner injection molding, gate residue 150 is left behind. In various embodiments, the gate may be located directly opposite an internal surface feature 140. The housing 100 is transparent in FIG. 9P in order to show details such as internal surface feature 140. FIGS. 9Q-9R illustrate examples of the molded housing 100 after subsequent processing. In various embodiments, a minor aperture may be opened directly opposite an internal surface feature 140. In some embodiments, internal surface features may be configured to provide structural or mechanical support to housing features that are added in subsequent processing steps.

In accordance with various embodiments, as illustrated in FIG. 10, a housing of unitary construction may be formed in an injection molding process. In operation 1000 a process for molding a housing of unitary construction may be started. In operation 1005, a major internal mold assembly may be obtained or provided. The major internal mold assembly may include providing a plurality of movable interior slides each having an extraction protrusion in a first position for forming an interior cavity of the housing. In operation 1010, a major external mold assembly may be obtained or provided. The major external mold assembly may include providing a plurality of movable components in a first position for forming a major external surface of the housing. A cavity may be formed between the major internal mold assembly and the major external mold assembly. The cavity may be configured for injecting resin to form the housing of unitary construction. The major external mold assembly may mate with the extraction protrusion of each of the plurality of movable interior slides. In operation 1015, resin may be injected in the cavity between the major internal mold assembly and the major external mold assembly. This injection may form a major internal surface and a major external surface, respectively. The formation of the surfaces forms the housing of unitary construction. In operation 1020, a major aperture may be formed in the housing of unitary construction. The aperture may pass from the interior cavity through the interior surface and the exterior surface of the housing. The major aperture may be formed around the extraction protrusions of each of the movable slides. For example, the aperture formation may be located where the major external mold assembly mates with the extraction protrusion of each of the plurality of movable interior slides. This location may be proximal to the cavity formed between the major internal mold assembly and the major external mold assembly. In operation 1030, a first moveable interior slide may be removed through the aperture formed in the housing of unitary construction. In operation 1040, a second moveable interior slide may be moved within the formed housing of unitary construction toward the aperture and in operation 1050, the second moveable interior slide may be removed through the aperture formed in the housing of unitary construction. In operation 1060, the first moveable exterior mold component may be removed. In operation 1070, the housing of unitary construction may be removed from the tooling. Although presented in one particular sequence in FIG. 10, one of skill in the art will appreciate that the various procedures may be completed in any of a variety of orders.

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In accordance with various embodiments, as illustrated in FIG. 11, an injection molding process which begins in operation 1800 may be utilized in forming a housing of unitary construction. In operation 1805, an interior surface assembly may be provided. For example, the interior surface assembly similar to the interior mold assembly 200. In operation 1810, an aperture assembly may be provided. The aperture assembly may contour a major aperture of the housing of unitary construction. For example, the aperture assembly may be similar to aperture mold assembly 300. In operation 1815, an exterior surface assembly may be provided.

In operation 1820a-c, an interior surface, interior surface features, an exterior surface, or an aperture surface may be molded. In an example, if the molding process is injection molding, 1820a-c may occur simultaneously as the mold material fills the available mold cavity space. In another example, the interior, exterior, or aperture surfaces may be molded in distinct steps. For example, multiple gates may provide mold material to different sectional volumes of the mold cavity. In operation 1825, after molding, a first interior mold component may be removed through the molded aperture, such as the motion discussed in the various examples above see e.g. 9A-B or FIG. 5E. In various embodiments, this first interior mold component may be removed at ninety degrees. In various embodiments, the first interior mold component may be removed at an angle. In still further embodiments, a sequence of interior mold components may be removed in a repetition of operation 1825. In operation 1830, a second interior mold component remaining within the molded housing may be moved towards the aperture, such as the motion discussed in the various examples above, see e.g. FIGS. 9C-D or FIG. 5F. In various embodiments, the second interior mold component's motion may cause other mold components to move. In still further embodiments, a sequence of interior mold components may be removed in a repetition of step 1830. In operation 1835, an exterior mold assembly may be removed. In various embodiments, the individual components of the exterior mold assembly may be removed sequentially. In other embodiments, the components may be removed contemporaneously. In operation 1840, a fixture may be coupled to the formed mold, see e.g. the coupling illustrated in FIGS. 9M-N. In some embodiments, the coupling may be a friction fit. In other embodiments, the fixture may actively adhere itself to the formed component with suction or some similar means. In operation 1845, the fixture and formed mold may be removed together over the interior mold components remaining within the interior volume of the formed housing. In various embodiments, the fixture and formed mold are removed at an angle. Although presented sequentially in FIG. 11, one of skill in the art will appreciate that the various procedures may be completed in a variety of orders.

In accordance with various embodiments as illustrated in FIG. 12, a mold for formation of a housing of unitary construction may be disassembled. In operation 1900, the process of disassembly may begin. In operation 1905, the disassembly may include removing a first interior surface assembly component beyond an interior volume of a formed mold. In various embodiments, the first slide may be removed at an angle. In other embodiments, the first slide may be removed at ninety degrees. In still further embodiments, a sequence of interior mold components may be removed in a repetition of operation 1905. In operation 1910, a second interior surface assembly component still within the formed mold may be compressed. The compression may, for example, be caused by the motion of another

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component. In operation 1915, a second interior surface assembly may be moved toward an aperture of the formed mold. In various embodiments, the second interior surface assembly may be made up of multiple individual slides, each of which may move together or independently toward the aperture of the formed mold. In still further embodiments, a sequence of interior mold components may be removed in a repetition of the previous processes. In operation 1920, components of an exterior mold assembly may be removed. In various embodiments, the individual components of the exterior mold assembly may be removed sequentially. In other embodiments, the components may be removed contemporaneously. In operation 1925, a fixture may be coupled to the formed mold, see e.g. the coupling illustrated in FIGS. 9M-N. In various embodiments, the coupling may be a friction fit. In other embodiments, the fixture may actively adhere itself to the formed component with suction or some similar means. In operation 1930, the fixture and formed mold may be removed together over the interior mold components remaining within the interior volume of the formed housing. In various embodiments, the fixture and formed mold are removed at an angle.

As used throughout this document in each of the embodiments, aspects, examples, lists and various descriptions of the subject matter contained herein, the word "or" is intended to be interpreted in its inclusive form (e.g. and/or) not in its exclusive form (e.g. only one of) unless explicitly modified to indicate only one item in a list is intended (e.g. only one of A, B, or C). For example, the phrase A, B, or C is intended to include any combination of the elements. The phrase can mean only A. The phrase can mean only B. The phrase can mean only C. The phrase can mean A and B. The phrase can mean A and C. The phrase can mean B and C. The phrase can mean A and B and C. This concept extends to any length of list (e.g. 1, 2, 3 . . . n) used herein.

Although the foregoing discussion has presented specific embodiments, the foregoing merely illustrates the principles of the invention. Persons skilled in the art will recognize that changes may be made in form and detail without departing from the spirit and scope of the disclosure as various modifications and alterations to the described embodiments will be apparent to those skilled in the art, in view of the teachings herein. For example, the processing steps may be performed in another order, or in different combinations. It will thus be appreciated that those having skill in the art will be able to devise numerous systems, arrangements and methods which, although not explicitly shown or described herein, embody the principles of the disclosure and are thus within the spirit and scope of the present invention. From the above description and drawings, it will be understood by those of ordinary skill in the art that the particular embodiments shown and described are for purposes of illustration only, and references to details of particular embodiments are not intended to limit the scope of the present invention, as defined by the appended claims.

We claim:

1. A housing for electronic components, the housing comprising:

- a body having a major interior surface that defines an interior cavity and a major exterior surface comprising at least first and second intersecting surfaces;
- a major aperture formed in the body and extending from the interior cavity through the major interior surface and major exterior surface, wherein the major aperture passes through a portion of the first surface and the second surface but not the entirety of the first surface and the second surface and wherein the interior cavity

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is dimensionally larger than the major aperture such that a largest cross-section of the interior cavity is larger than a largest cross-section of the major aperture;

- a receiving lip formed around a perimeter of the major aperture;

- a retention cap having first and second exterior cap surfaces that intersect at an elbow of the retention cap, wherein the retention cap is coupled to the receiving lip such that the first and second exterior cap surfaces are flush with the first and second surfaces of the body, respectively, and wherein the retention cap includes a protrusion that extends outward from the first exterior cap surface and a minor aperture that extends through the second exterior cap surface to the interior cavity; and

wherein the housing body is of a single, unitary construction formed of a rigid material of substantially uniform thickness that defines the entirety of the major exterior surface such that the major exterior surface does not include any seams.

2. The housing of claim 1 wherein the body includes at least one interior surface feature configured to couple to electronic components.

3. The housing of claim 1, wherein the major aperture additionally passes through a portion of a third surface and a fourth surface.

4. The housing of claim 3, wherein the major aperture comprises a substantially L-shaped cross section.

5. The housing of claim 3, wherein the first surface is orthogonal to the second surface, the third surface and the fourth surface; wherein the second surface is orthogonal to the third surface and the fourth surface; wherein the third surface and the fourth surface are parallel to one another.

6. The housing of claim 5, wherein the first surface, the second surface, the third surface and the fourth surface are all contiguous and have no separate surfaces mechanically attached to form any of the first surface, the second surface, the third surface and the fourth surface.

7. The electronic device housing set forth in claim 1 wherein major exterior surface of the body includes first and second opposing faces each of which is shaped as a concave hexagon having all right angles with at least some rounded corners.

8. A housing, comprising:

- an injection-molded body defining an interior cavity therein, the injection molded body having a major exterior surface comprising at least first surface and second intersecting surfaces; and

- a major aperture passing through the injection-molded body and opening to the interior cavity;

- a receiving lip formed around a perimeter of the major aperture;

- a retention cap having first and second exterior cap surfaces that intersect at an elbow of the retention cap, wherein the retention cap is coupled to the receiving lip such that the first and second exterior cap surfaces are flush with the first and second surfaces of the body, respectively, and wherein the retention cap includes a protrusion that extends outward from the first exterior cap surface and a minor aperture that extends through the second exterior cap surface to the interior cavity;

wherein the interior cavity is dimensionally larger than the major aperture such that a largest cross-section of the interior cavity is larger than a largest cross-section of the aperture; and

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the injection-molded body is of a unitary construction that does not include any seams along the major exterior surface.

9. The housing of claim 8, wherein the injection-molded body lacks a seam.

10. The housing of claim 8, wherein:

the injection-molded body defines at least a pair of sidewalls adjacent one another; and

the aperture passes through the at least a pair of sidewalls.

11. The electronic device housing set forth in claim 8 wherein major exterior surface of the body includes first and second opposing faces each of which is shaped as a concave hexagon having all right angles with at least some rounded corners.

12. An electronic device housing comprising:

a seamless body having a major exterior surface and a major interior surface that combine to define a plurality of walls which in turn define an interior volume, wherein the plurality of walls includes first and second opposing faces and a sidewall extending between the first and second opposing faces along a perimeter of the seamless body, the sidewall including first, second, third and fourth sidewall faces where the first and second sidewall faces meet at a first corner, the second and third sidewall faces meet at a second corner and the third and fourth sidewall faces meet at a third corner in a catercorner position to the first corner;

a major aperture formed at a corner of the seamless body catercorner to the second corner and opening to the interior volume, the major aperture formed between the first and second opposing faces and between the first and fourth sidewall segments, and the major aperture having a cross-sectional dimension between the first

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and fourth sidewall segments that is less than a cross-sectional dimension of the interior volume between the first and third corners;

a receiving lip formed around a perimeter of the major aperture; and

a retention cap having first and second exterior cap surfaces that intersect at an elbow of the retention cap, wherein the retention cap is coupled to the receiving lip such that the first and second exterior cap surfaces are flush with the first and fourth sidewall segments of the body, respectively.

13. The electronic device housing set forth in claim 12 further comprising a first electronic module comprising a plurality of electronic components, the first electronic module having a length that is substantially equal to a interior dimension of the internal cavity, a width that is substantially equal to the cross-sectional dimension of the major aperture between the third and fourth sidewall segments, and rounded corners that enable the first electronic module to be inserted through the aperture into the internal cavity and then rotated into a final position.

14. The electronic device housing set forth in claim 13 further comprising a second electronic module coupled to the first electronic component.

15. The electronic device housing set forth in claim 12 wherein the first, second and third corners are each rounded.

16. The electronic device housing set forth in claim 15 wherein each of the first and second opposing faces is shaped as a concave hexagon having all right angles.

17. The electronic device housing set forth in claim 16 wherein the retention cap includes a protrusion that extends outward from the first exterior cap surface and a minor aperture that extends through the second exterior cap surface to the interior volume.

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