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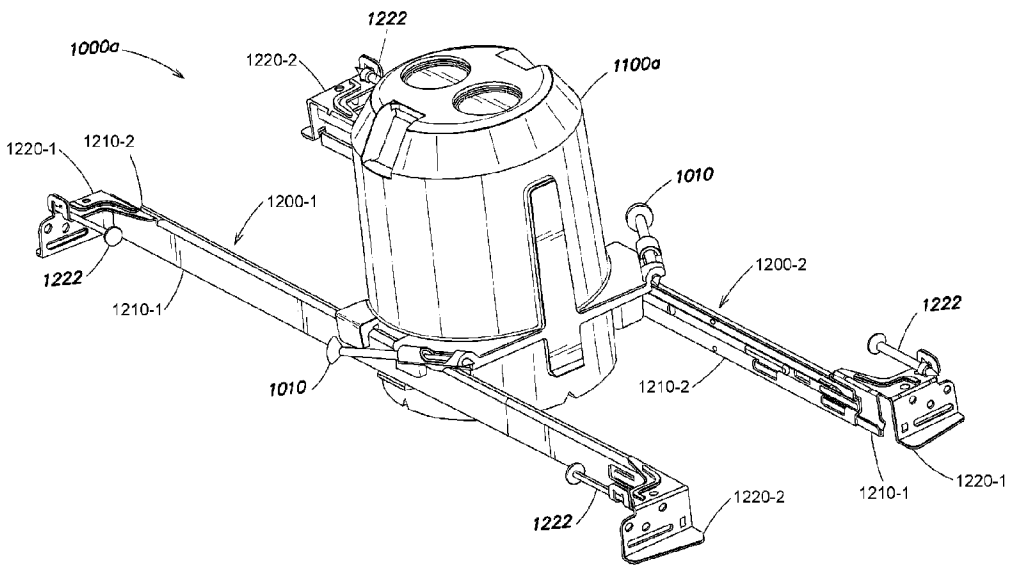



(57) Abrégé/Abstract:
A housing assembly for a recessed lighting system includes a housing with integrally formed cable routing features, mounting features, and alignment features. The integration of multiple features into the housing is enabled by forming the housing from a polymer using an injection molding process instead of sheet metal. For a new construction installation, the housing includes integrally formed bar hanger holders to support and guide bar hangers for installation onto two or more support structures, nail-in features for installation onto a single support structure, and one or more alignment features to position the housing against the single support structure when the nail-in features are used for installation. For a remodel installation, the housing includes a flange to abut a bottom surface of a ceiling and one or more spring clips mounted to the housing to abut a top surface of the ceiling.

## ABSTRACT

A housing assembly for a recessed lighting system includes a housing with integrally formed cable routing features, mounting features, and alignment features. The integration of multiple features into the housing is enabled by forming the housing from a polymer using an injection molding process instead of sheet metal. For a new construction installation, the housing includes integrally formed bar hanger holders to support and guide bar hangers for installation onto two or more support structures, nail-in features for installation onto a single support structure, and one or more alignment features to position the housing against the single support structure when the nail-in features are used for installation. For a remodel installation, the housing includes a flange to abut a bottom surface of a ceiling and one or more spring clips mounted to the housing to abut a top surface of the ceiling.


Date Reçue/Date Received 2021-07-16

# POLYMER HOUSING FOR A LIGHTING SYSTEM AND METHODS FOR USING SAME

## CROSS-REFERENCE TO RELATED APPLICATION(S)

**[0001]** The present application claims priority to U.S. Provisional Application No. 63/121,163, filed December 3, 2020, entitled "HOUSING WITH INTEGRATED BAR HANGER HOLDERS FOR A LIGHTING SYSTEM," and U.S. Provisional Application No. 63/053,260, filed July 17, 2020, entitled "HOUSING WITH INTEGRATED BAR HANGER HOLDERS FOR A LIGHTING SYSTEM." Each of the aforementioned applications is incorporated by reference herein in its entirety.

## BACKGROUND

**[0002]** A conventional lighting system (also referred to herein as a "lighting fixture") typically includes a housing (also referred to as an "enclosure") to contain a lighting module, which includes a light source, a driver, and/or one or more wires. The housing is typically supported by various components (e.g., a pan frame, bar hanger holders, bar hangers) to form a housing assembly. The supporting components include mounting features to facilitate installation of the housing assembly onto one or more support structures in the environment. The mounting features often vary depending on the type of installation (e.g., a remodel lighting fixture, a new construction lighting fixture) and the type of support structure disposed in the environment to support the housing assembly.

**[0003]** For example, a conventional housing assembly for a recessed lighting system typically includes a can housing to contain a light source and a junction box to receive and contain wires from an electrical power supply of a building and wire splices to electrically couple the wires to the light source.

**[0004]** In a new construction installation, the can housing and the junction box are generally supported by a pan frame and one or more adjustable bar hanger assemblies coupled to the pan frame to mount the housing assembly to various support structures located within the ceiling (e.g., a wood joist or stud, a metal joist or stud, a T-bar). Each bar hanger assembly generally includes (1) a pair of telescopically adjustable bar hangers slidably coupled to the pan frame and (2) a bar hanger head on each bar hanger with one or more mounting features to couple to various support structures. Once the housing assembly is mounted to the support structures, a piece of drywall (or



Date Reçue/Date Received 2021-07-16

a wood panel) is then installed to cover the ceiling and an opening is then cut to expose the housing. A lighting module may then be inserted into the housing with a trim to cover the opening formed in the ceiling.

**[0005]** In a remodel installation, the can housing and the junction box are supported by a frame and the housing assembly is inserted directly through an opening formed in the drywall already installed in the ceiling. Said in another way, a remodel installation does not require access to support structures disposed within the ceiling for installation. The can housing typically includes multiple spring clips to directly mount the housing assembly to the drywall. Once the housing assembly is mounted to the drywall, the lighting module and the trim may be installed in the same manner as in the new construction installation.

## SUMMARY

**[0006]** The Inventors, via previous innovative designs of lighting systems, have recognized and appreciated recessed lighting systems offer several benefits for ambient and task lighting including, but not limited to, making the environment appear larger (e.g., low ceiling environments), greater flexibility in tailoring lighting conditions (e.g., wall wash, directional, accent, general lighting), and fewer limitations on the installation location (e.g., a sloped ceiling, a vaulted ceiling, a wall). However, the Inventors have also recognized several limitations in the design and use of conventional housing assemblies for recessed lighting systems.

**[0007]** First, a conventional housing assembly typically includes a housing and other supporting components formed from sheet metal. Conventional sheet metal forming processes, however, are generally unsuitable for the production of complex-shaped components, such as a part with a variable wall thickness or a part with a rounded, enclosed wall with protruding structural features or flat sections. The formation of more complex structural features often entails additional processing steps, which can result in appreciably higher manufacturing costs. Furthermore, structural features that protrude from the surface of a part formed from sheet metal (e.g., a rib to structurally reinforce the part) can also be difficult to include, often entailing additional processing steps that add manufacturing time and cost or requiring the fabrication of separate parts that are subsequently attached together. In some instances, sheet metal components are formed from thicker sheet metal to achieve the desired structural rigidity at the expense of higher material costs.



Date Reçue/Date Received 2021-07-16

**[0008]** As a result, conventional housings for recessed lighting systems formed from sheet metal are often constructed from an assembly of parts with a limited set of structural features to keep manufacturing costs down. For example, a typical housing assembly includes a housing to contain a lighting module (e.g., a can housing, a junction box). The housing is often formed from multiple pieces of sheet metal that are welded or riveted together. The walls of the housing may include one or more knockouts to receive and support electrical wiring. The housing assembly may further include separate mounting components to facilitate installation of the housing onto one or more support structures. For example, conventional housing assemblies often include a pan frame or bar hanger holders that are manufactured separately from the housing.

**[0009]** Second, conventional housing assemblies are often limited to one mode of installation. For example, a housing assembly typically includes two bar hanger assemblies that each couple the housing to two support structures in the environment for a total of four attachment points. The length of each bar hanger assembly may be adjusted in order to traverse gaps of varying size between the two support structures and each respective bar hanger head in the bar hanger assembly typically may include different mounting features to couple the bar hanger assembly to the support structures. However, the bar hanger assemblies are not suitable for installation if only a single support structure is available for installation. Furthermore, the bar hangers have a finite length, which may prevent installation of the housing assembly in more confined spaces. For example, neighboring support structures may be separated by a gap that is smaller than the length of one bar hanger.

**[0010]** Third, a recessed lighting system may be designed and installed to meet specific safety standards in order to operate in certain environments. For example, a recessed lighting system installed into multifamily residential buildings may be required to meet various fire-rating standards set forth, for example, by the National Electric Code (NEC) or the Underwriter's Laboratory (UL), which may entail adding a fire-rated enclosure (e.g., a firebox) to enclose the recessed lighting system. The addition of the fire-rated enclosure may further complicate the installation as well as increase the overall size of the lighting system, thus limiting installation in more confined spaces.

**[0011]** In view of the foregoing limitations of conventional housings and housing assemblies, the present disclosure is thus directed to various inventive implementations of a housing assembly for



Date Reçue/Date Received 2021-07-16

a recessed lighting system that includes a housing with integrally formed cable routing features (e.g., knockouts, Romex feedthroughs), mounting features supporting multiple modes of installation, and alignment features to aid the installation of the housing assembly. In one aspect, the housing may be formed from a polymer instead of sheet metal and fabricated using, for example, an injection molding process. Individual parts formed by injection molding can more readily include complex structural features compared to conventional sheet metal forming processes. In some implementations, the polymer housings described herein may also satisfy the various safety standards (e.g., a fire-rating standards), thus obviating the need for a separate fire-rated enclosure. Although the housing assemblies described herein may form part of a lighting system, it should be appreciated that, in some applications, the housing assemblies may also be used to contain only electrical components (e.g., electrical wiring) similar in function as a junction box.

**[0012]** In one aspect, the housings described herein may combine the functions of a conventional can housing and a junction box by containing both a lighting module and receiving electrical wiring from an external power supply system of a building (e.g., the building mains). The housing may include a sidewall and a cover that define a cavity to contain a light source and/or a driver of the lighting module. The housing may also contain electrical wires and/or cables that supply electrical power to the driver (e.g., electrical wires from an external power supply system) and one or more wire splices.

**[0013]** Generally, the housing may be shaped and/or dimensioned to support recessed lighting installations corresponding to different trade sizes (e.g., a 2-inch trade size lighting installation, a 3-inch trade size lighting installation, a 4-inch trade size lighting installation, a 5-inch trade size lighting installation, a 6-inch trade size lighting installation, a 7-inch trade size lighting installation, an 8-inch trade size lighting installation). For example, the housing may have an interior width (e.g., the interior width of the sidewall at the open end of the housing, the maximum interior width of the sidewall) that ranges between about 3 inches to about 6 inches. The housing may also have an exterior depth (e.g., the distance from the open end of the housing to the cover) that ranges between about 4 inches to about 5 inches.

**[0014]** The housing may also have various cross-sectional shapes including, but not limited to, a circle, an ellipse, a square hexagon, a regular polygon (e.g., a polygon where the sides are equal in



Date Reçue/Date Received 2021-07-16

length), an irregular polygon (e.g., a polygon where the sides are not equal in length), or any combinations of the foregoing. In some implementations, the sidewall may also be shaped to facilitate stacking of multiple housings onto one another to increase the packing density during shipment. For example, the sidewall maybe tapered such that the characteristic width of the sidewall near the cover is smaller than the characteristic width of the sidewall at the open end. The width of the sidewall may further increase monotonically from the cover to the open end. In some implementations, the sidewall may also have a stepped profile or geometry where the sidewall is divided into at least three sidewall sections. For example, the sidewall may include a first sidewall section disposed near the cover, a second sidewall section joined to the first sidewall section, and a third sidewall section joined to the second sidewall section and including the open end. The first sidewall section may be dimensioned to have an exterior width that is smaller than an interior width of the third sidewall section. In this manner, the first sidewall section of one housing may fit within the portion of the cavity defined by the third sidewall section of another housing. The second sidewall section may further form a step upon which the bottom end of one housing may rest on the second sidewall section of another housing.

**[0015]** The housing may further include one or more removable knockouts and/or bendable Romex feedthrough tabs to receive a non-metallic sheathed cable (e.g., a Romex cable) or a metallic sheathed cable (e.g., a metal conduit) from the external power supply system, another lighting system in a daisy-chain configuration, or a separate junction box. In some implementations, the knockouts and/or the Romex feedthroughs may support electrical wiring that supplies electrical power to another lighting system in a daisy-chain configuration. The cables and/or wires may provide alternating current (AC) or direct current (DC) at standard voltages of at least about 120V. In some implementations, the housing may be dimensioned to have a cavity with sufficient volume to contain one or more wire splices for wires of varying gauge. For example, the housing may be dimensioned to comply with the requirements set forth in Article 314 of the 2020 NEC and, in particular, Section 314.16 entitled, "Number of Conductors in Outlet, Device, and Junction Boxes, and Conduit Bodies."

**[0016]** In some implementations, the housing may be designed for a new construction installation where the housing assembly is installed into a ceiling space prior to be enclosed by a drywall panel. Specifically, the housing may include one or more bar hanger holders integrally formed along the sidewall where each bar hanger holder supports and guides a respective pair of bar hangers to



Date Reçue/Date Received 2021-07-16

facilitate installation onto two support structures (e.g., a wood/metal joist or stud, a T-bar). The housing may also include an integrally formed fastener opening for each bar hanger holder to receive a locking fastener to lock the housing and the bar hangers in place. The housing may also include one or more notches formed along an open end of the housing to align the housing to other structures in the environment (e.g., another housing assembly). The housing assembly may thus include corresponding pairs of bar hangers supported by the bar hanger holders of the housing that each have a bar hanger head to mount the housing assembly onto the support structure via, for example, one or more fasteners.

**[0017]** The housing may also include one or more nail-in features joined to the sidewall to enable installation of the housing onto a single support structure. Specifically, the nail-in features may define a through hole to support and guide a fastener (e.g., a nail, a screw, a scrail) to directly attach the housing to the support structure. In some implementations, the fastener may be a wood screw specifically tailored to engage and fasten to a wood joist. The housing may further include one or more alignment features to align the housing to the support structure during installation. For example, the housing may include a mounting platform, a lip, one or more ribs, and/or one or more tabs protruding from the sidewall to physically contact one or more sides and/or corners of the support structure. In this manner, the housing may support several modes of installation (e.g., using an individual or multiple support structures).

**[0018]** In some implementations, the housing may include two nail-in features that are oriented at acute angles such that the two fasteners, when inserted through the corresponding through holes of the nail-in features and attached to the support structure, more stably support the housing. In some implementations, the nail-in features may be further angled upwards or downwards (when installing the housing into a ceiling space) to provide additional clearance for a tool (e.g., a hammer) to contact the fasteners.

**[0019]** In some implementations, the housing may be designed for a remodel installation where the housing assembly is inserted through an opening in a drywall panel and directly mounted to the drywall panel without requiring removal of the drywall panel. The housing may include a flange integrally formed on the open end of the housing to physically contact a bottom surface of the drywall panel (e.g., the surface facing an interior environment illuminated by the recessed lighting system). The housing assembly may include one or more spring clips mounted directly to



Date Reçue/Date Received 2021-07-16

the housing to physically contact a top surface of the drywall panel (e.g., the surface facing the ceiling space) when actuated. In this manner, the flange and the spring clips may securely couple the housing to the drywall panel. In some implementations, the housing may include openings formed along the sidewall to receive a portion of a corresponding spring clip to enable actuation of the spring clip from within the cavity of the housing and, by extension, through the open end of the housing once the housing is inserted through the opening of the drywall panel.

**[0020]** As noted above, the housings described herein are formed from a polymer, which provides greater flexibility in terms of manufacturability compared to conventional housings formed from sheet metal. For example, the housing may be fabricated using injection molding processes, which allows the housing to have more complex-shaped features (e.g., a circularly shaped sidewall and cavity, the bar hanger holders, the nail-in features, the knockouts and/or feedthrough tabs). The housing may be formed from various thermoplastic and thermosetting polymers including, but not limited to, polyvinyl chloride (PVC), acrylonitrile butadiene styrene (ABS), polycarbonate (PC), polyurethane (PU), polyethylene, polyethylene terephthalate, polypropylene, and polystyrene.

**[0021]** Polymer housings, when compared to conventional metal housings, are generally lighter weight, which can improve ease of handling during installation, and lower cost. Polymer housings may also more readily meet various safety standards. For example, polymer materials are generally more thermally insulating than metals and thus provide a more effective heat barrier to reduce the transfer of heat generated by the light source and/or the driver to other materials in the ceiling space (e.g., building thermal insulation materials). In some implementations, the housing may satisfy various fire-rating safety standards set forth by various organizations including, but not limited to, the NEC, the UL, the American Society for Testing and Materials (ASTM), and the National Fire Protection Association (NFPA).

**[0022]** Although the exemplary remodel and new construction installations of the housings and housing assemblies described herein are for a ceiling installation, it should be appreciated the same or similar housings and housing assemblies may be installed on a wall or a floor. Furthermore, the housings and housing assemblies are not limited for use with a drywall panel, but may also be used with a wood panel, and flooring materials.

**[0023]** It should be appreciated that all combinations of the foregoing concepts and additional concepts discussed in greater detail below (provided such concepts are not mutually inconsistent)



Date Reçue/Date Received 2021-07-16

are contemplated as being part of the inventive subject matter disclosed herein. In particular, all combinations of claimed subject matter appearing at the end of this disclosure are contemplated as being part of the inventive subject matter disclosed herein. It should also be appreciated that terminology explicitly employed herein that also may appear in any disclosure incorporated by reference should be accorded a meaning most consistent with the particular concepts disclosed herein.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0024]** The skilled artisan will understand that the drawings primarily are for illustrative purposes and are not intended to limit the scope of the inventive subject matter described herein. The drawings are not necessarily to scale; in some instances, various aspects of the inventive subject matter disclosed herein may be shown exaggerated or enlarged in the drawings to facilitate an understanding of different features. In the drawings, like reference characters generally refer to like features (e.g., functionally similar and/or structurally similar elements).

**[0025]** FIG. 1A shows a top, left, rear perspective view of an exemplary housing assembly for a new construction installation of a 3-inch trade size lighting system.

**[0026]** FIG. 1B shows a top, right, front perspective view of the housing assembly of FIG. 1A.

**[0027]** FIG. 1C shows a bottom, left, rear perspective view of the housing assembly of FIG. 1A.

**[0028]** FIG. 1D shows a top view of the housing assembly of FIG. 1A.

**[0029]** FIG. 1E shows a bottom view of the housing assembly of FIG. 1A.

**[0030]** FIG. 1F shows a front view of the housing assembly of FIG. 1A.

**[0031]** FIG. 1G shows a right-side view of the housing assembly of FIG. 1A.

**[0032]** FIG. 1H shows a left-side view of the housing assembly of FIG. 1A.

**[0033]** FIG. 1I shows an exploded top, left, front perspective view of the housing assembly of FIG. 1A.

**[0034]** FIG. 1J shows an exploded bottom, right, rear perspective view of the housing assembly of FIG. 1A.



Date Reçue/Date Received 2021-07-16

**[0035]** FIG. 1K shows a magnified exploded bottom, right, rear perspective view of the housing assembly of FIG. 1A without the bar hanger assemblies.

**[0036]** FIG. 1L shows a cross-sectional view of the housing assembly corresponding to the plane A-A of FIG. 1F.

**[0037]** FIG. 1M shows a cross-sectional view of the housing assembly corresponding to the plane B-B of FIG. 1F.

**[0038]** FIG. 2A shows a top, left, rear perspective view of the housing in the housing assembly of FIG. 1A.

**[0039]** FIG. 2B shows a bottom, right, rear perspective view of the housing of FIG. 2A.

**[0040]** FIG. 2C shows a top view of the housing of FIG. 2A.

**[0041]** FIG. 2D shows a bottom view of the housing of FIG. 2A.

**[0042]** FIG. 2E shows a front view of the housing of FIG. 2A.

**[0043]** FIG. 2F shows a right-side view of the housing of FIG. 2A.

**[0044]** FIG. 2G shows a left-side view of the housing of FIG. 2A.

**[0045]** FIG. 2H shows a cross-sectional right-side view of the housing corresponding to the plane A-A of FIG. 2E.

**[0046]** FIG. 2I shows a cross-sectional rear view of the housing corresponding to the plane B-B of FIG. 2F.

**[0047]** FIG. 2J shows a cross-sectional bottom perspective view of the housing corresponding to the plane C-C of FIG. 2G.

**[0048]** FIG. 3A shows a magnified front, right perspective view of the bar hanger holder and the nail-in feature of FIG. 2A.

**[0049]** FIG. 3B shows a magnified top view of the bar hanger holder and the nail-in feature of FIG. 3A.

**[0050]** FIG. 3C shows a magnified bottom view of the bar hanger holder and the nail-in feature of FIG. 3A.



Date Reçue/Date Received 2021-07-16

**[0051]** FIG. 3D shows a magnified front view of the bar hanger holder and the nail-in feature of FIG. 3A.

**[0052]** FIG. 3E shows a magnified right-side view of the bar hanger holder and the nail-in feature of FIG. 3A.

**[0053]** FIG. 4A shows a top, left, front perspective view of a bar hanger assembly in the housing assembly of FIG. 1A.

**[0054]** FIG. 4B shows a magnified front view of a bar hanger head in the bar hanger assembly of FIG. 4A.

**[0055]** FIG. 4C shows a magnified right-side view of the bar hanger head in the bar hanger assembly of FIG. 4A.

**[0056]** FIG. 5A shows a perspective view of the housing assembly of FIG. 1A aligned to a pair of wood joists prior to being installed onto the wood joists.

**[0057]** FIG. 5B shows a perspective view of the housing assembly of FIG. 5A coupled to the wood joists via the bar hanger assemblies.

**[0058]** FIG. 5C shows a front view of the housing assembly of FIG. 5B.

**[0059]** FIG. 6A shows a perspective view of the housing assembly of FIG. 1A coupled to a pair of T-bars via the bar hanger assemblies.

**[0060]** FIG. 6B shows a front view of the housing assembly of FIG. 6A.

**[0061]** FIG. 7A shows a perspective view of the housing assembly of FIG. 1A directly coupled to a wood joist using the nail-in features. The bar hanger assemblies are removed.

**[0062]** FIG. 7B shows a front view of the housing assembly of FIG. 7A.

**[0063]** FIG. 7C shows a top view of the housing assembly of FIG. 7A.

**[0064]** FIG. 8A shows a front view of another exemplary housing assembly with a gasket disposed on the sidewall of the housing. The bar hanger assemblies are not shown for clarity.

**[0065]** FIG. 8B shows a right-side view of the housing assembly of FIG. 8A.

**[0066]** FIG. 8C shows a left-side view of the housing assembly of FIG. 8A.



Date Reçue/Date Received 2021-07-16

**[0067]** FIG. 9A shows a front view of another exemplary housing assembly with a gasket disposed on the sidewall and abutting the mounting platform and the bar hanger holders. The bar hanger assemblies are not shown for clarity.

**[0068]** FIG. 9B shows a right-side view of the housing assembly of FIG. 9A.

**[0069]** FIG. 9C shows a left-side view of the housing assembly of FIG. 9A.

**[0070]** FIG. 10A shows a bottom, right, rear perspective view of another housing assembly where the housing is supported by at least one pipe or electric metallic tube (EMT).

**[0071]** FIG. 10B shows a right-side view of the housing assembly of FIG. 10A.

**[0072]** FIG. 11A shows a top, left, rear perspective view of another exemplary housing for a new construction installation of a 3-inch trade size lighting system.

**[0073]** FIG. 11B shows a bottom, right, front perspective view of the housing of FIG. 11A.

**[0074]** FIG. 11C shows a top view of the housing of FIG. 11A.

**[0075]** FIG. 11D shows a bottom view of the housing of FIG. 11A.

**[0076]** FIG. 11E shows a front-side view of the housing of FIG. 11A.

**[0077]** FIG. 11F shows a left-side view of the housing of FIG. 11A.

**[0078]** FIG. 11G shows a right-side view of the housing of FIG. 11A.

**[0079]** FIG. 11H shows a cross-sectional right-side view of the housing corresponding to the plane A-A of FIG. 11E.

**[0080]** FIG. 11I shows a cross-sectional front-side view of the housing corresponding to the plane B-B of FIG. 11G.

**[0081]** FIG. 12A shows a top, left, rear perspective view of another housing for a new construction installation of a 3-inch trade size lighting system.

**[0082]** FIG. 12B shows a bottom, right, front perspective view of the housing in FIG. 12A.

**[0083]** FIG. 12C shows a top view of the housing in FIG. 12A.

**[0084]** FIG. 12D shows a bottom view of the housing in FIG. 12A.

**[0085]** FIG. 12E shows a front view of the housing in FIG. 12A.



Date Reçue/Date Received 2021-07-16

**[0086]** FIG. 12F shows a left-side view of the housing in FIG. 12A.

**[0087]** FIG. 12G shows a right-side view of the housing in FIG. 12A.

**[0088]** FIG. 12H shows a cross-sectional right-side view of the housing corresponding to the plane A-A of FIG. 12E.

**[0089]** FIG. 12I shows a cross-sectional front-side view of the housing corresponding to the plane B-B of FIG. 12F.

**[0090]** FIG. 13 shows a cross-sectional right-side view of two of the housings of FIG. 12A stacked on top of one another where the cross-section plane corresponds to the plane A-A of FIG. 12E.

**[0091]** FIG. 14A shows a top, right, front perspective view of an exemplary housing assembly that includes the housing of FIG. 12A and bar hangers to couple to two or more support structures.

**[0092]** FIG. 14B shows a bottom view of the housing assembly of FIG. 14A.

**[0093]** FIG. 14C shows a cross-sectional left-side view of the housing assembly of FIG. 14A corresponding to the plane A-A of FIG. 14B.

**[0094]** FIG. 14D shows a cross-sectional front view of the housing assembly of FIG. 14A corresponding to the plane B-B of FIG. 14B.

**[0095]** FIG. 15A shows a top, front, left perspective view of an exemplary housing assembly that includes the housing of FIG. 12A and fasteners to couple to one support structure.

**[0096]** FIG. 15B shows a top, rear, right perspective view of the housing assembly of FIG. 15A.

**[0097]** FIG. 15C shows a front view of the housing assembly of FIG. 15A where the housing assembly is mounted to the support structure.

**[0098]** FIG. 16A shows a top, left, rear perspective view of an exemplary housing for a new construction installation of a 4-inch trade size lighting system.

**[0099]** FIG. 16B shows a bottom, right, front perspective view of the housing of FIG. 16A.

**[0100]** FIG. 16C shows a top view of the housing of FIG. 16A.

**[0101]** FIG. 16D shows a bottom view of the housing of FIG. 16A.

**[0102]** FIG. 16E shows a front-side view of the housing of FIG. 16A.



Date Reçue/Date Received 2021-07-16

**[0103]** FIG. 16F shows a left-side view of the housing of FIG. 16A.

**[0104]** FIG. 16G shows a right-side view of the housing of FIG. 16A.

**[0105]** FIG. 16H shows a cross-sectional right-side view of the housing corresponding to the plane A-A of FIG. 16E.

**[0106]** FIG. 16I shows a cross-sectional front-side view of the housing corresponding to the plane B-B of FIG. 16G.

**[0107]** FIG. 17A shows a top, left, rear perspective view of another housing for a new construction installation of a 4-inch trade size lighting system.

**[0108]** FIG. 17B shows a bottom, right, front perspective view of the housing in FIG. 17A.

**[0109]** FIG. 17C shows a top view of the housing in FIG. 17A.

**[0110]** FIG. 17D shows a bottom view of the housing in FIG. 17A.

**[0111]** FIG. 17E shows a front view of the housing in FIG. 17A.

**[0112]** FIG. 17F shows a left-side view of the housing in FIG. 17A.

**[0113]** FIG. 17G shows a right-side view of the housing in FIG. 17A.

**[0114]** FIG. 17H shows a cross-sectional right-side view of the housing corresponding to the plane A-A of FIG. 17E.

**[0115]** FIG. 17I shows a cross-sectional front-side view of the housing corresponding to the plane B-B of FIG. 17F.

**[0116]** FIG. 18 shows a cross-sectional right-side view of two of the housings of FIG. 17A stacked on top of one another where the cross-section plane corresponds to the plane A-A of FIG. 17E.

**[0117]** FIG. 19A shows a top, right, front perspective view of an exemplary housing assembly that includes the housing of FIG. 17A and bar hangers to couple to two or more support structures.

**[0118]** FIG. 19B shows a bottom, left, front perspective view of the housing assembly of FIG. 19A.

**[0119]** FIG. 20A shows a top, front, left perspective view of an exemplary housing assembly that includes the housing of FIG. 17A and fasteners to couple to one support structure.



Date Reçue/Date Received 2021-07-16

**[0120]** FIG. 20B shows a top, rear, right perspective view of the housing assembly of FIG. 20A.

**[0121]** FIG. 21A shows a top, left, rear perspective view of an exemplary housing assembly for a remodel installation of a 3-inch trade size lighting system.

**[0122]** FIG. 21B shows a bottom, right, front perspective view of the housing assembly of FIG. 21A.

**[0123]** FIG. 21C shows a top view of the housing assembly of FIG. 21A.

**[0124]** FIG. 21D shows a bottom view of the housing assembly of FIG. 21A.

**[0125]** FIG. 21E shows a front view of the housing assembly of FIG. 21A.

**[0126]** FIG. 21F shows a right-side view of the housing assembly of FIG. 21A.

**[0127]** FIG. 21G shows a cross-sectional front-side view of the housing of FIG. 21A corresponding to the plane A-A of FIG. 21F.

**[0128]** FIG. 21H shows a cross-sectional right-side view of the housing of FIG. 21A corresponding to the plane B-B of FIG. 21E.

**[0129]** FIG. 21I shows an exploded top, right, front perspective view of the housing assembly of FIG. 21A.

**[0130]** FIG. 22A shows a top, front, left perspective view of a spring clip in the housing assembly of FIG. 21A.

**[0131]** FIG. 22B shows a front view of the spring clip of FIG. 22A.

**[0132]** FIG. 23A shows a cross-sectional view of the housing assembly of FIG. 21A corresponding to the plane A-A of FIG. 21F where the housing is inserted into an opening of a ceiling.

**[0133]** FIG. 23B shows the cross-sectional view of 23A where the spring clips are pushed outwards to engage a top surface of the ceiling.

**[0134]** FIG. 23C shows the cross-sectional view of 23B where the spring clips are locked in place onto the housing after engagement with the ceiling.

**[0135]** FIG. 24A shows a top, left, rear perspective view of an exemplary housing assembly for a remodel installation of a 4-inch trade size lighting system.



Date Reçue/Date Received 2021-07-16

**[0136]** FIG. 24B shows a bottom, right, front perspective view of the housing assembly of FIG. 24A.

**[0137]** FIG. 24C shows a top view of the housing assembly of FIG. 24A.

**[0138]** FIG. 24D shows a bottom view of the housing assembly of FIG. 24A.

**[0139]** FIG. 24E shows a front view of the housing assembly of FIG. 24A.

**[0140]** FIG. 24F shows a right-side view of the housing assembly of FIG. 24A.

**[0141]** FIG. 24G shows a cross-sectional front-side view of the housing of FIG. 24A corresponding to the plane A-A of FIG. 24F.

**[0142]** FIG. 24H shows a cross-sectional right-side view of the housing of FIG. 24A corresponding to the plane B-B of FIG. 24E.

**[0143]** FIG. 24I shows an exploded top, right, front perspective view of the housing assembly of FIG. 24A.

## DETAILED DESCRIPTION

**[0144]** Following below are more detailed descriptions of various concepts related to, and implementations of, a housing for a recessed lighting system with integrally formed cable routing features, mounting features, and alignment features, such as an integrated bar hanger holder, an integrated nail-in feature, a flange, and/or knockouts and Romex feedthroughs. It should be appreciated that various concepts introduced above and discussed in greater detail below may be implemented in multiple ways. Examples of specific implementations and applications are provided primarily for illustrative purposes so as to enable those skilled in the art to practice the implementations and alternatives apparent to those skilled in the art.

**[0145]** The figures and example implementations described below are not meant to limit the scope of the present implementations to a single embodiment. Other implementations are possible by way of interchange of some or all of the described or illustrated elements. Moreover, where certain elements of the disclosed example implementations may be partially or fully implemented using known components, in some instances only those portions of such known components that are necessary for an understanding of the present implementations are described, and detailed



Date Reçue/Date Received 2021-07-16

descriptions of other portions of such known components are omitted so as not to obscure the present implementations.

**[0146]** In the discussion below, various examples of inventive housing assemblies are provided, wherein a given example or set of examples showcases one or more particular features of a housing assembly that includes a polymer housing with a bar hanger holder, a nail-in feature, a flange, a knockout, a feedthrough tab, ribs for alignment during installation, tabs for alignment during installation as well as spring clips. It should be appreciated that one or more features discussed in connection with a given example of a housing assembly may be employed in other examples of housing assemblies according to the present disclosure, such that the various features disclosed herein may be readily combined in a given housing assembly according to the present disclosure (provided that respective features are not mutually inconsistent).

**[0147]** Certain dimensions and features of the housing assembly, the housing, the bar hangers, and/or the spring clips are described herein using the terms "approximately," "about," "substantially," and/or "similar." As used herein, the terms "approximately," "about," "substantially," and/or "similar" indicates that each of the described dimensions or features is not a strict boundary or parameter and does not exclude functionally similar variations therefrom. Unless context or the description indicates otherwise, the use of the terms "approximately," "about," "substantially," and/or "similar" in connection with a numerical parameter indicates that the numerical parameter includes variations that, using mathematical and industrial principles accepted in the art (e.g., rounding, measurement or other systematic errors, manufacturing tolerances, etc.), would not vary the least significant digit.

**A Housing Assembly for a New Construction Installation**

**[0148]** FIGS. 1A-1M show several views of an exemplary housing assembly 1000a with a housing 1100a for a new construction installation of a 3-inch trade size lighting system. In a typical new construction installation, the housing assembly 1000a is installed before the construction of the environment is complete. For example, a ceiling space may have exposed support structures (e.g., a wood/metal joist or stud, a T-bar, a hat channel) before a drywall panel is installed to enclose the ceiling space. The housing assembly 1000a may be first mounted to one or more of the support structures. Once the housing assembly 1000a is installed, various electrical wiring and/or cabling may be routed into the housing and the drywall panel may then be installed to enclose the ceiling



Date Reçue/Date Received 2021-07-16

space and the support structures. An opening may then be cut to reveal the housing 1100a and a light source (not shown) and associated electronics, such as a driver (not shown), may then be inserted into the housing 1100a and electrically coupled to an external electrical power supply system (e.g., building mains, another lighting system).

**[0149]** In some implementations, the housing may be tailored in shape and/or dimensions to accommodate a particular trade size. For example, the housing 1100a may be a 3-inch housing (i.e., the housing 1100a has a 3-inch trade size) that may be used as part of a 3-inch lighting installation where the housing 1100a may fit into an opening formed in a ceiling having, for example, a diameter ranging between about 3 inches to about 3.5 inches. It should be appreciated the housing 1100a may be used in installations with a different trade size (e.g., a 2-inch trade size lighting installation, a 3-inch trade size lighting installation, a 4-inch trade size lighting installation, a 5-inch trade size lighting installation, a 6-inch trade size lighting installation, a 7-inch trade size lighting installation, an 8-inch trade size lighting installation) where the diameter of the opening in the ceiling is scaled according to the trade size. It should also be appreciated that the housing 1100a may be scaled in size such that the housing has a trade size that ranges between 2 inches to 8 inches.

**[0150]** As shown, the housing 1100a defines a cavity 1104 and has an opening 1102 providing access into the cavity 1104. During installation of the lighting system, the lighting components (e.g., the light source, the driver) are inserted into the cavity through the opening 1102. During operation of the lighting system, the light source emits light through the opening 1102 and into the environment being illuminated. In some implementations, the lighting components may be packaged as a lighting module to improve ease of handling and installation. For example, the lighting module may include a separate module housing (also referred to herein as a "secondary housing") that supports and substantially contains the light source and/or the driver. In this manner, the module housing, together with the light source and/or the driver, may be inserted through the opening 1102 and into the cavity 1104 during assembly and/or subsequent replacement.

**[0151]** The housing 1100a may also contain, in part, a trim (not shown) to cover the opening 1102 and the opening formed in the ceiling through which the housing 1100a is disposed. In some implementations, the lighting module may not be directly coupled to the housing 1100a (e.g., the lighting module does not physically contact the housing 1100a). Instead, the lighting module may



Date Reçue/Date Received 2021-07-16

be coupled to the housing 1100a via the trim. For example, the lighting module may be coupled to the trim via a first coupling mechanism (e.g., a twist and lock mechanism, a snap-fit connector) and the trim, in turn, may include a second coupling mechanism (e.g., a friction clip, a spring clip, a sharp clip (e.g., a mechanism that bites into the housing 1100a), a snap-fit connection, and a screw fastener) to couple the trim to the sidewall 1110a of the housing 1100a. During installation, the lighting module and the trim may be inserted into the cavity 1104 together through the opening 1102 of the housing 1100a. In some implementations, the lighting module may include an integrated trim (e.g., the trim is formed as part of the module housing) to reduce the number of parts for assembly of the lighting system. As before, the lighting module with the integrated trim may be inserted into the housing 1100a as a single unit.

**[0152]** The housing 1100a may further include one or more knockouts 1122 and/or Romex feedthrough tabs 1132 to route electrical cables and wires into the cavity 1104 to supply electrical power to the light source. In some implementations, the electrical cables and wires may transmit electrical power to another lighting system in a daisy-chain configuration.

**[0153]** To mount the housing 1100a to one or more support structures, the housing 1100a may include integrally formed bar hanger holders 1160a-1 and 1160a-2 (collectively referred to herein as a "bar hanger holder 1160a") to support and guide corresponding bar hanger assemblies 1200-1 and 1200-2, respectively. The bar hanger assemblies 1200-1 and 1200-2 (collectively referred to herein as "a bar hanger assembly 1200") may each include a pair of bar hangers 1210-1 and 1210-2 with bar hanger heads 1220-1 and 1220-2, respectively, to couple the housing 1100a to two (or more) support structures using, for example, corresponding fasteners 1222.

**[0154]** The bar hangers 1210-1 and 1210-2 may be slidably coupled to the bar hanger holder 1160a and telescopically slidable with respect to each other. In this manner, the length of the bar hanger assemblies 1200-1 and 1200-2 may be adjusted to traverse a gap between two support structures in the environment. The position of the housing 1100a along the bar hanger assemblies 1200-1 and 1200-2 may also be adjusted to place the housing 1100a at a desired location in the environment. The housing 1100a may further include integrally formed fastener openings 1170 for each bar hanger holder 1160a to receive corresponding locking fasteners 1020 to lock the position of the housing 1100a along the bar hanger assemblies 1200-1 and 1200-2. Said in another way, the



Date Reçue/Date Received 2021-07-16

fastener 1020 prevents the housing 1100a from sliding along the bar hangers 1210-1 and 1210-2 when sufficiently tightened.

**[0155]** The housing 1100a may also include integrally formed nail-in features 1150a-1 and 1150a-2 (collectively referred to herein as a "nail-in feature 1150") to directly mount the housing 1100a to a single support structure. Each nail-in feature 1150 may include a cylindrical wall 1153 that defines a through hole 1152 to receive a fastener 1010. During installation, the fasteners 1010 may be inserted into corresponding through holes 1152 and into the support structure (e.g., a joist) to securely couple the housing 1100a to the support structure. In this manner, the placement and orientation of the nail-in features 1150a-1 and 1150a-1 may provide multiple attachment points to couple the housing 1100a to a single support structure.

**[0156]** It should be appreciated that some of the components of the housing assembly 1000a may be excluded during installation or when sold as a product depending, in part, on the desired mode of installation. For example, the housing assembly 1000a may not include the fasteners 1010 if the bar hanger assemblies 1200a and 1200b are used for installation. Similarly, the housing assembly 1000a may not include the bar hanger assemblies 1200-1 and 1200-2 and the fasteners 1020 and 1222 if the nail-in features 1150a are used for installation.

**[0157]** FIGS. 2A-2J show several views of the housing 1100a. As shown, the housing 1100a may include a sidewall 1110a and a cover 1120a (also referred to herein as a "cover section 1120a") that together define the cavity 1104 and the opening 1102. Specifically, the sidewall 1110a may have a first end 1111-1 that includes an interior edge 1112 defining the opening 1102. The sidewall 1110a may also include a second end 1111-2 joined to the cover 1120a. In some implementations, the cover 1120a may include a base end 1121 and a tapered wall 1130 that joins the base end 1121 to the sidewall 1110a as shown in FIG. 2A.

**[0158]** The cover 1120a may generally conform in shape with the sidewall 1110a. For example, the housing 1100a may be substantially cylindrical in shape (e.g., the sidewall 1110a may have a substantially circular or circular cross-sectional shape). The base end 1121 and the tapered wall 1130 may similarly have a circular shape. It should be appreciated, however, that the housing 1100a may have other shapes. Generally, the sidewall 1110a may have a cross-section that has various shapes including, but not limited to, a circle, an ellipse, a square hexagon, a regular polygon (e.g., a polygon where the sides are equal in length), an irregular polygon (e.g., a polygon



Date Reçue/Date Received 2021-07-16

where the sides are not equal in length), or any combinations of the foregoing. In some implementations, the at least a portion of the sidewall 1110a may have a cross-section shaped as an annulus (i.e., concentric circles) corresponding to the interior and exterior sides of the sidewall 1110a.

**[0159]** In some implementations, the sidewall 1110a may also have a tapered profile. For example, FIGS. 2E and 2F show the sidewall 1110a may include a first sidewall section 1110a-1 joined to the cover 1120a and a second sidewall section 1110a-2 joined to the first sidewall section 1110a-1 and the first end 1111-1. As shown, the first sidewall section 1110a-1 may be tapered (i.e., have a draft angle) such that the exterior width increases monotonically from the cover 1120a to the second sidewall section 1110a-2. The second sidewall section 1110a-2 may be tapered such that the exterior width increases monotonically from the first end 1111-1 to the first sidewall section 1110a-1. In other words, the largest exterior width of the sidewall 1100a may occur where the first and second sidewall sections 1110a-1 and the 1110a-2 meet. FIGS. 2H and 2I further show the sidewall 1110a may have an interior width that monotonically increases from the second end 1111-2 to the first end 1111-1. In other words, the thickness of the sidewall 1110a may vary due to the tapered profile along its exterior surface.

**[0160]** The tapered profile may help to improve manufacturability of the housing 1100a. For example, the housing 1100a may be formed of injection molded plastic using a first mold covering the first sidewall section 1110a-1 and a second mold covering the second sidewall section 1110a-2. The tapered profile may aid the removal of the respective molds after the housing 1100a is formed.

**[0161]** In some implementations, tapered profile may also facilitate stacking of multiple housings 1100a onto to one another to increase the packing density during shipment. For example, the exterior width of the first sidewall section 1110a-1 near the cover 1120a may be smaller than the interior width of the second sidewall section 1110a-2 near the first end 1111-1 such that the top portion of the housing 1100a encompassing the cover 1120a and at least a portion of the first sidewall section 1110a-1 may fit within the bottom portion of the cavity 1104 of another housing 1100a. Additional examples of a sidewall profile to facilitate stacking of housings will be discussed in further detail below (see, for example, the housing 1100e).



Date Reçue/Date Received 2021-07-16

**[0162]** As described above, the housing 1100a may also be shaped and/or dimensioned to provide a sufficiently large cavity 1104 to contain the various lighting components (e.g., the lighting module), at least a portion of the trim (not shown), and/or one or more wire splices and corresponding wires. In some implementations, the housing 1100a may contain a lighting module that has an exterior width of about 3 inches. In order to provide sufficient clearance for the lighting module and the trim, the cavity 1104 may have an interior width ($D_{int}$) that is about 3.25 inches. It should be appreciated the housing 1100a may be scaled in size to accommodate different-sized lighting modules. For example, the lighting modules may generally have an exterior width that ranges between about 3 inches and about 4 inches. The interior width ($D_{int}$) of the cavity 1104 may generally range between about 3 inches to about 6 inches.

**[0163]** The housing 1100a may also have an exterior depth ($H_{ext}$) chosen in part, to accommodate smaller, more confined spaces in the ceiling while providing a sufficiently deep cavity 1104 for the desired trade size of the installation. For example, the exterior depth may be chosen such that the lighting module is positioned at a sufficient distance from the opening 1102 to reduce glare. The housing 1100a may have an exterior depth ($H_{ext}$) of about 4.5 inches to accommodate the 3-inch trade size lighting installation. More generally, the exterior depth ($H_{ext}$) of the housing 1100a may range between about 4 inches and about 5 inches.

**[0164]** The term "about," when used to describe the various dimensions of the housing 1100a, is intended to cover manufacturing tolerances. For example, "about 3 inches" may correspond to the following dimensional ranges: 2.97 to 3.03 inches (+/- 1% tolerance), 2.976 to 3.024 inches (+/- 0.8% tolerance), 2.982 to 3.018 inches (+/- 0.6% tolerance), 2.988 to 3.012 inches (+/- 0.4% tolerance), 2.994 to 3.006 inches (+/- 0.2% tolerance).

**[0165]** In some implementations, the dimensions of the housing 1100a and, by extension, the volume of the cavity 1104 may be chosen based on the number and/or the size of the cables, wires, and/or conductors that are routed into the housing 1100a and disposed within the remaining, unoccupied portion of the cavity 1104 after a lighting module and/or a portion of the trim are inserted into the cavity 1104 of the housing 1100a. Said in another way, the housing 1100a may be dimensioned to provide a desired volume allowance (i.e., the available free space within the cavity 1104) for each cable, wire, and/or conductor disposed within the housing 1100a.



Date Reçue/Date Received 2021-07-16

**[0166]** For example, the dimensions of the housing 1100a may be chosen to comply with the requirements set forth in Article 314 of the 2020 NEC and, in particular, Section 314.16 entitled, "Number of Conductors in Outlet, Device, and Junction Boxes, and Conduit Bodies." For instance, the housing 1100a may be dimensioned such that, after a lighting module and/or at least a portion of the trim are inserted into the housing 1100a, the remaining portion of the cavity 1104 provides a volume allowance of 1.5 cubic inches for each 18 AWG conductor disposed within the cavity 1104 and/or a volume allowance of 5.0 cubic inches for each 6 AWG conductor disposed within the cavity 1104. Said in another way, the housing 1100a may be dimensioned such that the remaining space within the cavity 1104 after the lighting module and the trim are installed is sufficient to contain (1) three 12 AWG wires, cables, and/or conductors (e.g., a load wire, a neutral wire, a ground wire) that are routed into the housing 1100e and (2) three 12 AWG wires, cables, and/or conductors that are routed out of the housing 1100e for connection with another lighting system or an electrical switch. It should be appreciated that wires, cables, and/or conductors of different size (e.g., 14 AWG, 22 AWG) may also be routed into or out of the housing 1100a as well.

**[0167]** The housing 1100a may include one or more knockouts 1122, which may be removed to provide an opening for a cable or a wire (e.g., a metal conduit cable) to be inserted from the environment (e.g., a ceiling space) into the cavity 1104. As shown in FIGS. 2A, 2I, and 2J, the knockouts 1122 may have a thickness smaller than the base end 1121 to facilitate removal. The periphery of the knockouts 1122 may further include one or more recesses, which further reduces the thickness of the knockout 1122 to facilitate removal of the knockout 1122 along its periphery. The dimensions and, in particular, the thickness of the knockout 1122 may be chosen, in part, to facilitate removal by hand (e.g., the user presses onto the knockout until snaps off) or with a tool (e.g., the user uses a hammer or a screwdriver to facilitate removal). The knockouts 1122 may also be positioned so as to not protrude outwards from the interior side and the exterior side of the base end 1121.

**[0168]** FIGS. 2A and 2C also show the knockouts 1122 may be identical. However, it should be appreciated the housing 1100a in other implementations may include different-sized knockouts 1122 to accommodate, for example, different wire gauges, different jacket sizes of the wire, and/or a different number of wires routed through a single knockout. Different sized wires may be used depending on the electrical requirements of the lighting system (e.g., the mains voltage, the current



Date Reçue/Date Received 2021-07-16

rating). Furthermore, the housing 1100a may include multiple knockouts 1122 so that multiple cables and/or wires can pass through the housing assembly 1000a. For example, the housing assembly 1000a may receive wiring from a building power supply or another lighting system through one knockout 1122 and provide wiring through another knockout 1122 to supply electrical power to another lighting system in a daisy-chain configuration.

**[0169]** In some implementations, the housing 1100a may only include one pair of knockouts 1122 disposed on the base end 1121. Additionally, the pair of knockouts 1122 may be arranged such that the housing 1100a has a symmetry plane that bisects each of the knockouts 1122 (e.g., a vertical plane parallel to a front/rear plane of the housing 1100a).

**[0170]** The housing 1100a may also include one or more feedthrough tabs 1132 disposed within corresponding feedthrough openings 1136 formed, in part, on the tapered wall 1130. In some implementations, the feedthrough openings 1136 may extend to include a portion of the sidewall 1110a and the base end 1121. In some implementations, the housing 1100a may include multiple feedthrough openings 1136 arranged around the tapered wall 1130. For example, FIG. 2C shows the housing 1100a may include two feedthrough openings 1136 with feedthrough tabs 1132 disposed diametrically opposite of one another. It should be appreciated, however, the feedthrough tabs 1132 may generally be rotationally offset at any angle with respect to one another along the tapered wall 1130.

**[0171]** The feedthrough tab 1132 may be sufficiently compliant such that it can be bent into the cavity 1104 through the feedthrough opening 1136 such that a cable or a wire (e.g., a non-metallic sheathed cable or a Romex cable) may be inserted from the environment into the cavity 1104 through the feedthrough opening 1136. As shown in FIG. 2E, the feedthrough tabs 1132 may be joined to a portion of the sidewall 1110a located near the tapered wall 1130. Thus, the feedthrough tabs 1132 may bend inwards into the cavity 1104 about an axis intersecting the portion of the sidewall 1110a supporting the feedthrough tabs 1132. Unlike the knockout 1122, the feedthrough tab 1132 is not intended to be removable from the housing 1100a.

**[0172]** In some implementations, the feedthrough tab 1132 may be sufficiently elastic or pre-stressed such that when an external force (e.g., a user's hand, the insertion of a cable or wire) is applied to bend the feedthrough tab 1132 into the cavity 1104, an internal restoring force arises that opposes the external force. When a cable or wire is inserted into the cavity 1104 of the housing



Date Reçue/Date Received 2021-07-16

1100a, the restoring force may cause the feedthrough tab 1132 to contact and press the cable or wire against the base end 1121 of the cover 1120a. In this manner, the combination of the feedthrough tab 1132 and the base end 1121 may function as a clamp to hold the cable or wire in place. In some implementations, the feedthrough tab 1132 and the base end 1121 may also function as a strain relief feature by restraining the cable or wire to the housing 1100a once inserted into the cavity 1104. When a cable or wire is removed and/or is not present, the restoring force may return the feedthrough tab 1132 to its original position.

**[0173]** In some implementations, the interior side of the base end 1121 may also include corresponding catches 1135 disposed proximate to each feedthrough opening 1136. The catch 1135 may be formed as a rib protruding from the base end 1121 that physically contacts the cable or wire when inserted into the cavity 1104 and clamped by the feedthrough tab 1132. FIG. 2H shows the catch 1135 may have a tapered profile that narrows at its tip, which may aid the restraint of the cable or the wire by increasing the pressure applied to the cable or the wire as a result of the restoring force of feedthrough tab 1132. In other words, the reactionary force applied by the catch 1135 in response to the restoring force of the feedthrough tab 1132 exerted onto the cable or the wire is distributed over a smaller area of the cable or the wire.

**[0174]** In some implementations, the feedthrough tab 1132 may also include a mechanical stop 1134-1 that contacts a corresponding mechanical stop 1134-2 disposed on the sidewall 1110a. The mechanical stops 1134-1 and 1134-2 may be arranged and positioned to limit the extent the feedthrough tab 1132 can be bent into the cavity 1104 when an external force is applied. As shown in FIGS. 2D, 2H, and 2J, the mechanical stops 1134-1 and 1134-2 may be formed as ribs that protrude from the interior sides of the feedthrough tab 1132 and the sidewall 1110a, respectively. The mechanical stops 1134-1 and 1134-2 may contact one another when the feedthrough tab 1132 is bent sufficiently far into the cavity 1104. Once the mechanical stops 1134-1 and 1134-2 make contact, the feedthrough tab 1132 is prevented from being bent further into the cavity 1104.

**[0175]** FIGS. 2A and 2C show the knockouts 1122 and the feedthrough tabs 1132 may generally be disposed on or near the cover 1120a, respectively. The placement of the knockouts 1122 and the feedthrough tabs 1132 ensures any cables and/or wires inserted into the cavity 1104 are located near the cover 1120a. This location coincides with a portion of the cavity 1104 where electrical wires may be spliced and/or connected to the driver of the lighting module. In some



Date Reçue/Date Received 2021-07-16

implementations, the knockouts 1122 may only be disposed on the base end 1121 of the cover section 1120a. Additionally, the feedthrough tabs 1132 may only be formed primarily on the tapered wall 1130. This arrangement may improve the ease of manufacture of the housing 1100a by eliminating undercuts and facilitating removal of the housing 1100a from one or more molds similar to the sidewall 1110a.

**[0176]** In some applications, the opening 1102 may provide access to splice and/or connect the electrical wires fed through the knockouts 1122 and/or the feedthrough tabs 1132 before a lighting module is inserted into the housing 1110a. The cables and/or wires inserted through the knockouts 1122 and/or the feedthrough tabs 1132 may generally carry alternating current (AC) or direct current (DC) at standard voltages of at least about 120 V.

**[0177]** In some implementations, the housing 1100a may also include one or more notches 1114 disposed on the first end 1111-1 of the sidewall 1110a. In some implementations, the notches 1114 may be triangular in shape. The notches 1114 may be arranged in pairs that are disposed diametrically opposite from one another along the first end 1111-1 of the housing 1110a. For example, FIG. 2D shows two pairs of notches 1114 that divide the edge 1112 into substantially equal or equal quadrants.

**[0178]** The notches 1114 may be arranged in this manner to facilitate alignment of the housings 1100a to the various support structures and/or other housing assemblies in the environment during installation. For example, multiple housing assemblies 1000a may be installed in an environment and arranged in a row. In order to align the housings 1100a, a laser guide may be used to provide a laser beam that defines an alignment axis. The alignment axis may be based on the desired location of the housings 1100a in the environment or may be used to locate an axis of one housing 1100a that is already installed in the environment. When installing the housing assemblies 1000a, the position of each housing 1100a may be adjusted such that the laser beam passes through a respective pair of notches 1114. In this manner, the housings 1100a may be aligned along a common axis within the environment.

**[0179]** FIGS. 3A-3E show additional views of the bar hanger holders 1160a on the housing 1100a. As shown, each bar hanger holder 1160a generally includes structural features that define a passageway 1172 that allows the bar hangers 1210-1 and 1210-2 to slidably move along a longitudinal direction of the bar hanger assembly 1200 with respect to the housing 1100a. In some



Date Reçue/Date Received 2021-07-16

implementations, the bar hanger older 1160a may also limit or, in some instances, mitigate (1) unwanted lateral motion (i.e., lateral play) of the bar hangers 1210-1 and 1210-2 with respect to the housing 1100a and (2) unwanted lateral motion between the bar hangers 1210-1 and 1210-2.

**[0180]** For example, FIG. 3A shows the bar hanger holder 1160a may include a first tab 1162a, a second tab 1164a, and a third tab 1166a that together define the passageway 1172 through which the bar hangers 1210-1 and 1210-2 move longitudinally. In some implementations, the passageway 1172 defined by the bar hanger older 1160a may have a length (e.g., the distance between the left side of the second tab 1164a and the right side of the first tab 1162a of the bar hanger older 1160a-2) of about 2 inches. More generally, the length of the passageway 1172 may range between about 2 inches and about 3 inches.

**[0181]** As shown in FIG. 3E, the first and second tabs 1162a and 1164a may form a U-shaped structure that extends from the sidewall 1110a to support and constrain the top, front, and rear sides of the bar hangers 1210-1 and 1210-2. As shown, the U-shaped structure may include a first section 1161 joined to the sidewall 1110a, a second section 1163 joined to the first section 1161 and protruding outwards away from the sidewall 1110a, and a third section 1165 joined to the second section 1163. The first and third sections 1161 and 1165 may physically contact the front and rear sides of the bar hangers 1210-1 and 1210-2 while the second section 1163 may physically contact the top side of the bar hangers 1210-1 and 1210-2. The third tab 1166a may similarly extend from the sidewall 1110a and form a L-shaped structure that supports and constrains the bottom side and one of the front or rear sides (e.g., the side nearest the sidewall 1110a) of the bar hangers 1210-1 and 1210-2. Specifically, the L-shaped structure may include a first section 1167 joined to the sidewall 1110a and a second section 1169 that protrudes out and away from the sidewall 1110a. In this manner, the combination of the first, second, and third tabs 1162a, 1164a, and 1166a may substantially constrain the bar hangers 1210-1 and 1210-2 laterally with respect the longitudinal axis of the banger assembly 1200. In other words, the first, second, and third tabs 1162a, 1164a, and 1166a may only allow the bar hangers 1210-1 and 1210-2 to move along the left or right directions.

**[0182]** The geometry of the first, second, and third tabs 1162a, 1164a, and 1166a and, in turn, the geometry of the passageway 1172 may generally depend, in part, on the geometry of the bar hangers 1210-1 and 1210-2. For example, FIG. 1L shows the passageway 1172 may be shaped to



Date Reçue/Date Received 2021-07-16

substantially conform with the cross-sectional shape of the bar hangers 1210-1 and 1210-2 as assembled in order to constrain the bar hangers 1210-1 and 1210-2 laterally.

**[0183]** In some implementations, the bar hanger assemblies 1200 may be assembled before being mounted to the housing 1100a. For example, the bar hangers 1210-1 and 1210-2 may be telescopically coupled such that one bar hanger cannot be removed from the other. The bar hangers 1210-1 and 1210-2 may also each have bar hanger heads 1220-1 and 1220-2, respectively. As a result, it may not be possible for the bar hanger assemblies 1200 to be inserted through the passageway 1172 as assembled. To accommodate a pre-assembled bar hanger assembly 1200, the tabs 1162a, 1164a, and 1166a may be arranged to allow insertion of the bar hanger assembly 1200 laterally from the front side or rear side of the housing 1100a depending on the particular bar hanger holder 1160a-1 or 1160a-2. In some implementations, the bar hanger holder 1160a may further include a groove 1174 formed along one or more of the tabs 1162a, 1164a, and/or 1166a to provide additional clearance for the bar hangers 1210a and/or 1210b to be inserted at an angle into the passageway 1174. For example, the groove 1174 may be formed along the respective second sections 1163 of the first and second tabs 1162a and 1164a. In some implementations, the tabs 1162a, 1164a, and/or 1166a may be shaped to form a snap-fit connection with the bar hangers 1210-1 and 1210-2 (see, for example, the housing 1100e in FIGS. 11A-11I).

**[0184]** It should be appreciated that, in other implementations, the bar hanger assembly 1200 may only be partially assembled before being mounted to the housing 1100a. For example, each bar hanger 1210-1 and 1210-2 may have a corresponding bar hanger head 1220-1 and 1220-2, but may not be telescopically coupled to one another. This may allow the bar hangers 1210-1 and 1210-2 to be inserted longitudinally through the passageway 1172 and telescopically coupled to one another at the same time. Although the first, second, and third tabs 1162a, 1164a, and 1166a may be tailored based on particular geometry of the bar hangers 1210-1 and 1210-2 used in the housing assembly 1100a, it should be appreciated that the bar hanger holder 1160a may support other designs and/or types of bar hangers 1210-1 and 1210-2 with a similar physical envelope (e.g., the bar hangers fit through the passageway 1172). This may include commercial-off-the-shelf bar hangers or bar hangers tailored for the housing assembly 1100a as will be discussed in more detail below.



Date Reçue/Date Received 2021-07-16

**[0185]** The bar hanger holder 1160a may also include structural features to receive the locking fastener 1020, which, as described above, is used to lock the position of the housing 1100a to the bar hangers 1210-1 and 1210-2. For instance, FIGS. 3A, 3C and 3D show the bar hanger holder 1160a may include a fastener opening 1170 formed on a bottom portion of the second tab 1164a. The fastener opening 1170 may be disposed within a recess 1168 shaped such that the fastener 1020 may be partially nested within the recess 1168 (i.e., the fastener 1020 does not protrude appreciably below the portion of the second tab 1164a. As shown in FIG. 1M, the head of the fastener 1020 may physically contact and press the bar hanger 1210-2 against the second section 1163 of the second tab 1164a when the fastener 1020 is tightened, thus imparting a frictional force that prevents the bar hangers 1210-1 and 1210-1 from moving along the passageway 1172 of the housing 1100a. In some implementations, a washer may be disposed between the head of the fastener 1020 and the bar hangers 1210-1 and 1210-2 to provide, in part, a larger contact area with the bar hangers 1210-1 and 1210-2.

**[0186]** It should be appreciated in other implementations, the opening 1170 may be located along the front side or rear side of one of the first or second tabs 1162a and 1164a depending on the bar hanger holder 1160a-1 and 1160a-2. When the fastener 1020 is inserted through the opening 1170 and subsequently tightened, the fastener 1020 may press the bar hangers 1210-1 and 1210-2 against the sidewall 1110a, again producing a frictional force to restrict movement of the bar hangers 1210-1 and 1210-2 relative to the housing 1100a.

**[0187]** During installation, the housing 1100a may be positioned such that a portion of the housing 1100a is disposed within the opening formed in the ceiling of the illuminated environment. In some implementations, the first end 1111-1 of the housing 1100a may be flush with the bottom surface of the ceiling (i.e., the first end 1111-1 and the bottom surface of the ceiling lie on the same horizontal plane) or partially recessed within the opening so that no portion of the housing 1100a protrudes into the illuminated environment. In order to accommodate the placement of the housing 1100a and the thickness of the ceiling, the various features protruding outwards from the sidewall 1110a of the housing 1100a may be sufficiently offset from the first end 1111-1 to ensure the housing assembly 1000a does not interfere or collide with the ceiling.



Date Reçue/Date Received 2021-07-16

**[0188]** For instance, the bar hanger holder 1160a may be offset from the first end 1111-1 by an offset distance, $h_1$. As shown in FIG. 1H, the offset distance $h_1$ may be defined as the distance between the bottom-most portion of the third tab 1166a and the first end 1111-1.

**[0189]** In some implementations, the housing 1100a may be fixed vertically in a ceiling with respect to the support structures. A drywall panel may also be directly mounted to the support structures. Thus, the location of the bottom plane of the drywall panel corresponding to the bottom surface of the drywall panel may vary depending on the thickness of the drywall panel. The offset distance $h_1$ may thus be chosen based on the thickness of the ceiling. For example, a drywall panel has a typical thickness of 5/8 inch, but may be as thin as 1/2 inch. To ensure the housing 1100a does not protrude through the opening formed in the ceiling, the offset distance $h_1$ may be chosen based on the thinnest drywall commonly used (e.g., 1/2 inch thick drywall). Therefore, the offset distance $h_1$ may be about 1/2 inch. In some implementations, the offset distance $h_1$ may also be chosen based on the position and extent of the bar hanger head 1210 relative to the drywall as will be discussed in more detail below.

**[0190]** In some implementations, the offset distance $h_1$ may be as small as 0 inches. In other words, the bottom portion of the bar hanger holder 1160a may be flush with the first end 1111-1 (i.e., the bottom surface of the third tab 1166a of the bar hanger holder 1160a and the first end 1111-1 may lie on the same horizontal plane). Thus, the housing 1100a may not be disposed within an opening in the ceiling or even be in physical contact with the drywall, but rather positioned deeper within the ceiling space. A lighting module, a trim, or a lighting/module trim combination may still be attached to the housing 1100a in this configuration so long as the mounting features (e.g., spring clips, friction clips) are able to extend sufficiently far into the cavity 1104.

**[0191]** Although the housing 1100a described herein includes integrally formed bar hanger holders 1160a, it should be appreciated that, in some implementations, the bar hanger holder may be a separate component that provides additional modes of adjustment to position and orient the housing in the environment. The housing may still include one or more integrated nail-in features 1150a. For example, the housing may include a slot (e.g., a vertical slot) and the bar hanger holder may be coupled to the slot using, for example, a bolt fastener and a butterfly screw/nut. The slot may be oriented along an axis that is not parallel with the longitudinal axis of the bar hangers 1210-1 and 1210-2. For instance, the slot may define an axis orthogonal to the longitudinal axis of the



Date Reçue/Date Received 2021-07-16

bar hangers 1210-1 and 1210-2. In this manner, the position of the housing relative to the bar hanger assembly 1200 may be adjusted horizontally and vertically when installed into, for example, a ceiling. The separate bar hanger holder may incorporate several of the same features as the bar hanger holder 1160a. For example, the bar hanger holder may include one or more tabs to support the bar hangers 1210-1 and 1210-2 and/or a locking mechanism to lock the respective positions of the bar hangers 1210-1 and 1210-2 to the bar hanger holder.

**[0192]** In some implementations, the bar hanger holder may be manufactured together with the housing and separated post fabrication. For example, the bar hanger holder and the housing may be both formed from injection-molded plastic. A single mold may be used to fabricate the bar hanger holder and the housing at the same time. The mold may include one or more sprues, gates, and/or runners to direct molten plastic to the desired sections of the mold defining the housing and/or the bar hanger holder. After the injection molding process, the bar hanger holder may be coupled to the housing via one or more sections of plastic that are shaped based on the one or more sprues, gates, and/or runners. The bar hanger holder and the housing may be separated from these residual plastic components (e.g., by snapping the desired component off from a gate). For assembly, the bar hanger holder may be coupled to the housing using various mechanisms including, but not limited to a screw fastener, a bolt fastener, a snap-fit connector, and an adhesive. In this manner, the manufacturing and material costs may still be reduced compared to previous housing assemblies where the bar hanger holder is formed from metal.

**[0193]** FIGS. 3A-3E also show magnified views of the nail-in feature 1150a on the housing 1100a. As shown, the housing 1100a may include mounting platforms 1140a-1 and 1140a-2 (collectively referred to herein as a "mounting platform 1140a" or a "support platform 1140a") that extend outwards from the sidewall 1110a to support the nail-in features 1150a-1 and 1150a-2, respectively. In some implementations, the support platform 1140a may be merged together with the second section 1163 of the second tab 1164a. The nail-in feature 1150a may include a cylindrically shaped wall 1153 that defines the through hole 1152 to support and guide the fastener 1010.

**[0194]** The nail-in feature 1150a may also include several notches or openings formed along the top and bottom sides of the wall 1153 to improve manufacturability by eliminating undercuts. As shown in FIGS. 3B-3E, the nail-in feature 1150a may include a first notch 1154 located on the top



Date Reçue/Date Received 2021-07-16

and center of the nail-in feature 1150a and second and third openings 1156 and 1158 located on the bottom and respective ends of the nail-in feature 1150a. As shown in FIGS. 3B and 3C, the first opening 1154 may overlap with the second and third openings 1156 and 1158 when viewing the housing 1100a from the top or bottom. The notches 1154, 1156, and 1158 may also be tapered to improve ease of manufacture by eliminating undercuts and facilitating removal of the housing 1100a from one or more molds similar to the sidewall 1110a.

**[0195]** The nail-in feature 1150a may generally be shaped to receive one or more types and/or sizes of fasteners 1010. For example, the fastener 1010 may be any type of fastener including, but not limited to, a nail, a screw fastener, and a scrail (i.e., a nail with screw threads). In some implementations, the fastener 1010 may be a wood screw tailored specifically for attachment with a wood joist or, more generally, a support structure formed of wood. In implementations where the fastener 1010 has screw threads, the interior surfaces of the wall 1153 may also have threads to engage the screw threads of the fastener 1010. In some implementations, the housing 1100a may be formed of a sufficiently soft material such that the screw forms threads onto the interior surfaces of the nail-in feature 1150 as the fastener 1010 is screwed through the nail-in feature 1150a. The diameter of the through hole 1152 may also be chosen to accommodate fasteners 1010 of varying size. For example, the diameter of the through hole 1152 in the nail-in features 1150a may be about 0.1 inches. More generally, the diameter of the through hole 1152 may range between about 0.1 inches and about 0.2 inches.

**[0196]** As shown in FIGS. 2C and 2D, the housing 1100a may include two nail-in features 1150a-1 and 1150a-2 disposed on opposite sides of the housing 1100a. The housing 1100a may further include a mounting platform 1142 disposed along the sidewall 1110a between the mounting platforms 1140a-1 and 1140a-2 and spanning a vertical portion of the sidewall 1110a. As shown in FIG. 2A, the mounting platforms 1140a-1, 1140a-2, and 1142 may collectively function as alignment features for the housing 1100a providing a substantially flat or flat surface to abut a surface of the support structure (e.g., the flat side of a wood joist). The mounting platforms 1140a-1 and 1140a-2 may generally provide a surface that extends horizontally along the support structure while the mounting platform 1142 provides a surface that extends vertically along the support structure. In this manner, the housing 1100a may accommodate different-sized support structures (e.g., different-sized joists). As shown in FIG. 2A, the walls 1153 of the nail-in features 1150a-1 and 1150a-2 may also be shaped to have a substantially flat end that aligns with the



Date Reçue/Date Received 2021-07-16

mounting platforms 1140a-1, 1140a-2, and 1142 to ensure the housing 1100a can be placed flat against the support structure.

**[0197]** The housing 1100a may also include a lip 1144 disposed at one end of the mounting platform 1142 that protrudes outward from the sidewall 1110a. The lip 1144 may be shaped to contact an edge or a corner of the support structure to align the housing 1100a to the support structure horizontally and vertically. In some implementations, the lip 1144 may be shaped to conform with standard support structures, such as standard-sized wood joists.

**[0198]** In some implementations, the nail-in features 1150a-1 and 1150a-2 may be oriented such that the fasteners 1010 are inserted at an acute angle relative to the surface of the mounting platforms 1140a-1, 1140a-2, and 1142 abutting the support structure or, more generally, an acute angle relative to each other. For example, FIG. 2C shows the nail-in features 1150a-1 and 1150a-2 are oriented along axes 1151-1 and 1151-2, respectively. The axes 1151-1 and 1151-2, in turn, are at equal, but opposite angles relative to a normal axis 1143 of the mounting platform 1142. With this arrangement, the fasteners 1010 may be inserted into the support structure at different angles, which allows for a more stable and secure attachment by utilizing the frictional force and reactionary transverse forces generated between the surface of the fastener 1010 and the support structure. In some implementations, the nail-in features 1150a-1 and 1150a-2 may be oriented at an angle relative to the axis 1143 ranging between about 30 to about 45 degrees.

**[0199]** In some implementations, the nail-in features 1150a-1 and 1150a-2 may be further oriented at a second angle with respect to a plane that is not parallel with the mounting platform 1142 (e.g., a vertical plane orthogonal to the mounting platform 1142). For example, the nail-in features 1150a-1 and 1150a-2 may be rotated such that the heads of the fasteners 1010 are oriented towards the environment being illuminated by the lighting system (i.e., towards a ceiling panel) or away from the illuminated environment. Orienting the nail-in features 1150a-1 and 1150a-2 in this manner may provide more clearance for a tool (e.g., a hammer) to contact the fasteners 1010 during installation. For instance, the housing 1100a may be installed in close proximity to one or more obstacles in a ceiling space (e.g., a joist, a duct), which may prevent a hammer from contacting the fasteners 1010 unless rotated about a vertical plane.

**[0200]** As described above, the various features extending outwards from the sidewall 1110 may be offset form the front end 1111-1 to provide sufficient clearance for the ceiling. Similar to the



Date Reçue/Date Received 2021-07-16

bar hanger holder 1160a, the mounting platform 1142 and, in particular, the lip 1144 may be offset form the first end 1111-1 of the sidewall 1110a by an offset distance, $h_2$. The offset distance $h_2$ may be defined as the distance between the first end 1111-1 and the bottom-most portion of the lip 1144. Similar to the offset distance $h_1$, the offset distance $h_2$ may be at least about 1/2 inch.

**[0201]** As described above, in a typical recessed lighting installation, the housing 1100a may be partially disposed through an opening formed in a ceiling to allow, for example, light from a lighting module to illuminate an environment. The creation of the opening in the ceiling, however, may compromise the insulating properties of the ceiling (e.g., thermal resistance, sound attenuation, air tightness, water resistance). The housing 1100a, however, may be designed to compensate or at least offset some of these losses.

**[0202]** For example, the housing assembly 1000a and the housing 1100a may withstand a fire for at least 1 hour and, more preferably, 2 hours, during which the housing 1100a may function as a barrier to prevent the spread of flames and/or smoke from one environment to another environment (e.g., from one floor to another floor of a building). This may be accomplished, in part, by forming the housing 1100a from a non-combustible material, providing a housing 1100a with a sufficient thickness or gauge, and/or limiting and/or obstructing any openings that may be formed in the housing 1100a. For instance, one knockout 1122 may be removed to allow wiring into the housing 1100a, but the opening may be blocked by the presence of a lighting module, a trim, or a combination of the foregoing in the housing 1100a.

**[0203]** In another example, the installation of conventional housing assemblies often leads to gaps formed between the housing and the opening in the ceiling resulting in unwanted air leakage. For example, the user may accidentally cut an opening in the ceiling that is larger than required to accommodate the housing 1100a. If not compensated properly, air leakage may lead to higher energy consumption and/or costs for cooling and/or heating of the environment. Air leakage may also leave the ceiling space susceptible to moisture accumulation and mold growth. To mitigate air leakage, the housing 1100a may form an air-tight seal with the ceiling. For instance, the housing assembly 1000a may include a gasket that substantially seals the gap(s) formed between the housing 1100a and the opening in the ceiling. It should be appreciated the housing 1100a is not limited only to gaskets, but other sealing components may be used to provide an air-tight seal including, but not limited to an O-ring and flexible tape.



Date Reçue/Date Received 2021-07-16

**[0204]** In yet another example, the gaps formed between the housing and the opening in the ceiling in conventional housing assemblies may also compromise the soundproofing of the ceiling, which may lead to unwanted noise in the environment especially in a multi-family residential structures and/or an office. Similar to the mitigation of air leakage, an air-tight housing assembly 1000a may also reduce unwanted sound transfer. Additionally, the housing 1100a may be formed from a material and/or have a sufficient thickness to attenuate unwanted acoustic noise.

**[0205]** In some implementations, the various properties of the housing assembly 1000a may satisfy one or more safety standards related to fire resistance, sound attenuation, air tightness, concrete tightness, structural rigidity, and water resistance. For example, the housing 1100a may be qualified as a luminaire fixture based on the specifications set forth by the National Electric Code (NEC) and/or the Underwriter's Laboratory (UL). For instance, the housing 1100a may be qualified as a luminaire fixture if the housing 1100a satisfies UL1598 corresponding to the UL standard for luminaires. In another example, the housing 1100a may be qualified as a junction box if the housing 1100a satisfies UL514C, which is the UL standard for nonmetallic outlet boxes, flush-device boxes, and covers. In yet another example, the housing 1100a may be classified with a "poke-through fire-rating" (e.g., UL263), which allows products to be installed in a fire-rated ceiling without the use of a secondary fire-stop material.

**[0206]** The housing 1100a may also be classified as being fire-rated 1100a if the housing 1100a satisfies UL263, which corresponds to the UL standard for fire tests of building construction and materials, or the standards set forth by the American Society for Testing and Materials (ASTM) and/or the National Fire Protection Association (NFPA). For example, the housing 1100a may have an hourly rating (e.g., 1 hour, 2 hour) and a location rating (e.g., ceiling) based on the location of the housing assembly 1000a in the environment.

**[0207]** The housing 1100a may also satisfy structural rigidity specifications set forth by the NEC and/or the UL (e.g., UL 1598, UL 514C) for a luminaire fixture or an electrical junction box. The housing 1100a may also be insulation contact (IC) rated, allowing insulation in a ceiling to physically contact the housing 1100a during operation. An IC rated housing 1100a may enable the housing assembly 1000a to be installed without use of a separate enclosure (e.g., a firebox). The housing 1100a may also meet air tightness standards (e.g., ASTM E283 certification). The housing



Date Reçue/Date Received 2021-07-16

1100a may also meet sound ratings according to the specifications set forth by the Sound Transmission Class (STC) and/or the Impact Insulation Class (IIC).

**[0208]** It should be appreciated the safety standards cited herein are exemplary. The housing assembly 1000a may generally satisfy similar and/or equivalent safety standards from other organizations and/or associations, which may vary by municipality, county, state, province, or country. Furthermore, the housing assembly 1100a may satisfy the specifications set forth by safety standards as they are modified and/or updated over time.

**[0209]** As described above, the housing(s) in conventional recessed lighting systems are typically formed from sheet metal, which limits the geometry and structural features on the housing due to the limitations and added costs of conventional sheet metal forming processes. In contrast, the housing 1100a may be formed from a polymer, which is intrinsically lighter and lower cost than sheet metal. Polymer housings may also more easily meet the various safety standards described above. For example, polymers typically have a lower thermal conductivity than metals. Thus, a polymer housing may provide a more effective heat barrier compared to a sheet metal housing. Alternatively, a polymer housing may use less material (e.g., a smaller thickness) while providing similar thermal insulating properties as conventional sheet metal housings. Furthermore, a polymer housing may be formed using manufacturing techniques that are more readily able to form complex, non-uniform structural features unlike conventional sheet metal forming processes, such as injection molding.

**[0210]** Generally, the housing 1100a may be formed from various thermoplastic and thermosetting polymers including, but not limited to, polyvinyl chloride (PVC), acrylonitrile butadiene styrene (ABS), polycarbonate (PC), polyurethane (PU), polyethylene, polyethylene terephthalate, polypropylene, and polystyrene. The housing 1100a may be fabricated using various manufacturing techniques and processes including, but not limited to, injection molding, 3D printing, and blow molding.

**[0211]** FIGS. 4A-4C show several additional views of the bar hanger assembly 1200 in the housing assembly 1000a. As described above, the bar hanger assembly 1200 may be an optional component depending on whether the nail-in features 1150a are used for installation. Furthermore, the bar hanger assembly 1200 shown in FIGS. 1A-1M may include off-the-shelf components to reduce manufacturing and material costs. As described above, however, the bar hanger assembly 1200 is



Date Reçue/Date Received 2021-07-16

not limited to commercially available components, but, in other implementations, may also include bar hangers that are custom-tailored specifically for the housing assembly 1000a. The housing 1100a may thus be compatible with a wide variety of different bar hanger assemblies 1200.

**[0212]** The bar hanger assembly 1200 may generally provide several features to facilitate the adjustment and/or attachment of the housing 1100a to a support structure. The following includes references to features in the bar hanger assembly 1200 shown in FIGS. 4A-4C. However, it should be appreciated the particular implementation of the features in the bar hanger assembly 1200 are exemplary. Similar and/or identical features may be incorporated in other off-the-shelf and/or custom-made bar hanger assemblies in similar or different arrangements.

**[0213]** The bar hanger assembly 1200 may include bar hangers 1210-1 and 1210-2 with respective bar hanger heads 1220-1 and 1220-2, which are supported by the integrated bar hanger holder 1160a of the housing 1100a. Generally, the bar hangers 1210-1 and 1210-2 may slide telescopically with respect to one another and slide with respect to the housing 1100a along the passageway 1172 defined by the bar hanger holder 1160a. In this manner, the overall length of the bar hanger assembly 1200 may be adjusted in order to traverse gaps of varying size between adjacent support structures in various environments. Each of the bar hangers 1210-1 and 1210-2 may include a locking tab 1212 and a tab opening (not shown). When the bar hangers 1210-1 and 1210-2 are telescopically coupled to one another, the locking tab 1212 of the bar hanger 1210-1 may engage the tab opening of the bar hanger 1210-2 when the bar hangers 1210-1 and 1210-2 are fully extended, thus preventing separation of the bar hangers 1210-1 and 1210-2.

**[0214]** The bar hangers 1210a and 1210b and/or the bar hanger heads 1220a and 1220b may have various dimensions and/or shapes. In some implementations the bar hanger assembly 1200 may be replaced by a pipe, such as an electric metallic tube (EMT), to support the housing 1100a. The bar hanger holder 1160a (also referred to herein as a "pipe holder"), in turn, may be shaped and/or dimensioned to accommodate the particular geometry of the bar hanger assembly 1200.

**[0215]** The bar hanger heads 1220-1 and 1220-2 provide one or more mounting features to couple the bar hanger assembly 1200 and, hence, the housing assembly 1000a to a support structure. In general, the mounting features may be tailored for attachment to various types of support structures including, but not limited to, a wood joist or stud, a metal joist or stud, a T-bar, and a hat channel. For example, FIGS. 4B and 4C show the bar hanger heads 1220-1 and 1220-2 may each include a



Date Reçue/Date Received 2021-07-16

base 1228 that joins the bar hanger heads 1220-1 and 1220-2 to the respective bar hangers 1210-1 and 1210-2 and a flange 1226 that extends from the base 1228 to abut a wood or metal joist. As shown, the flange 1226 may have an L-shaped structure to abut two sides of a wood/metal joist or stud. The base 1228 may be shaped to receive the fastener 1222, which is used to fasten the bar hanger heads 1220-1 and 1220-2 to the wood/metal joist or stud.

**[0216]** FIG. 4B further shows the base 1228 of the bar hanger 1210a may have a slot 1224 between the bar hanger 1210-1 and the flange 1226. The bar hanger 1210-2 may similarly provide a slot or a channel 1224 with the bar hanger 1210-2. The channel 1224 may be shaped to receive a portion of a T-bar. In some implementations, the flange 1226 may further include openings 1227 for other fasteners (not shown) to couple the bar hanger heads 1220-1 and 1220-2 to the T-bar or another support structure.

**[0217]** In some implementations, the bar hangers 1210-1 and 1210-2 and the bar hanger heads 1220-1 and 1220-2 may have substantially identical shapes and/or dimensions. In other implementations, the bar hangers 1210-1 and 1210-2 and the bar hanger heads 1220-1 and 1220-2 may have different shapes and/or dimensions. The shape and dimensions of the bar hanger assembly 1200 may depend, in part, on the shape of the bar hanger holder 1160a and, in particular, the passageway 1172. Specifically, the bar hangers 1210-1 and 1210-2 should preferably fit through the passageway 1172 such that the gaps between the bar hangers 1210-1 and 1210-2 and the first, second, and third tabs 1162a, 1164a, and 1166a are kept small in order to reduce unwanted lateral play.

**[0218]** In some implementations, the bar hanger assembly 1200 may also be shaped and dimensioned to provide sufficient clearance for the ceiling. For example, FIG. 1F shows the bottom-most portion of the bar hanger assembly 1000a coincides with the bottom portion of the flange 1226. As before, an offset distance, $h_3$, may be defined between the edge 1112 and the bottom portion of the flange 1226. The offset distance $h_3$ may be at least about 1/2 inch. Alternatively, the shape, dimensions, and location of the bar hanger holder 1160a along the sidewall 1110a of the housing 1100a may instead be tailored to accommodate the bar hanger assembly 1200. For example, the flange 1226 of the bar hanger heads 1220-1 and 1220-2 may extend appreciably downwards from the base 1228 in some implementations. To accommodate the bar hanger assembly 1200, the offset distance $h_2$ of the bar hanger holder 1160 may be



Date Reçue/Date Received 2021-07-16

increased such that the offset distance $h_3$ of the bar hanger assembly 1200 is maintained at about 1/2 inch.

**[0219]** In some implementations, the bar hanger holder 1160a may be compatible with multiple types and/or sized bar hanger assemblies 1200. For example, the bar hanger assembly 1200 may include commercial-off-the-shelf bar hangers and/or bar hanger heads. In another example, the bar hanger assembly 1200 may include bar hangers and/or bar hanger heads that are tailored for the housing 1100a and/or provide additional features, such as greater lateral constraints to reduce unwanted play, greater ease of manufacture (e.g., identical bar hangers), and/or particular mounting features for other support structures, such as a hat channel. Examples of bar hangers and bar hanger heads and/or bar hanger heads that provide these desired features may be found in U.S. Application No. 16/886,365, filed on May 28, 2020, entitled, "ADJUSTABLE HANGER BAR ASSEMBLY" and International Application No. PCT/US2019/054220, filed on October 2, 2019, entitled, "A BAR HANGER ASSEMBLY WITH MATING TELESCOPING BARS." The contents of each of the aforementioned applications is incorporated by reference herein in its entirety.

**Installation of the Housing Assembly**

**[0220]** As described above, the housing 1100a in the housing assembly 1000a may provide multiple integrated features (e.g., the bar hanger holder 1160a, the nail-in feature 1150a) supporting multiple modes of installation. Furthermore, unlike previous housings in conventional recessed lighting systems, the housing 1100a may integrate these features together in a single component. The following provides several examples that illustrate the different support structures and/or modes of installation provided by the housing assembly 1000a described herein.

**[0221]** FIGS. 5A-5C show several views of the housing assembly 1000a installed onto two wood joists 100-1 and 100-2 via the bar hanger assemblies 1200-1 and 1200-2. In particular, the housing assembly 1000a in FIG. 5A is placed below the wood joists 100-1 and 100-2 to show the alignment of the respective bar hanger heads 1220-1 and 1220-2 of the bar hanger assemblies 1200-1 and 1200-2 to the wood joists 100-1 and 100-2. FIG. 5B shows the housing assembly 1000a coupled to the wood joists 100-1 and 100-2. FIG. 5C shows the respective flanges 1226 of each bar hanger head 1220-1 and 1220-2 may abut two sides of the wood joists 100-1 and 100-2. The fasteners 1222 may then be used to attach the housing assembly 1000a to the wood joists 100-1 and 100-2.



Date Reçue/Date Received 2021-07-16

**[0222]** FIGS. 6A and 6B show several views of the housing assembly 1000a installed onto two T-bars 200-1 and 200-2 via the bar hanger assemblies 1200-1 and 1200-2. As shown, the T-bars 200-1 and 200-2 may fit into the respective channels 1224 of each bar hanger head 1220-1 and 1220-2 such that the housing assembly 1000a fits onto the T-bars 200-1 and 200-2. Fasteners (not shown) may be inserted through the openings 1227 of each bar hanger head 1220-1 and 1220-2 to secure the housing assembly 1000a to the T-bars 200-1 and 200-2.

**[0223]** FIGS. 7A-7C show several views of the housing assembly 1000a installed onto a single wood joist 100-3 via the nail-in features 1150a-1 and 1150a-2. For this example, the housing assembly 1000a does not include the bar hanger assemblies 1200-1 and 1200-2. The portion of the fasteners 1010 disposed within the wood joist 100-3 are depicted in dash lines for the purposes of showing the placement and orientation of the fasteners 1010 in the wood joist 100-3 after installation.

**[0224]** As shown, the mounting platform 1142 may abut one side of the wood joist 100-3 and the lip 1144 may contact a corner and/or edge of the wood joist 100-3. Thus, the mounting platform 1142 and the lip 1144 may align the housing 1100a to the wood joist 100-3. FIG. 7C shows respective fasteners 1010 may be inserted through the nail-in features 1150a-1 and 1150a-2 for attachment to the wood joist 100-3. As shown, the fasteners 1010 are inserted at acute angles in order to support the housing assembly 1000a via the frictional forces as well as the reactionary transverse forces generated between the wood joist 100-3 and the surfaces of the fastener 1010 based on the orientation of the two fasteners 1010.

**A Housing Assembly with a Sealing Component**

**[0225]** In some implementations, the housing assembly may also include features to facilitate an air-tight seal with a ceiling. As described above, an air-tight seal may beneficial in reducing air leakage particularly in environments that are susceptible to appreciable temperature variations and/or moisture infiltration. In some implementations, this may be accomplished by incorporating a sealing component, such as a gasket, into the housing assembly that physically contacts the ceiling, thus forming a seal to substantially reduce or, in some instances, mitigate air leakage. The sealing component may be integrated into the housing assembly in several ways.

**[0226]** For example, FIGS. 8A-8C show an exemplary housing assembly 1000b with a gasket support 1180a mounted to a housing 1100b and supporting a gasket 1182. As shown, the gasket



Date Reçue/Date Received 2021-07-16

1182 may be disposed along the sidewall 1110a and located between the bar hanger holder 1160a and the front end 1111-1 of the housing 1100b. The gasket support 1180a may be a structural feature disposed along the exterior of the sidewall 1110a to support the gasket 1182. During installation, the housing 1100b may be inserted through an opening formed in the ceiling such that the gasket 1182 contacts the interior surface (i.e., the surface facing the ceiling space), thus forming the seal.

**[0227]** Thus, the gasket support 1180a and the gasket 1182 may limit how far the housing 1100b is inserted into the opening. Generally, the gasket 1182 may be offset from the front end 1111-1 by a distance ($h_4$). The distance, $h_4$, may range from 0 inches (i.e., coincident with the front end 1111-1) to the offset distances $h_1$ or $h_2$ corresponding to the bar hanger holder 1160a and the mounting platform 1142, respectively.

**[0228]** In some implementations, a force may be imparted to press the gasket 1182 against the interior surface. For example, the vertical location of the housing assembly 1000b may be adjusted such that the gasket 1182 is positioned slighting below a plane where a top surface of the ceiling panel is located. Thus, the ceiling panel is pressed against the gasket 1182 when installing the ceiling panel onto the ceiling. The resultant compression force applied to the gasket 1182 may thus form a higher quality seal. In some implementations, the quality of the seal by the gasket 1182 may evaluated according to well-established standards. For example, the gasket 1182 may form a seal that satisfies the Title 24 requirement corresponding to the building energy efficiency standards established by the California Energy Commission.

**[0229]** As shown, the gasket support 1180a may be a lip that extends around the periphery of the housing 1100b. The gasket support 1180a may provide a substantially flat surface onto which the gasket 1182 may be mounted. The shape of the gasket support 1180a may further conform with the desired shape of the gasket 1182. The gasket 1182 may have various shapes including, but not limited to, a circle, an ellipse, a polygon, and any combination of the foregoing. The gasket 1180a may be coupled to the gasket support 1180a using a variety of coupling mechanisms including, but not limited to, an adhesive, a snap-fit connection, a clamp, and a fastener.

**[0230]** The gasket support 1180a may be integrally formed with the sidewall 1110a. Thus, the gasket support 1180a may be formed from the same material as the housing 1100b. The gasket



Date Reçue/Date Received 2021-07-16

1182 may be formed from various types of polymers including, but not limited to, polyethylene foam, silicone rubber, and neoprene rubber.

**[0231]** It should be appreciated other types of sealing components may be used instead of the gasket 1182. For example, the sealing component may be an O-ring or flexible tape. In the example of an O-ring, the O-ring may have a toroidal shape (e.g., a donut shape). The supporting structure on the housing 1100b, in turn, may include a channel to receive a portion of the O-ring.

**[0232]** FIGS. 9A-9C show another exemplary housing assembly 1000c with a housing 1100c and a gasket support 1180b that abuts the bar hanger holder 1160a and the mounting platform 1142. The gasket 1182 may once again be supported by the gasket support 1180b. As shown, the gasket support 1180b may span a portion of the sidewall 1110a. For example, FIG. 9A shows the gasket support 1180b may form a gap 1184 to provide access to the recess 1168 where the opening 1170 is located to secure the bar hanger assembly (not shown) to the bar hanger holder 1160. Once the housing 1100c is secured to the bar hanger assembly, the gasket 1182 may be installed onto the gasket support 1180b. In some implementations, the gap 1184 may be filled with a sealant once the locking fastener 1020 is tightened.

**A Housing Assembly with an EMT**

**[0233]** As described above, the housing assembly may incorporate a variety of bar hanger assemblies, some of which may include off-the-shelf components and/or components tailor-made for the housing assembly. In some implementations, the housing assembly may also include other types of components to support the housing.

**[0234]** For example, FIGS. 10A and 10B show one example of a housing assembly 1000d with a pair of pipes 1230-1 and 1230-2 (collectively referred to herein as a "pipe 1230") to support the housing 1100d. As shown, the housing 1100d may include respective pipe holders 1160b-1 and 1160b-2 (collectively referred to herein as a "pipe holder 1160b") that each include a first tab 1162b, a second tab 1164b, and a third tab 1166b that together define a passageway to guide and support the pipes 1230. As before, the housing 1100d may be adjusted with respect to the pipes 1230 along a longitudinal axis defined by the passageway. The housing 1100d may be further secured to the pipes 1230 in a similar manner to the housing 1100a. For example, a locking fastener (not shown) may be inserted into an opening in the pipe holder 1160 to press the pipe 1230 against



Date Reçue/Date Received 2021-07-16

at least one portion of one of the tabs 1162, 1164, and 1166 to impart a frictional force, thus preventing relative movement between the housing 1100d and the pipe 1230.

**[0235]** Similar to the bar hanger holder 1160a, the pipe holder 1160b may also be shaped to conform with the shape of the pipe 1230. For example, FIG. 10B shows the tabs 1162b, 1164b, and 1166b may each have a semi-circular section that conforms with the circular cross-sectional shape of the pipe 1230. However, it should be appreciated the pipe 1230 may have other cross-sectional shapes including, but not limited to, an ellipse, a square, a rectangle, a polygon, and any combination of the foregoing. The shape of the tabs 1162b, 1164b, and 1166b may be shaped to conform to the particular cross-sectional shape of the pipe 1230.

**[0236]** In some implementations, the pipes 1230 may be installed together with the housing 1100d. For example, the pipes 1230 may be mounted to a surface of a ceiling using one or more clamps (e.g., a pipe clamp). The pipes 1230 may be mounted to a variety of support structures including, but not limited to, a wood joist or stud, a metal joist or stud, and a T-bar. In some implementations, the housing assembly 1100d may be installed directly onto a flat surface (e.g., a concrete slab) via one or more clamps.

**[0237]** In some implementations, the pipes 1230 may be part of the ceiling space. Thus, the pipes 1230 may be considered to be support structures that form part of the environment. For example, the pipe 1230 may each be an EMT to form part of an electric conduit for wiring in the ceiling space. In some implementations, the wiring in the pipes 1230 may form part of a circuit that includes wiring routed into the housing 1100d to supply electrical power to, for example, a lighting module disposed therein.

**[0238]** The pipe 1230 may be formed from various metals and polymers including, but not limited to, aluminum, aluminum alloys, steel, copper, polyvinyl chloride (PVC), acrylonitrile butadiene styrene (ABS), polycarbonate (PC), polyurethane (PU), polyethylene, polyethylene terephthalate, polypropylene, and polystyrene.

**A Stackable Housing for a New Construction Installation**

**[0239]** FIGS. 11A-11I show another exemplary housing 1100e for a new construction installation of a 3-inch trade size lighting system. The housing 1100e may generally include several of the same or similar features as the housings 1100a-1100d. For example, the housing 1100e may define



Date Reçue/Date Received 2021-07-16

a cavity 1104 with an opening 1102 into the cavity 1104. Specifically, the housing 1100e may include a sidewall 1110b with a first end 1111-1 having an edge 1112 defining the opening 1102 and a second end 1111-2. The first end 1111-1 may include one or more notches 1114 for alignment. The housing 1100e may further include a cover 1120a with a base end 1121 and a tapered wall 1130 joined to the sidewall 1110b. The sidewall 1110b and the cover 1120a together define the cavity 1104.

**[0240]** The housing 1100e may include a pair of knockouts 1122 disposed on the cover 1120a and a pair of feedthrough tabs 1132 disposed within corresponding feedthrough openings 1136 formed on the tapered wall 1130. The housing 1100e may further include integrated bar hanger holders 1160c-1 and 1160c-2 (collectively referred to herein as a "bar hanger holder 1160c") to support bar hanger assemblies (e.g., bar hanger assemblies 1200) when installing the housing 1100e between support structures in the ceiling space. The housing 1100e may also include a pair of nail-in features 1150b-1 and 1150b-2 (collectively referred to herein as a "nail-in feature 1150b") to directly couple the housing 1100e to a wood joist. The nail-in features 1150b-1 and 1150b-2 may be coupled to the sidewall 1110b via mounting platforms 1140b-1 and 1140b-2 (collectively referred to herein as "a mounting platform 1140b" or " a support platform 1140b"). Similar to the housings 1100a-1100d, the housing 1100e may be formed as a single polymer component using, for example, an injection molding process.

**[0241]** The shape and dimensions of the housing 1100e may generally be similar to the housings 1100a-1100d. For example, the sidewall 1110b may have a round shape (e.g., at least a portion of the sidewall 1110b may have a cross-section that is shaped as an annulus). The housing 1100e may also be dimensioned to provide a cavity 1104 that is sufficiently large to contain a lighting module and/or a trim. In some implementations, the housing 1100e may also be dimensioned such that the space remaining within the cavity 1104 after the lighting module and the trim are installed is sufficient to contain (1) three 12 AWG wires, cables, and/or conductors (e.g., a load wire, a neutral wire, a ground wire) that are routed into the housing 1100e and (2) three 12 AWG wires, cables, and/or conductors that are routed out of the housing 1100e for connection with another lighting system or an electrical switch. More generally, the remaining portion of the cavity 1104 may provide a volume allowance of 1.5 cubic inches for each 18 AWG conductor disposed within the cavity 1104 and/or a volume allowance of 5.0 cubic inches for each 6 AWG conductor disposed within the cavity 1104. It should be appreciated that wires, cables, and/or conductors of different



Date Reçue/Date Received 2021-07-16

size (e.g., 14 AWG, 18 AWG, 22 AWG) may also be routed into or out of the housing 1100e as well. The housing 1100e may contain a larger or smaller number wires depending on the size of the wire to ensure the housing 1100e complies with 2020 NEC 314.16.

**[0242]** In some implementations, the sidewall 1110b of the housing 1100e may have a stepped profile to facilitate, in part, stacking of multiple housings 1100e onto one another to increase the packing density during shipment of several housings 1100e. Said in another way, a greater number of housings 1100e may be packaged together within a fixed volume for shipment or storage. For example, FIGS. 11E and 11H show the sidewall 1110b may include a first sidewall section 1110b-1 joined to the tapered wall 1130 of the cover 1120a, a second sidewall section 1110b-2 joined to the first sidewall section 1110b-1, a third sidewall section 1110b-3 joined to the second sidewall section 1110b-2, and a fourth sidewall section 1110b-4 joined to the third sidewall section 1110b-3 and including the first end 1111-1.

**[0243]** As shown, the first sidewall section 1110b-1 may generally have an exterior width that is smaller than an interior width of the third and fourth sidewall sections 1110b-3 and 1110b-4 so that the cover 1120a and the first sidewall section 1110b-1 of one housing 1100e may be disposed within the portion of the cavity 1104 defined by the third and fourth sidewall sections 1110b-3 and 1110b-4 of another housing 1100e (see, for example, the housings 1100f in FIG. 15). For example, FIG. 11H shows the first sidewall section 1110b-1 may have a tapered profile with an exterior diameter ($D_{ext,1}$) is largest at the second sidewall section 1110b-2 and the fourth sidewall section 1110b-4 may have an interior width ($D_{int}$) at the first end 1111-1 that is larger than the exterior diameter $D_{ext,1}$. The interior sides of the third and fourth sidewall sections 1110b-3 and 1110b-4 may also have a tapered profile that is substantially similar or the same as the tapered profile of the first sidewall section 1110b-1. By shaping the sidewall 1110b in this manner, the cover 1120a and the first sidewall section 1110b-1 of one housing 1100b may readily fit within the cavity 1104 of another housing 1100b.

**[0244]** The second sidewall section 1110b-2 may also form a step between the first and third sidewall sections 1110b-1 and 1110b-3. When two housings 1100e are stacked on top of one another, the first end 1111-1 of one housing 1100e may rest on the step formed by the second sidewall section 1110b-2 of the other housing 1100e. In this manner, the shape of the second sidewall section 1110b-2 may limit how much one housing 1100e is disposed within the cavity



Date Reçue/Date Received 2021-07-16

1104 of another housing 1100e. For example, FIG. 11H shows third sidewall section 1110b-3 has an exterior width ($D_{ext,2}$) where the third sidewall section 1110b-3 joins the second sidewalls section 1110b-2. As shown, the exterior depth $D_{ext,2}$ may be larger than the interior depth $D_{int}$ at the first end 1111-1.

**[0245]** The sidewalls sections 1110b-1 through 1110b-4 may each have a tapered profile to improve ease of manufacture of the housing 1100b. For example, the exterior width of the first, second, and third sidewall sections 1110b-1 through 1110b-3 may increase from the cover 1120a to the first end 1111-1. The draft angle (i.e., the angle of the surface relative to a vertical axis) of the second sidewall section 1110b-2 may be larger than the first and third sidewall sections 1110b-1 and 1110b-3 to form the step. The fourth sidewall section 1110b-4 may have a different tapered profile along the exterior surface where the exterior width of the fourth sidewall section 1110b-4 decreases from the third sidewall section 1110b-3 to the first end 1111-1. Again, the different tapers may facilitate removal of the housing 1100b from different molds (e.g., an upper mold and a lower mold as described above with respect to the housing 1100a). In some implementations, the interior surface of the fourth sidewall section 1110b-4 may have the same or similar tapered profile as the third sidewall section 1110b-3. FIG. 11H further shows the thickness of the sidewall sections 1110b-1 through 1110b-3 may be substantially constant or constant. The thickness of the sidewall section 1110b-4, however, may decrease towards the first end 1111-1 due to the different tapered profiles.

**[0246]** The bar hanger holders 1160c may be similar to the bar hanger holders 1160a in the housing 1100a. As before, each bar hanger holder 1160c may include a first tab 1162c, a second tab 1164c, and a third tab 1166c that collectively define a passageway 1172 to support and guide the bar hanger assembly 1200. The first and second tabs 1162c and 1164c may each form a U-shaped structure with a first section 1161 joined to the sidewall 1110b, a second section 1163 joined to the first section 1161 and protruding away from the sidewall 1110b, and a third section 1165 joined to the second section 1163. The third section 1166c may also form a L-shaped structure that include a first section 1167 joined to the sidewall 1110b and a second section 1169 joined to the first section 1167 and protruding away from the sidewall 1110b. The bar hanger holders 1160c may also include a fastener opening 1170 disposed within a recess 1168 to receive a locking fastener (e.g., the locking fastener 1020) to lock the position of the housing 1100e to the bar hangers.



Date Reçue/Date Received 2021-07-16

**[0247]** In this implementation, the interior side of the third section 1165 in each of the first and second tabs 1162c and 1164c may not directly contact the bar hangers. Instead, the first and second tabs 1162c and 1164c may each have a rib 1175 (also referred to as a "bump 1175") joined at least to the third section 1165 and protruding into the passageway 1172 to physically contact one of the bar hangers. The ribs 1175 may reduce the contact area between the bar hangers and the bar hanger holder 1160c, thus allowing the housing 1100e to slide more smoothly along the bar hangers during installation. In some implementations, the first sections 1161 of the first and second tabs 1162c and 1164c or the first section 1167 of the third tab 1166c may also include ribs (not shown) that protrude into the passageway 1172 as well.

**[0248]** The third tab 1166c may also include an integrally formed snap-fit hook 1176 to facilitate assembly of bar hangers to the housing 1100e and to guide the movement of the bar hangers after assembly. Similar to the housing 1100a, the bar hanger assembly may be assembled before being mounted to the housing 1100e and may thus be inserted into the passageway 1172 from the front (or rear) side of the bar hanger holders 1160c. For example, the top half of the bar hangers may be first inserted into the passageway 1172 until contact is made with the interior sides of the first and second tabs 1162c and 1164c. In some implementations, the first and second tabs 1162c and 1164c may include grooves 1174 to provide additional clearance for the insertion of the bar hangers. Then, the bottom half of the bar hangers may be inserted into the passageway 1172 by pressing the bar hangers against the leading surface of the snap-fit hook 1176 to deflect the second section 1169 of the third tab 1166c downwards until the bar hangers are able to be moved into the passageway 1172. Once the bar hangers are disposed in the passageway 1172, the second section 1169 of the third tab 1166c may return to its original position and the third tab 1166 may thereafter limit and/or otherwise constrain the movement of the bar hangers.

**[0249]** The nail-in features 1150b may also be similar to the nail-in features 1150a in the housings 1100a-1100d. As before, each nail-in features 1150b may have a cylindrical wall 1153 that defines the through hole 1152. The nail-in features 1150b-1 and 1150b-2 may further be joined to the sidewall 1110b via mounting platforms 1140b-1 and 1140b-2, respectively. In this implementation, the cylindrical wall 1153 may include a lead-in surface 1159 to guide the fastener 1010 into the through hole 1152. The diameter of the through hole 1152 may also be about 0.175 inches. As before, the diameter of the through hole 1152 may generally range between about 0.1 inches and about 0.2 inches.



Date Reçue/Date Received 2021-07-16

**[0250]** The housing 1100e may also provide multiple alignment features to align the housing 1100e to a support structure when installing the housing 1100e using the nail-in features 1150b. For example, FIG. 11A shows the housing 1100e may include the mounting platforms 1140b-1 and 1140b-2 as before. Additionally, the housing 1100e may include tabs 1145a-1 and 1145a-2 (collectively referred to herein as a "tab 1145a" or a "rib 1145a") that protrude from the sidewall 1110b and extend vertically across the second and third sidewall sections 1110b-2 and 1110b-3. The ribs 1145 may be not extend above the second sidewall section 1110b-2 to ensure the housing 1100e remains stackable as described above. The housing 1100e may further include a lip 1144 disposed between and below the ribs 1145a-1 and 1145a-2 to contact an edge or a corner of the support structure.

**[0251]** In this implementation, the mounting platforms 1140b-1 and 1140b-2 and the ribs 1145a-1 and 1145a-2 may provide multiple discrete points or regions of contact with the support structure (e.g., a joist) rather than a single continuous surface as in the housing 1100a. By providing multiple discrete points or areas of contact, the alignment features of the housing 1100e may more readily accommodate support structures with uneven or non-flat surfaces. Generally, the alignment features may provide at least three points of contact to align and constrain the housing 1100e to the support structure. For the housing 1100e, FIGS. 11A-11I show the mounting platforms 1140b-1 and 1140b-2, the ribs 1145a-1 and 1145a-2, and the lip 1144 may collectively provide five points of contact with the support structure. Specifically, the mounting platforms 1140b-1 and 1140b-2 may have contact regions 1147-1 and 1147-2, respectively. The ribs 1145a-1 and 1145a-2 may have contact regions 1146-1 and 1146-2, respectively.

**[0252]** FIG. 11A further shows the vertical ribs 1145a may be tapered and partially recessed with respect to the mounting platforms 1140b and the lip 1144. Said in another way, the ribs 1145a may be inclined at an angle such that only the top portions of the rib 1145a corresponding to the contact region 1146 contact the support structure. In some implementations, the tapered shape of the ribs 1145a may provide a surface of which only a small portion physically contacts the support structure. For example, if the housing 1100e is coupled to a single wood joist that is larger in height than the rib 1145a, the rib 1145a may contact the wood joist such that the contact region 1146 is located near the top of the rib 1145a. In some implementations, the tapered shape of the ribs 1145a may allow the housing to be manufactured with fewer or, in some instances, no side actions in the



Date Reçue/Date Received 2021-07-16

injection mold (e.g., portions of the injection mold that move laterally relative to the respective halves of the injection mold to form undercut features).

**[0253]** FIGS. 12A-12I show another exemplary housing 1100f for a new construction installation of a 3-inch trade size lighting system. Similar to the housings 1100a-1100e, the housing 1100f may support multiple modes of installation by including one or more nail-in features 1150b to facilitate installation onto a single support structure (see, for example, the housing assembly 1000f in FIGS. 15A-15C) and one or more bar hanger holders 1160d to facilitate installation onto two or more support structures (see, for example, the housing assembly 1000e in FIGS. 14A-14D).

**[0254]** As shown, the housing 1100f may include the sidewall 1110b and the cover 1120a, which together define the cavity 1104 to contain a lighting module, at least a portion of a trim, one or more electrical wires and/or cables from an external power supply system, and one or more wire splices. The sidewall 1110b includes the first end 1111-1 with multiple alignment notches 1114 and the interior edge 1112 defining the bottom opening 1102 to provide access to the cavity 1104. The sidewall 1110b may further include the second end 1111-2, which is joined to the cover 1120a. The cover 1120a includes the base end 1121 supporting multiple knockouts 1122 and the tapered wall 1130, which joins the base end 1121 to the sidewall 1110b, supporting multiple feedthrough tabs 1132 disposed within corresponding feedthrough openings 1136. FIG. 12H shows the cover 1120a may also include multiple catches 1135 disposed on a bottom side of the base end 1121 and arranged in parallel alignment with one another for each feedthrough tab 1132. The inclusion of multiple catches 1135 may provide multiple points of contact with a wire or cable inserted through the feedthrough opening 1136 and clamped by the feedthrough tab 1132.

**[0255]** The sidewall 1110b may also have a stepped profile to facilitate stacking of multiple housings 1100f onto one another similar to the housing 1100e. Specifically, the sidewall 1110b includes from top to bottom, the first sidewall section 1110b-1 adjoining the tapered wall 1130 of the cover 1120a, the second sidewall section 1110b-2 adjoining the first sidewall section 1110b-1, the third sidewall section 1110b-3 adjoining the second sidewall section 1110b-2, and the fourth sidewall section 1110b-4 adjoining the third sidewall section 1110b-3 and including the first end 1111-1. FIG. 12H shows the exterior diameter ($D_{ext,2}$) where the third sidewall section 1110b-3 joins the second sidewall section 1110b-2 may be larger than the exterior diameter ($D_{ext,1}$) where the first sidewall section 1110b-1 joins the second sidewall section 1110b-2. FIG. 12H also shows



Date Reçue/Date Received 2021-07-16

the second sidewall section 1110b-2 may be sloped downwards towards the first end 1111-1 at a shallower angle than the first and third sidewall sections 1110b-3 and 1110b-4, thus forming a step around the periphery of the sidewall 1110b.

**[0256]** FIG. 12H further shows the interior diameter ($D_{int}$) defined by the interior edge 1112 of the first end 1111-1 may be greater than or equal to the exterior diameter $D_{ext,1}$, but smaller than the exterior diameter $D_{ext,2}$. As shown in FIG. 13, the geometry of the sidewall 1110b allows the first sidewall section 1110b-1 and the cover 1120 of one housing 1100f-1 to fit within the portion of the cavity 1104 defined by the third and four sidewall sections 1110b-3 and 1110b-4 of another housing 1100f-2. Specifically, the interior edge 1112 of the housing 1100f-2 may be disposed proximate to or, in some instances, in alignment with the exterior edge formed between the sidewall sections 1110b-2 and 1110b-3 of the housing 1100f-1. This, in turn, may allow the first end 1111-1 of the housing 1100f-2 to rest upon the exterior surface of the second sidewall section 1110b-2 of the housing 1100f-1.

**[0257]** Similar to the housings 1100a-1100e, the bar hanger holder 1160d of the housing 1100f may include a first tab 1162d, a second tab 1164d, and a third tab 1166d defining a passageway 1172 to support and guide a pair of bar hangers (e.g., the bar hangers 1210-1 and 1210-2). In some implementations, the passageway 1172 defined by the bar hanger holder 1160d may have a length (e.g., the distance between the left side of the second tab 1164d and the right side of the first tab 1162d of the bar hanger older 1160d-2) of about 3 inches. More generally, the length of the passageway 1172 may range between about 2 inches and about 3 inches.

**[0258]** Specifically, the first and second tabs 1162d and 1164d each form a U-shaped structure that includes a first section 1161 joined to the sidewall 1100b, a second section 1163 adjoining the first section 1161, and a third section 1165 adjoining the second section 1163 to constrain the top, front, and rear sides of the bar hangers 1200-1 and 1200-2. In this implementation, the third tab 1166d may also form a U-shaped structure with a first section 1167 adjoining the sidewall 1100b, the second section 1169 adjoining the first section 1167, and a third section 1171 adjoining the second section 1169 to constraint the bottom, front, and rear sides of the bar hangers 1200-1 and 1200-2. In this manner, the bar hanger holder 1160d may constrain the lateral motion of the bar hangers even if one or both of the bar hangers 1200-1 and 1200-2 are only in contact with two of the first, second, and third tabs 1162d, 1164d, and 1166d.



Date Reçue/Date Received 2021-07-16

**[0259]** As shown in FIGS. 12A, 12B, and 12E, the third section 1171 of the third tab 1166d may also have at triangular shape when viewing the housing 1100f from the front or rear sides. The triangular geometry of the third tab 1166d may aid the manufacture of the housing 1100f by providing a tapered surface to facilitate the release of the third tab 1166d from a mold when the housing 1100f is injection molded. FIGS. 12D and 12E show the second tab 1164d may also extend directly below the nail-in feature 1150b such that the second tab 1164d and the cylindrical wall 1153 of the nail-in feature 1150b are merged directly together.

**[0260]** FIGS. 12B, 12D, and 12E also show the bar hanger holder 1160d may include a fastener opening 1170 to receive the locking fastener 1020 to lock the relative position of the housing 1100f and the bar hanger assemblies 1200. As shown, the fastener opening 1170 may extend through the mounting platform 1140c and the second tab 1164d. The bar hanger holder 1160d may further include a recess 1195 formed directly below the fastener opening 1170 and a recess 1168 formed directly below the recess 1195. The recess 1195 may be shaped and/or dimensioned to contain at least a portion of the shank of the fastener 1020 and the recess 1168, which is larger than the recess 1195, may be shaped and/or dimensioned to contain at least a portion of the head of the fastener 1020 and/or a washer 1021.

**[0261]** As shown in FIGS. 14C and 14D, the housing assembly 1000e may also include the washer 1021 for each locking fastener 1020 to provide a larger contact area to physically contact the bar hangers 1200-1 and 1200-2. As shown in FIG. 14C, the washer 1021 may be disposed above and support by the head of the locking fastener 1020. When the fastener 1020 is tightened, the washer 1020 may press the bar hangers 1200-1 and 1200-2 against the second sections 1163 of the first and second tabs 1162d and 1164d, thus imparting a clamping force that restricts movement of the housing 1100f relative to the bar hangers 1200-1 and 1200-2.

**[0262]** The housing 1100f may also include multiple alignment features to align the housing 1100f to a support structure (e.g., a wood joist) when using the nail-in features 1150b for installation. For example, FIG. 12A shows the housing 1100f may include a pair of ribs 1145b-1 and 1145b-2 (collectively referred to herein as a "rib 1145b") to provide respective contact regions 1146-1 and 1146-2 to physically contact one side of the support structure. Similar to the ribs 1145a, the ribs 1145b may provide a tapered surface a portion of which contacts the support structure. As shown in FIG. 12F, the ribs 1145b may extend vertically along the second sidewall section 1110b-2 and



Date Reçue/Date Received 2021-07-16

the third sidewall section 1110b-3. Additionally, the ribs 1145b-1 and 1145b-2 may include recesses 1149-1 and 1149-2, respectively, which may reduce the thickness of the sidewall 1110b and the amount of material used for manufacture.

**[0263]** The housing 1100f may also include tabs 1148a-1 and 1148a-2 (collectively referred to herein as a "tab 1148a") that extend from the support platforms 1140c-1 and 1140c-2, respectively. In some implementations, each tab 1148a may be disposed between a nail-in feature 1150b and a rib 1145b. As shown in FIG. 12A, the housing 1100f may include multiple tabs 1148a to provide greater more mechanical stability when aligning the housing 1100f to a support structure.

**[0264]** The tab 1148a may have an L-shaped structure that includes contact regions 1190 and 1191 oriented at different angles to physically contact two different sides of the support structure (e.g., a bottom side and a left/right side of the support structure). In some implementations, the contact regions 1190 and 1191 may be oriented at a substantially right angle or a right angle with respect to one another. For example, FIG. 12E shows the contact region 1191 may be oriented substantially horizontal or horizontal to abut a bottom surface 102 of a joist 100-3 and the contact region 1190 may be oriented substantially vertical or vertical to abut a side 101 of the joist 100-3 as shown in FIG. 15C. In some implementations, the contact region 1190 may be tapered such that only a portion of the contact region 1190 physically contacts the joist 100-3 similar to the ribs 1145b.

**[0265]** In some implementations, the tabs 1148a may be arranged such that the respective contact regions 1190 of the tabs 1148a-1 and 1148a-2 may be in parallel alignment with one another. In some implementations, the respective contact regions 1191 of the tabs 1148a-1 and 1148a-2 may be in parallel alignment with one another. FIGS. 12E and 12F further show the tabs 1148a may be shaped and/or dimensioned such that the contact regions 1190 extend downwards from the mounting platform 1140c towards the first end 1111-1 of the housing 1100f. In some implementations, the height of the contact regions 1190 may be chosen such that the bottom surface of the contact regions 1191 are positioned along the same plane as the bottom surface of the third tabs 1166d. In other words, the tabs 1148a may be offset from the first end 1111-1 to provide clearance for the housing 1100f to be disposed within an opening formed in a ceiling.

**[0266]** FIGS. 12B and 12D also show each tab 1148a may include a rib 1193 formed along an interior side of the contact region 1190 to increase the mechanical rigidity of the tab 1148a. Said in another way, the rib 1193 may prevent unwanted deflection of the tab 1148a when the housing



Date Reçue/Date Received 2021-07-16

1100f is placed in physical contact with the support structure. As shown, in some implementations, the rib 1193 may extend from the mounting platform 1140c to the contact region 1191.

**[0267]** Although the housing 1100f may support several modes of installation, it should be appreciated that some of the components affiliated with each mode of installation may be excluded during installation and/or not packaged together with the housing 1100f during sale to provide users a kit tailored specifically for one mode of installation. For example, FIGS. 14A-14D show the housing assembly 1000e tailored for installation onto two or more support structures by including the housing 1100f together with the bar hanger assemblies 1200-1 and 1200-2, the locking fasteners 1020, and the washers 1021. In some implementations, the housing assembly 1000e may also include the fasteners 1222 to couple the bar hanger assemblies 1200 to a support structure. In another example, FIGS. 15A-15C show the housing assembly 1000f tailored for installation onto one support structure by including the housing 1100f together with the fasteners 1010 for each nail-in features 1150b.

**[0268]** FIGS. 16A-16I show another exemplary housing 1100g for a new construction installation of a 4-inch trade size lighting system (e.g., the housing 1100g may fit into an opening formed in a ceiling having, for example, a diameter of approximately 4 inches).

**[0269]** Despite the larger size, the housing 1100g may nevertheless include the same or similar features as the housings 1100a-1100f. For example, the housing 1100g may include a sidewall 1110c and a cover 1020b that together define a cavity 1104 and an opening 1102 into the cavity 1104. The housing 1100g may further include integrated bar hanger holders 1160e-1 and 1160e-2 (collectively referred to herein as "a bar hanger holder 1160e") similar to the bar hanger holders 1160c to support bar hanger assemblies (not shown) when installing the housing 1100g between two or more structures in the ceiling space. The housing 1100g may also include a pair of nail-in features 1150c-1 and 1150c-2 (collectively referred to herein as "a nail-in feature 1150c") similar to the nail-in features 1150b to directly couple the housing 1100g to a single support structure. The housing 1100g may also include multiple alignment features to provide multiple discrete points or regions of contact with the support structure when the nail-in features 1150c are used for installation. For example, the housing 1100g may include mounting platforms 1140d-1 and 1140d-2 similar to the mounting platforms 1140b, ribs 1145a-1 and 1145a-2, and a lip 1144. Similar to



Date Reçue/Date Received 2021-07-16

the housings 1100a-1100f, the housing 1100g may be formed as a single plastic component using, for example, an injection molding process.

**[0270]** The sidewall 1110c may be dimensioned to have a larger width compared to the housings 1100a-1100f. For example, the interior width ($D_{int}$) of the sidewall 1110c at the first end 1111-1 may be about 4.1 inches. The exterior depth ($H_{ext}$) of the housing 1100g may be about 4.5 inches, which is the same as the housings 1100a-1100f. In other words, the 4-inch trade size housing 1100g may be enlarged only along its width compared to the 3-inch trade size housing 1100e to accommodate a larger lighting module and/or more electrical wires/cables. The dimensions of the bar hanger holder 1160e, the nail-in features 1150c, the mounting platforms 1140c may also be larger to accommodate the larger the housing 1100e while retaining the same or similar set of features.

**[0271]** The sidewall 1110c may also have a stepped profile similar to the sidewall 1110b to facilitate stacking of multiple housings 1100g onto one another. Specifically, the sidewall 1110c includes from top to bottom, the first sidewall section 1110c-1 adjoining the tapered wall 1130 of the cover 1120a, the second sidewall section 1110c-2 adjoining the first sidewall section 1110c-1, the third sidewall section 1110c-3 adjoining the second sidewall section 1110c-2, and the fourth sidewall section 1110c-4 adjoining the third sidewall section 1110c-3 and including the first end 1111-1. FIG. 16H shows the exterior diameter ($D_{ext,2}$) where the third sidewall section 1110c-3 joins the second sidewall section 1110c-2 may be larger than the exterior diameter ($D_{ext,1}$) where the first sidewall section 1110c-1 joins the second sidewall section 1110c-2. FIG. 16H also shows the second sidewall section 1110c-2 may be sloped downwards towards the first end 1111-1 at a shallower angle than the first and third sidewall sections 1110c-3 and 1110c-4, thus forming a step around the periphery of the sidewall 1110c.

**[0272]** Similar to the housings 1100a-1100f, a lighting module and/or a trim may also be inserted into the housing 1100g as part of a lighting system. In some implementations, the housing 1100g may be dimensioned such that the remaining space within the cavity 1104 after the lighting module and the trim are installed is sufficient to contain (1) three 12 AWG wires, cables, and/or conductors (e.g., a load wire, a neutral wire, a ground wire) that are routed into the housing 1100g and (2) six 12 AWG wires, cables, and/or conductors that are routed out of the housing 1100g or connection with another lighting system or an electrical switch. It should be appreciated that wires, cables,



Date Reçue/Date Received 2021-07-16

and/or conductors of different size (e.g., 14 AWG, 18 AWG, 22 AWG) may also be routed into or out of the housing 1100g as well. The housing 1100g may contain a larger or smaller number wires depending on the size of the wire to ensure the housing 1100g complies with 2020 NEC 314.16.

**[0273]** As before, the housing 1100g may include a pair of knockouts 1122 disposed on the cover 1120b. The cover 1120b, however, may include additional feedthrough tabs 1132 disposed on the tapered wall 1130 compared to the housing 1100e. For example, FIG. 13A shows the cover 1120b may include two pairs of feedthrough tabs 1132 disposed diametrically opposite of one another along the tapered wall 1130. Each pair of feedthrough tabs 1132 may be separated by a rib 1131. The rib 1131 may also be tapered to conform with the sidewall 1110c, the tapered wall 1130, and the base end 1121.

**[0274]** The bar hanger holder 1160e may also include a first tab 1162e, a second tab 1164e, and a third tab 1166e, which together define a passageway to support and guide the bar hangers 1210-1 and 1210-2. The first and second tabs 1162e and 1164e may each form a U-shaped structure that includes a first section 1161 joined to the sidewall 1100b, a second section 1163 adjoining the first section 1161, and a third section 1165 adjoining the second section 1163 to constrain the top, front, and rear sides of the bar hangers 1200-1 and 1200-2. The third tab 1166e may form a L-shaped structure that includes a first section 1167 joined to the sidewall 1110b and a second section 1169 joined to the first section 1167 and protruding away from the sidewall 1110b. The third tab 1166e may further include a snap-fit hook 1176. Thus, the third tab 1166e may constrain the bottom, front, and rear sides of the bar hangers 1200-1 and 1200-2. The first and second tabs 1162e and 1164e may further include a groove 1175 to facilitate installation of the bar hangers 1200-1 and 1200-2 from the front or rear sides of the housing 1100g depending on the bar hanger holder 1160e-1 or 1160e-2.

**[0275]** FIGS. 19A-19I show another exemplary housing 1100h for a new construction installation of a 4-inch trade size lighting system. The housing 1100h may once again support multiple modes of installation by including one or more nail-in features 1150c to facilitate installation onto a single support structure (see, for example, the housing assembly 1000h in FIGS. 20A and 20B) and one or more bar hanger holders 1160f to facilitate installation onto two or more support structures (see, for example, the housing assembly 1000g in FIGS. 19A and 19B).



Date Reçue/Date Received 2021-07-16

**[0276]** As shown, the housing 1100h may include the sidewall 1110c and the cover 1120b defining a cavity 1104 and a bottom opening 1102. The cover 1120b may include a base section 1121 with multiple knockouts 1122 and a tapered wall 11130 with multiple pairs of feedthrough tabs 1132 disposed within corresponding feedthrough openings 1136 and separated by a rib 1131.

**[0277]** The sidewall 1110c may have a stepped profile to facilitate stacking of multiple housings 1100h onto one another. Specifically, the sidewall 1110c includes from top to bottom, the first sidewall section 1110c-1 adjoining the tapered wall 1130 of the cover 1120b, the second sidewall section 1110c-2 adjoining the first sidewall section 1110c-1, the third sidewall section 1110c-3 adjoining the second sidewall section 1110c-2, and the fourth sidewall section 1110c-4 adjoining the third sidewall section 1110c-3 and including the first end 1111-1. FIG. 17H shows the exterior diameter ($D_{ext,2}$) where the third sidewall section 1110c-3 joins the second sidewall section 1110c-2 may be larger than the exterior diameter ($D_{ext,1}$) where the first sidewall section 1110c-1 joins the second sidewall section 1110c-2. FIG. 17H also shows the second sidewall section 1110c-2 may form a step around the periphery of the sidewall 1110c.

**[0278]** FIG. 17H also shows the interior diameter ($D_{int}$) defined by the interior edge 1112 of the first end 1111-1 may be greater than or equal to the exterior diameter $D_{ext,1}$, but smaller than the exterior diameter $D_{ext,2}$. As shown in FIG. 18, the geometry of the sidewall 1110b allows the first sidewall section 1110b-1 and the cover 1120 of one housing 1100f-1 to fit within the portion of the cavity 1104 defined by the third and four sidewall sections 1110b-3 and 1110b-4 of another housing 1100f-2.

**[0279]** FIGS. 17A, 17F, and 17H show each bar hanger holder 1160f may include a first tab 1162f, a second tab 1164f, and a third tab 1166f defining a passageway 1172 to support and guide a pair of bar hangers (e.g., the bar hangers 1210-1 and 1210-2). In some implementations, the passageway 1172 defined by the bar hanger holder 1160d may have a length (e.g., the distance between the left side of the second tab 1164f and the right side of the first tab 1162f of the bar hanger older 1160f-2) of about 3 inches. More generally, the length of the passageway 1172 may range between about 2 inches and about 3.5 inches.

**[0280]** The first, second, and third tabs 1162f, 1164f, and 1166f may each form a U-shaped structure. Specifically, the first and second tabs 1162f and 1164f may have a first section 1161, a second section 1163, and a third section 1165 that constrain the top, front, and rear sides of the bar



Date Reçue/Date Received 2021-07-16

hangers 1200-1 and 1200-2. The third tab 1166f may have a first section 1167, a second section 1169, and a third section 1171 that constrain the bottom, front, and rear sides of the bar hangers 1200-1 and 1200-2. In this implementation, the third section 1171 may have a rounded square shape when viewing the housing 1100f from the front or rear sides.

**[0281]** The bar hanger holder 1160f may further include a fastener opening 1170 formed as a through hole to receive the fastener 1020. The bar hanger holder 1160d may further include a recess 1195 formed directly below the fastener opening 1170 to contain at least a portion of the shank of the fastener 1020 and a recess 1168 formed directly below the recess 1195 to contain at least a portion of the head of the fastener 1020 and/or the washer 1021.

**[0282]** The nail-in features 1150c may be joined to the sidewall 1110c of the housing 1100h via mounting platforms 1140e-1 and 1140e-2. Each nail-in feature 1150c may have a cylindrical wall 1153 defining a through hole 1152 to receive the fastener 1010. In some implementations, the interior surface of the cylindrical wall 1153 may include a bump 1157 or, more generally, a protrusion 1157 shaped and/or dimensioned to engage the threads of the fastener 1010 (see, for example, FIG. 17C). The protrusion 1157 may prevent the fastener 1010 from sliding through the through hole 1152. Instead, the fastener 1010 should be rotated such that the protrusion 1157 rides along the grooves formed by the thread of the fastener 1010. In some implementations, the housing 1100f may be packaged together with the fasteners 1010. Thus, the protrusion 1157 may reduce the likelihood or, in some instances, prevent accidental loss of the fastener 1010 during shipment and handling.

**[0283]** The housing 1100h may also include multiple alignment features to align the housing 1100h to a support structure (e.g., a wood joist) when using the nail-in features 1150c for installation. For example, FIGS. 17A and 17F show the housing 1100h may include a pair of ribs 1145b-1 and 1145b-2 with respective contact regions 1146-1 and 1146-2 and recesses 1149-1 and 1149-2. In some implementations, the ribs 1145b may be disposed only along the third sidewall section 1110c-3. The housing 1100h may also include a pair of tabs 1148b-1 and 1148b-2 (collectively referred to herein as a "tab 1148b") with respective contact regions 1190 and 1191 to physically contact and abut two different sides of a support structure (e.g., a bottom side and a left/right side of a wood joist). As shown, the tabs 1148b may extend from the mounting platform 1140e and may be disposed between the nail-in feature 1150c and the rib 1145b. FIGS. 17B and



Date Reçue/Date Received 2021-07-16

17D also show the tab 1148b may include a rib 1193 disposed along an interior side of the contact region 1190 to increase the mechanical rigidity of the tab 1148b. FIG. 17 shows that, in some implementations, the contact region 1190 may have a tapered shape where the width of the tab 1148b decreases towards the first end 1111-1 of the housing 1100h.

**[0284]** Similar to the housings 1100a-1100g, the housing 1100h may support several modes of installation, but some of the components affiliated with each mode of installation may be excluded during installation and/or not packaged together with the housing 1100f during sale. For example, FIGS. 20A and 20B show the housing assembly 1000g tailored for installation onto two or more support structures by including the housing 1100h together with the bar hanger assemblies 1200-1 and 1200-2, the locking fasteners 1020, and the washers 1021. In some implementations, the housing assembly 1000g may also include the fasteners 1222 to couple the bar hanger assemblies 1200 to a support structure. In another example, FIGS. 21A and 21B show the housing assembly 1000h tailored for installation onto one support structure by including the housing 1100h together with the fasteners 1010 for each nail-in features 1150c.

**A Housing Assembly for a Remodel Installation**

**[0285]** In some implementations, the plastic housings and housing assemblies disclosed herein may be tailored to support a remodel installation of a lighting system. In a typical remodel installation, a built environment is modified to facilitate installation of the lighting assembly. For example, the environment may include a previously installed drywall panel on the ceiling. To install the lighting system, the housing assembly is inserted through an opening on the drywall panel, which may have been formed for a previous installation or may be newly formed for the new installation. The housing assembly may then be secured directly to the drywall panel. In this manner, the housing assembly may be installed without removing the drywall panel and/or accessing the ceiling space above the drywall panel. Once the housing assembly is installed, a lighting module and a trim may then be inserted into the housing.

**[0286]** FIGS. 21A-21I show several views of a housing assembly 1000i tailored for remodel installations. As shown, the housing assembly 1000i may include a housing 1100i with a sidewall 1110d and a cover 1120a that together defines a cavity 1104 and a bottom opening 1102 to provide access to the cavity 1104. The cavity 1104 may contain a lighting module, at least a portion of a trim, and various electrical wire and wiring connections with an external power supply system.



Date Reçue/Date Received 2021-07-16

The sidewall 1110d may further include an integrally formed flange 1113 that extends radially outward from the sidewall 1110d. The housing assembly 1000i may further include multiple spring clips 1300 mounted directly to the housing 1100i to provide an attachment mechanism to couple the housing 1100i to a drywall panel of a ceiling. Specifically, the spring clips 1300 and the flange 1113 may together form a clamping mechanism to mount the housing 1100i onto the bottom and top surfaces of the drywall panel as discussed in more detail below.

**[0287]** As shown, the sidewall 1110d may include a first end 1111-1 with an interior edge 1112 defining the opening 1102 into the cavity 1104. The sidewall 1110d may also include a second end 1111-2 where the sidewall 1110d is joined to the cover 1120a. The cover 1120a includes the base end 1121 supporting multiple knockouts 1122 and the tapered wall 1130, which joins the base end 1121 to the sidewall 1110b, supporting multiple feedthrough tabs 1132 disposed within corresponding feedthrough openings 1136. The cover 1120a may further include multiple catches 1135 disposed on a bottom side of the base end 1121 as shown in FIG. 21H.

**[0288]** In some implementations, the sidewall 1110d may have a round shape. For example, FIGS. 21A, 21C, and 21D show the sidewall 1110d may generally have a substantially circular or circular cross-sectional shape. The base end 1121 and the tapered wall 1130 may similarly have a circular shape to conform with the sidewall 1110d. It should be appreciated, however, that the housing 1100a may have other shapes. Generally, the sidewall 1110d may have a cross-section that has various shapes including, but not limited to, a circle, an ellipse, a square hexagon, a regular polygon (e.g., a polygon where the sides are equal in length), an irregular polygon (e.g., a polygon where the sides are not equal in length), or any combinations of the foregoing. In some implementations, the at least a portion of the sidewall 1110d may have a cross-section shaped as an annulus (i.e., concentric circles) corresponding to the interior and exterior sides of the sidewall 1110d.

**[0289]** In some implementations, the sidewall 1110d may have a tapered profile where the interior diameter and/or the exterior diameter of the sidewall 1110d may increase monotonically from the second 1111-2 to the first end 1111-1 as shown in FIGS. 21E-21H. In some implementations, the interior and exterior sides of the sidewall 1110d may be tapered in the same manner such that the thickness of the sidewall 1110d is substantially constant or constant between and including the first end 1111-1 and the second end 1111-2.



Date Reçue/Date Received 2021-07-16

**[0290]** In order to provide sufficient clearance for the lighting module and the trim, the cavity 1104 may have an interior width ($D_{int}$) that is about 3.25 inches. More generally, the interior width ($D_{int}$) of the cavity 1104 may range between about 3 inches to about 6 inches. The housing 1100i may also have an exterior depth ($H_{ext}$) chosen in part, to accommodate smaller, more confined spaces in the ceiling while providing a sufficiently deep cavity 1104 for the desired trade size of the installation. For example, the housing 1100i may have an exterior depth ($H_{ext}$) of about 4.5 inches to accommodate the 3-inch trade size lighting installation. More generally, the exterior depth ($H_{ext}$) of the housing 1100i may range between about 4 inches and about 5 inches. In some implementations, the dimensions of the housing 1100i may be tailored such that the cavity 1104 provides sufficient volume allowance after a lighting module and/or a trim is installed to support a specific number of wires and/or cables of a particular gauge in accordance with 2020 NEC 314.16.

**[0291]** The housing assembly 1000i may generally include multiple spring clips 1300 disposed, in part, around the sidewall 1110d to provide multiple attachment points to couple the housing 1100i to a drywall panel. The spring clips 1300 may generally be arranged on opposing sides of the housing 1000i so that the housing 1100i is mechanically supported on different sides. In other words, the spring clips 1300 may be arranged so that the housing 1100i is not mounted only on one side when coupled to the drywall panel. In some implementations, the spring clips 1300 may be distributed uniformly about a centerline axis 1101a corresponding to a vertical axis intersecting the center of the base end 1121. For example, the housing assembly 1000i may include two spring clips 1300 rotationally offset by 180 degrees with respect to one another. This results in the spring clips 1300 being disposed diametrically opposite of one another as shown in FIGS. 21C and 21D. In another example, the housing assembly 1000i may include three spring clips 1300 that are rotationally offset by 120 degrees about the centerline axis 1101a. In yet another example, the housing assembly 1000i may include four spring clips 1300 that are rotationally offset by 90 degrees about the centerline axis 1101a.

**[0292]** The sidewall 1110d may generally include connection sections 1118 for each spring clip 1300 to facilitate attachment of the spring clip 1300 to the housing 1100i. As shown in FIGS. 21G, 21H, and 21I, each connection section 1118 may be formed as a flat wall adjoining the first end 1111-1 and merged with the curved portions of the sidewall 1110d. In some implementations, the exterior surface of the connection section 1118 may protrude outwards from the exterior surface



Date Reçue/Date Received 2021-07-16

of the curved portion of the sidewall 1110d. However, it should be appreciated that, in some implementations, the exterior surface of the connection section 1118 may be recessed with respect to the exterior surface of the curved portion of the sidewall 1110d.

**[0293]** The connection section 1118 may generally be shaped and/or dimensioned such that a base section 1311 of the spring clip 1300, which includes a hook 1313, may wrap around the interior and exterior surfaces of the connection section 1118 and the portion of the first end 1111-1 subtended by the connection section 1118. In some implementations, the exterior and interior surfaces of connection section 1118 may be tapered in a similar manner as the curved portions of the sidewall 1110d. However, it should be appreciated that, in some implementations, the exterior and interior surfaces of connection section 1118 may be oriented substantially vertically or vertically.

**[0294]** The thickness of the connection section 1118 and/or the dimensions of the hook 1313 may be chosen to provide a tight fit between the hook 1313 and the connection section 1118. In some implementations, the hook 1313 and the connection section 1118 may form an interference fit. In some implementations, the thickness of the connection section 1118 may be less than the thickness of the curved portions of the sidewall 1110d as shown in FIG. 21G. In some implementations, the spring clip 1300 may further include one or more teeth 1312, which are disposed within the channel formed by the hook 1313, to dig into the connection section 1118 of the housing 1100i to securely couple the spring clip 1300 to the housing 1100i. Thus, the thickness of the connection section 1118 may be chosen to be sufficiently large to allow the teeth 1312 to dig into the connection section 1118 without piercing the connection section 1118. Said in another way, the teeth 1312 may not extend through the connection 1118 and into the cavity 1104 of the housing 1100i.

**[0295]** The sidewall 1110d may further include an opening 1115 for each spring clip 1300 as well. As shown in FIG. 21F, the opening 1115 may generally be disposed directly above the connection section 1118 along the curved portion of the sidewall 1110d. In some implementations, each opening 1115 may be a T-shaped opening. Specifically, each T-shaped opening 1115 may include a wide portion 1116 and a narrow portion 1117 disposed directly above and adjoining the wide portion 1116. The narrow and wide portions 1117 and 1116 may be centered about a vertical plane intersecting the centerline axis 1101a of the housing 1100i. The wide portion 1116 may be shaped and/or dimensioned to receive a wide section 1325 of a push flange 1320 on the spring clip 1300



Date Reçue/Date Received 2021-07-16

while the narrow portion 1117 may be shaped and/or dimensioned to receive a narrow section 1326 of the push flange 1320.

**[0296]** During installation, the spring clip 1300 may be deflected outwards by pushing the wide section 1325 through the wide portion 1116 of the opening 1115. The narrow section 1326 may engage the narrow portion 1117 of the opening 1115 to lock the spring clip 1300 in place once engaged with the drywall panel as will be discussed in more detail below.

**[0297]** The sidewall 1110d may also include the flange 1113 formed along and around the first end 1111-1. The flange 1113 may generally provide a top surface to abut the bottom surface of a drywall panel (see, for example, FIGS. 23A-23C). In this manner, the flange 1113 may limit the extent the housing 1100i can be inserted into a ceiling space. In some implementations, the flange 1113 may shaped such that the bottom surface of the flange 1113 is coplanar with the first end 1111-1 of the sidewall 1110d. The flange 1300 may not extend fully around the first end 1111-1. Instead, one or more notches 1119 may be formed along the flange 1300 corresponding to the location of the connection sections 1118 on the sidewall 1110d. The notches 1119 may provide space to attach the spring clip 1300 to the connection section 1118. For example, FIGS. 21C and 21D show the housing 1100i may include two notches 1119 corresponding to the two connection sections 1118.

**[0298]** FIG. 21D shows the flange 1113 may generally have a width ($w_f$), which is defined as the distance between an outer edge of the flange 1113 and an inner edge of the flange 1113 joining the first end 1111-1 along a radial axis 1101b intersecting the centerline axis 1110a. As shown in FIGS. 21C and 21D, the width $w_f$ of the flange 1113 may vary in magnitude around the first end 1111-1. For example, the width $w_f$ of the flange 1113 may be larger near the spring clips 1300 and smaller further away from the spring clips 1300. Specifically, FIG. 21D shows the width $w_f$ of the flange 1113 is largest at points 1191-1 proximate to and/or abutting the spring clips 1300 and smallest at points 1191-2 located further from the pair of spring clips 1300.t

**[0299]** The width $w_f$ of the flange 1113 may vary, in part, to compensate for potential distortions in the housing 1100i during installation. Specifically, the spring clips 1300, when engaged to the drywall, may each impart a force onto the drywall panel. The force may include a force component oriented radially outwards from the centerline axis 1101a of the housing 1100i, which is applied onto the interior surfaces and/or edges defining the opening in the drywall panel. The drywall



Date Reçue/Date Received 2021-07-16

panel, in turn, may impart a reaction force oriented radially inwards towards the centerline axis 1101a of the housing 1100i. The drywall panel is mechanically rigid and thus does not appreciably deform when the housing assembly 1000i is installed. However, the housing 1100i may be more mechanically compliant than the drywall panel. Thus, the reaction forces applied to the spring clips 1300, which are transferred directly to the housing 1300, may cause the housing 1100i to distort in shape.

**[0300]** For example, the two spring clips 1300 of the housing assembly 1000i may give rise to two reaction forces when the housing assembly 1000i is mounted to the drywall panel. Since the two spring clips 1300 are disposed on opposing sides of the housing 1100i, one reaction force is applied on the left side of the housing 1100i while the other reaction force is applied on the right side of the housing 1100i. The reaction forces may thus squeeze the housing 1100i, which, in turn, may cause the portions of the sidewall 1110d located near the spring clips 1300 to move inwards towards the centerline axis 1101a and the portions of the sidewall 1110d located further away from the spring clips 1300 to move outwards away from the centerline axis 1101a. In other words, the cross-section of the sidewall 1110d may change from a circle to an oval.

**[0301]** The distortions in the sidewall 1110d, in turn, may cause distortions in the flange 1113 as well. Specifically, the portions of the flange 1113 located near the points 1191-1 may be displaced inwards towards the centerline axis 1101a while the portions of the flange 1113 located near the points 1191-2 may be displaced outwards away from the centerline axis 1101a. If the width $w_f$ of the flange 1113 remained constant around the sidewall 1110d, the portions of the flange 1113 located near the points 1191-2 may be displaced to such an extent the outer edges of the flange 1113 would interfere with the installation of a trim onto the housing 1100i. Thus, to compensate for this displacement, the width $w_f$ of the flange 1113 near the points 1191-2 may be smaller than the width $w_f$ of the flange 1113 near the points 1191-1. In some implementations, the outer edges of the flange 1113 may become substantially circular or circular when the sidewall 1110d is distorted.

**[0302]** It should be appreciated that, in some implementations, the housing 1110d may be made more mechanically rigid to reduce or, in some instances, mitigate distortions to the sidewall 1110d and/or the flange 1113. For example, the thickness of sidewall 1110d may be increased to increase the mechanical stiffness of the sidewall 1110d. In another example, one or more ribs may be



Date Reçue/Date Received 2021-07-16

formed along the sidewall 1110d to increase the mechanical stiffness of the sidewall 1110d. In yet another example, the spring clip 1300 may be shaped such that the radial force component applied to the drywall panel is reduced. Said in another way, the force applied by the spring clip 1300 onto the drywall panel may be oriented substantially vertical or vertical.

**[0303]** FIGS. 22A and 22B show several additional views of the spring clip 1300. As shown, the spring clip 1300 may include the base section 1311, which includes the hook 1313 and the teeth 1312 to couple the spring clip 1300 to the housing 1100i. In some implementations, the base section 1311 may include multiple teeth 1312 shaped as triangular protrusions that extend into the channel formed by the hook 1313. The teeth 1312 may further be oriented such that when the spring clip 1300 is pressed onto the connection section 1118 of the housing 1100i, the teeth 1312 may dig into the housing 1100i, thus limiting or, in some instances, preventing the removal of the spring clip 1300 from the housing 1100i.

**[0304]** The spring clip 1300 may further include a bent section 1310 joined to the base section 1311. The bent section 1310 may protrude outwards from the sidewall 1110d to engage a top surface of a drywall panel for installation. As shown, the bent section 1310 may extend up to the push flange 1320, which is disposed within the opening 1115 of the sidewall 1110d as described above. The bent section 1310 may be tapered in shape such that the bent section 1310 includes flat sections that are not oriented vertically. This geometry may provide more leverage to deflect the bent section 1310 about the portion of the spring clip 1300 where the base section 1311 joins the bent section 1310. More generally, the bent section 1310 may have various shapes including, but not limited to, a V-shaped bend, a round-shaped bend, an arc where the spring clip 1300 bends outwards to clasp the drywall panel.

**[0305]** The push flange 1320, in turn, may be adjoined to the bent section 1310. The push flange 1320 may pass through the opening 1115 as described above. In some implementations, the push flange 1320 may be oriented horizontally. In some implementations, the push flange 1320 may be oriented at an angle relative to a horizontal plane. The spring clip 1300 may further include a handle 1324 joined to the push flange 1320 to provide a surface the user may press on to push the push flange 1320 through the opening 1115 and deflect the bent section 1310 outwards. The push flange 1320 may include a wide section 1325 and a narrow section 1326 disposed near the handle 1324. The narrow section 1326 may be formed by a pair of notches 1322 disposed on opposing



Date Reçue/Date Received 2021-07-16

sides of the push flange 1320 as shown in FIG. 22A. The spring clip 1300 may be generally formed of a metal. For example, the spring clip 1300 may be formed of galvanized steel in the form of sheet metal.

**[0306]** The following describes an exemplary remodel installation of the housing assembly 1000i for a ceiling 90. It should be appreciated that the same or similar steps may be used to install the housing assembly 1000i in a wall or a floor.

**[0307]** The installation of the housing assembly 1000i may first begin with the removal of one or more of the knockouts 1122 on the housing 1100i to provide an opening for one or more electrical wires and/or cables to be inserted into the cavity 1104 of the housing 1100i. As before, once the external electrical wire connections are inserted into the housing 1100i, FIG. 23A shows the housing 1100i may then be inserted through the opening 91 formed on the ceiling drywall panel 90 until the top surface of the flange 1113 abuts the bottom surface 92 of the drywall panel 90. Once the housing assembly 1000i is disposed within the ceiling space, the installer may then press the handle 1324 of each spring clip 1300 to deflect the bent section 1310 of the spring clip 1300 outwards.

**[0308]** FIG. 23B shows that as the user presses the handle 1324, the wide section 1325 of the push flange 1320 passes through the wide portion 1116 of the opening 1115 and the bent section 1310 rotates about the portion of the spring clip 1300 where the base section 1311 joins the bent section 1310 towards the top surface 93 of the drywall panel 90. As the bent section 1310 is deflected closer towards the top surface 93, the rotational motion of the bent section 1310 causes the push flange 1320 to displace upwards towards the base end 1121 of the housing 1100i. However, the upward displacement of the push flange 1320 is limited due to physical contact between the top surface of the wide section 1325 and the edge of the opening 1115 forming the wide portion 1116. The constraints imposed by the wide portion 1116 may cause the push flange 1320 to bend towards the bent section 1310 as the bent section 1310 is deflected further outwards. Said in another way, the angle between the push flange 1320 and the bent section 1310 may decrease from $\Theta_1$ to $\Theta_2$ as shown in FIGS. 23A and 23B.

**[0309]** When the push flange 1320 is sufficiently displaced through the opening 1115 such that the narrow section 1326 is disposed within the wide portion 1116 of the opening 1115, the edges of the opening 1115 may no longer constrain the push flange 1320. Once this occurs, the internal



Date Reçue/Date Received 2021-07-16

restoring force generated within the spring clip 1300 by the deflection of the push flange 1320 relative to the bent section 1310 may cause the push flange 1320 to move upwards such that the narrow section 1326 is disposed within the narrow portion 1117 of the opening 1115 as shown in FIG. 23C. Once this occurs, the edges of the push flange 1320 defining the notches 1322 may prevent the push flange 1320 from moving in or out through the opening 1115, thus locking the bent section 1310 in place. In this manner, the spring clip 1300 and the flange 1113 of the housing 1100i may clamp onto the drywall panel 90.

**[0310]** During installation, the installer may actuate both spring clips 1300 by pressing on the corresponding handles 1324, thus providing multiple points of attachment between the housing assembly 1000i and the drywall panel 90. As described above, the pair of spring clips 1300 may be disposed diametrically opposite to one another, thus providing two attachment points on opposite sides of the housing assembly 1000i. To uninstall and remove the housing assembly 1000i, the handle 1324 of each spring clip 1300 may be pulled downwards, causing the push flange 1320 to move downwards into the wide portion 1116 of the opening 1115. Once this occurs, the handle 1324 may then be pulled inwards into the cavity 1104 to disengage the bent section 1310 from the drywall panel 90.

**[0311]** FIGS. 24A-24I show another exemplary housing assembly 1000j tailored for a remodel installation of a 4-inch trade size lighting system. As shown the housing assembly 1000j includes a housing 1100j with a sidewall 1110e and a cover 1120b. The housing assembly 1000j further includes a pair of spring clips 1300.

**[0312]** The cover 1120b may include a base section 1121 supporting multiple knockouts 1122 and a tapered wall 1130 supporting multiple pairs of feedthrough tabs 1132 disposed in corresponding feedthrough openings 1136 and separated by a rib 1131. The sidewall 1110e may be round in shape and include a first end 1111-1 with an interior edge 1112 defining a bottom opening 1102 into a cavity 1104. In this implementation, the interior diameter ($D_{int}$) of the cavity 1104 may be about 4 inches. More generally, the interior width ($D_{int}$) of the cavity 1104 may range between about 3 inches to about 6 inches. The exterior height ($\underline{H_{ext}}$) of the housing 1100j may be about 4.6 inches. More generally, the exterior depth ($H_{ext}$) of the housing 1100j may range between about 4 inches and about 5 inches.



Date Reçue/Date Received 2021-07-16

**[0313]** The housing 1100j may include several of the same or similar feature as the housing 1100i to facilitate installation. For example, the housing 1100j may include a flange 1113 joined to and surrounding the first end 1111-1. As shown in FIGS. 24C and 24D, the flange 1113 may have a non-uniform width, similar to the housing 1100i, to compensate for distortions to the housing 1100j during installation. The housing 1100j may further include a pair of connection sections 1118 formed along the bottom portion of the sidewall 1110e and adjoining the first end 1111-1 to provide a mounting surface for the spring clips 1300. The housing 1100j may also include a pair of T-shaped openings 1115 to receive the push flange 1320 of the spring clips 1300. The housing assembly 1000j may be installed and/or uninstalled onto a drywall panel of a ceiling in a similar manner as the housing assembly 1000i described above.

**Conclusion**

**[0314]** All parameters, dimensions, materials, and configurations described herein are meant to be exemplary and the actual parameters, dimensions, materials, and/or configurations will depend upon the specific application or applications for which the inventive teachings is/are used. It is to be understood that the foregoing embodiments are presented primarily by way of example and that, within the scope of the appended claims and equivalents thereto, inventive embodiments may be practiced otherwise than as specifically described and claimed. Inventive embodiments of the present disclosure are directed to each individual feature, system, article, material, kit, and/or method described herein.

**[0315]** In addition, any combination of two or more such features, systems, articles, materials, kits, and/or methods, if such features, systems, articles, materials, kits, and/or methods are not mutually inconsistent, is included within the inventive scope of the present disclosure. Other substitutions, modifications, changes, and omissions may be made in the design, operating conditions and arrangement of respective elements of the exemplary implementations without departing from the scope of the present disclosure. The use of a numerical range does not preclude equivalents that fall outside the range that fulfill the same function, in the same way, to produce the same result.

**[0316]** Also, various inventive concepts may be embodied as one or more methods, of which at least one example has been provided. The acts performed as part of the method may in some instances be ordered in different ways. Accordingly, in some inventive implementations,



Date Reçue/Date Received 2021-07-16

respective acts of a given method may be performed in an order different than specifically illustrated, which may include performing some acts simultaneously (even if such acts are shown as sequential acts in illustrative embodiments).

**[0317]** All publications, patent applications, patents, and other references mentioned herein are incorporated by reference in their entirety.

**[0318]** All definitions, as defined and used herein, should be understood to control over dictionary definitions, definitions in documents incorporated by reference, and/or ordinary meanings of the defined terms.

**[0319]** The indefinite articles "a" and "an," as used herein in the specification and in the claims, unless clearly indicated to the contrary, should be understood to mean "at least one."

**[0320]** The phrase "and/or," as used herein in the specification and in the claims, should be understood to mean "either or both" of the elements so conjoined, *i.e.*, elements that are conjunctively present in some cases and disjunctively present in other cases. Multiple elements listed with "and/or" should be construed in the same fashion, *i.e.*, "one or more" of the elements so conjoined. Other elements may optionally be present other than the elements specifically identified by the "and/or" clause, whether related or unrelated to those elements specifically identified. Thus, as a non-limiting example, a reference to "A and/or B", when used in conjunction with open-ended language such as "comprising" can refer, in one embodiment, to A only (optionally including elements other than B); in another embodiment, to B only (optionally including elements other than A); in yet another embodiment, to both A and B (optionally including other elements); etc.

**[0321]** As used herein in the specification and in the claims, "or" should be understood to have the same meaning as "and/or" as defined above. For example, when separating items in a list, "or" or "and/or" shall be interpreted as being inclusive, *i.e.*, the inclusion of at least one, but also including more than one, of a number or list of elements, and, optionally, additional unlisted items. Only terms clearly indicated to the contrary, such as "only one of" or "exactly one of," or, when used in the claims, "consisting of," will refer to the inclusion of exactly one element of a number or list of elements. In general, the term "or" as used herein shall only be interpreted as indicating exclusive alternatives (*i.e.* "one or the other but not both") when preceded by terms of exclusivity,



Date Reçue/Date Received 2021-07-16

such as "either," "one of," "only one of," or "exactly one of." "Consisting essentially of," when used in the claims, shall have its ordinary meaning as used in the field of patent law.

**[0322]** As used herein in the specification and in the claims, the phrase "at least one," in reference to a list of one or more elements, should be understood to mean at least one element selected from any one or more of the elements in the list of elements, but not necessarily including at least one of each and every element specifically listed within the list of elements and not excluding any combinations of elements in the list of elements. This definition also allows that elements may optionally be present other than the elements specifically identified within the list of elements to which the phrase "at least one" refers, whether related or unrelated to those elements specifically identified. Thus, as a non-limiting example, "at least one of A and B" (or, equivalently, "at least one of A or B," or, equivalently "at least one of A and/or B") can refer, in one embodiment, to at least one, optionally including more than one, A, with no B present (and optionally including elements other than B); in another embodiment, to at least one, optionally including more than one, B, with no A present (and optionally including elements other than A); in yet another embodiment, to at least one, optionally including more than one, A, and at least one, optionally including more than one, B (and optionally including other elements); etc.

**[0323]** In the claims, as well as in the specification above, all transitional phrases such as "comprising," "including," "carrying," "having," "containing," "involving," "holding," "composed of," and the like are to be understood to be open-ended, *i.e.*, to mean including but not limited to. Only the transitional phrases "consisting of" and "consisting essentially of" shall be closed or semi-closed transitional phrases, respectively, as set forth in the United States Patent Office Manual of Patent Examining Procedures, Section 2111.03.



Date Reçue/Date Received 2021-07-16

## CLAIMS

1. A housing for a lighting system, the housing comprising:

a sidewall defining a cavity and having a first end and a second end, the first end defining a first opening into the cavity;

a cover enclosing the second end of the sidewall; and

a first bar hanger holder, disposed directly on the sidewall, to slidably support one or more first bar hangers when the one or more first bar hangers are present,

wherein the housing is formed as a single polymer component.

2. The housing of claim 1, wherein the first bar hanger holder comprises:

a plurality of U-shaped tabs extending from the sidewall and defining a passageway for the one or more first bar hangers to pass through when the one or more first bar hangers are present, each U-shaped tab of the plurality of U-shaped tabs having one side joined to the sidewall.

3. The housing of claim 1, further comprising:

a second bar hanger holder, disposed directly on the sidewall, to slidably support one or more second bar hangers when the one or more second bar hangers are present.

4. A housing assembly, comprising:

the housing of claim 3; and

the one or more first bar hangers slidably coupled to the first bar hanger holder; and

the one or more second bar hangers slidably coupled to the second bar hanger holder.

5. The housing assembly of claim 4, wherein:

the first bar hanger holder includes a first fastener opening;

the second bar hanger holder includes a second fastener opening; and

the housing assembly further comprises:

a first fastener, inserted into the first fastener opening, to lock the housing to the one or more first bar hangers; and

a second fastener, inserted into the second fastener opening, to lock the housing to the one or more second bar hangers.



Date Reçue/Date Received 2021-07-16

6. The housing of claim 1, wherein:

the sidewall comprises:

a first sidewall section joined to the cover;

a second sidewall section joined to the first sidewall section; and

a third sidewall section joined to the second sidewall section and having the first end defining the first opening;

the first sidewall section has a first exterior diameter where the first sidewall section joins the second sidewall section, the first exterior diameter being the largest exterior diameter of the first sidewall section;

the third sidewall section has a second exterior diameter where the third sidewall section joins the second sidewall section;

the first exterior diameter being smaller than the second exterior diameter; and

the third sidewall section has an interior diameter at the first end, the interior diameter being greater than or equal to the first exterior diameter and less than the second exterior diameter.

7. The housing of claim 1, further comprising:

at least one knockout disposed on the cover; and

at least one feedthrough tab.

8. The housing of claim 1, further comprising:

at least one nail-in feature joined to the sidewall.

9. The housing of claim 8, further comprising:

one or more ribs, coupled to the sidewall and protruding outwards away from the sidewall, having corresponding contact regions to physically contact a joist so as to align the housing to the joist when the housing is installed onto the joist.

10. The housing of claim 9, wherein:

the one or more ribs physically contacts a first side of the joist when the housing is installed onto the joist; and



Date Reçue/Date Received 2021-07-16

the housing further comprises:

a tab, coupled to the sidewall and protruding outwards away from the sidewall, to physically contact a second side of the joist different from the first side when the housing is installed onto the joist.

11. A housing for a lighting system, the housing comprising:

a sidewall defining a cavity and having a first end and a second end, the first end defining a first opening into the cavity;

a cover enclosing the second end of the sidewall;

at least one knockout disposed only on the cover;

at least one feedthrough tab; and

at least one nail-in feature joined to the sidewall, each nail-in feature of the at least one nail-in feature supporting a joist fastener that, when present, couples the housing directly to a single joist when the housing is installed onto the joist,

wherein:

the housing is formed as a single polymer component; and

the sidewall does not include a fastener opening disposed proximate to or on the first end to receive a fastener.

12. The housing of claim 11, wherein each nail-in feature of the at least one nail-in feature comprises:

a cylindrically-shaped wall connected to the sidewall via a support platform and defining a through hole to support the joist fastener when present, the cylindrically-shaped wall having a plurality of notches intersecting the through hole, the plurality of notches being shaped and arranged along the cylindrically-shaped sidewall to eliminate undercuts.

13. The housing of claim 11, wherein the at least one nail-in feature comprises:

a first nail-in feature defining a first through hole; and

a second nail-in feature defining a second through hole, the second nail-in feature being oriented at an acute angle with respect to the first nail-in feature.



Date Reçue/Date Received 2021-07-16

14. The housing of claim 11, further comprising:

a plurality of alignment features, protruding outwards from the sidewall, providing a corresponding plurality of contact regions to physically contact one or more sides of the joist so as to align the housing to the joist when the housing is installed onto the joist.

15. The housing of claim 14, wherein the plurality of alignment features comprises:

one or more ribs, coupled to the sidewall and protruding outwards away from the sidewall, to physically contact a first side of the joist when the housing is installed onto the joist, each rib of the one or more ribs being tapered such that only one portion of the rib physically contacts the first side of the joist.

16. The housing of claim 14, wherein the plurality of alignment features comprises:

one or more tabs, coupled to the sidewall and protruding outwards away from the sidewall, to physically contact a first side of the joist and a second side of the joist different from the first side when the housing is installed onto the joist.

17. The housing of claim 11, wherein:

the sidewall comprises:

a first sidewall section joined to the cover;

a second sidewall section joined to the first sidewall section; and

a third sidewall section joined to the second sidewall section and having the first end defining the first opening;

the first sidewall section has a first exterior diameter where the first sidewall section joins the second sidewall section, the first exterior diameter being the largest exterior diameter of the first sidewall section;

the third sidewall section has a second exterior diameter where the third sidewall section joins the second sidewall section;

the first exterior diameter being smaller than the second exterior diameter; and

the third sidewall section has an interior diameter at the first end, the interior diameter being greater than or equal to the first exterior diameter and less than the second exterior diameter.



Date Reçue/Date Received 2021-07-16

18. The housing of claim 11, further comprising:

at least one bar hanger holder, disposed directly on the sidewall, to slidably support one or more bar hangers when the one or more bar hangers are present.

19. A housing for a lighting system, the housing comprising:

a sidewall defining a cavity, at least a portion of the sidewall having a circular cross-section, the sidewall comprising:

a first sidewall section having a first end;

a second sidewall section joined to the first sidewall section; and

a third sidewall section joined to the second sidewall section and having a second end defining a first opening into the cavity;

a cover joined to the first end of the first sidewall section and enclosing the first end;

at least one knockout disposed only on the cover; and

at least one feedthrough tab,

wherein:

the first sidewall section has a first exterior diameter where the first sidewall section joins the second sidewall section, the first exterior diameter being the largest exterior diameter of the first sidewall section;

the third sidewall section has a second exterior diameter where the third sidewall section joins the second sidewall section;

the first exterior diameter being smaller than the second exterior diameter;

the third sidewall section has an interior diameter at the second end, the interior diameter being greater than or equal to the first exterior diameter and less than the second exterior diameter; and

the housing is formed as a single polymer component.

20. The housing of claim 19, further comprising:

one or more ribs, disposed on at least the third sidewall section and protruding outwards from the sidewall, having corresponding contact regions to physically contact a joist so as to align the housing to the joist when the housing is installed onto the joist.



Date Reçue/Date Received 2021-07-16

21. The housing of claim 20, further comprising:

at least one bar hanger holder, disposed on the third sidewall section, to slidably support one or more bar hangers when the one or more bar hangers are present.

22. The housing of claim 20, further comprising:

at least one nail-in feature joined to the third sidewall section.

23. The housing of claim 19, wherein:

the housing has an exterior height equal to about 4.5 inches; and

the interior diameter ranges between about 3.25 inches and about 4.1 inches.

24. A housing for a lighting system, the housing comprising:

a sidewall defining a cavity and having a first end and a second end, the first end defining a first opening into the cavity, at least a portion of the sidewall having a cross-section shaped as an annulus;

a cover, joined to the sidewall via a tapered wall, to enclose the second end of the sidewall;

only one pair of knockouts disposed on the cover;

a first feedthrough tab disposed on the tapered wall within a first feedthrough opening, the first feedthrough tab having a first mechanical stop to limit the rotational displacement of the first feedthrough tab when pushed into the cavity;

a second feedthrough tab disposed on the tapered wall within a second feedthrough opening, the second feedthrough tab having a second mechanical stop to limit the rotational displacement of the second feedthrough tab when pushed into the cavity;

a first catch formed on an interior side of the cover and disposed proximate to the first feedthrough tab, the first catch and the first feedthrough tab together forming a first clamp to restrain a cable when the first feedthrough tab is bent into the cavity and the cable is inserted through the first feedthrough opening; and

a second catch formed on the interior side of the cover and disposed proximate to the second feedthrough tab, the second catch and the second feedthrough tab together forming a second



Date Reçue/Date Received 2021-07-16

clamp to restrain a cable when the second feedthrough tab is bent into the cavity and the cable is inserted through the second feedthrough opening,

wherein:

the housing having one plane symmetry bisecting each knockout of the pair of knockouts; and

the housing is formed as a single polymer component.

25. The housing of claim 24, further comprising:

at least one bar hanger holder, disposed directly on the sidewall, to slidably support one or more bar hangers when the one or more bar hangers are present.

26. The housing of claim 25, further comprising:

at least one nail-in feature joined to the sidewall.

27. The housing of claim 26, further comprising:

one or more ribs, protruding outwards from the sidewall, having corresponding contact regions to physically contact the joist so as to align the housing to the joist when the housing is installed onto the joist.

28. The housing of claim 24, further comprising:

a flange disposed on the first end of the sidewall and extending radially outward from the sidewall.

29. A housing assembly, comprising:

the housing of claim 28, further comprising:

a first spring clip opening disposed on the sidewall; and

a second spring clip opening disposed on the sidewall diametrically opposite with respect to the first spring clip opening;

a first spring clip coupled to the sidewall and disposed through the first spring clip opening such that the first spring clip is partially disposed outside the housing and actuated from within the cavity of the housing; and



Date Reçue/Date Received 2021-07-16

a second spring clip coupled to the sidewall and disposed through the second spring clip opening such that the second spring clip is partially disposed outside the housing and actuated from within the cavity of the housing,

wherein the first spring clip, the second spring clip, and the flange together securely couple the housing assembly to a ceiling panel when the housing is installed onto the ceiling panel.

30. The housing assembly of claim 29, wherein:

the first spring clip is identical to the second spring clip;

the first spring clip comprises:

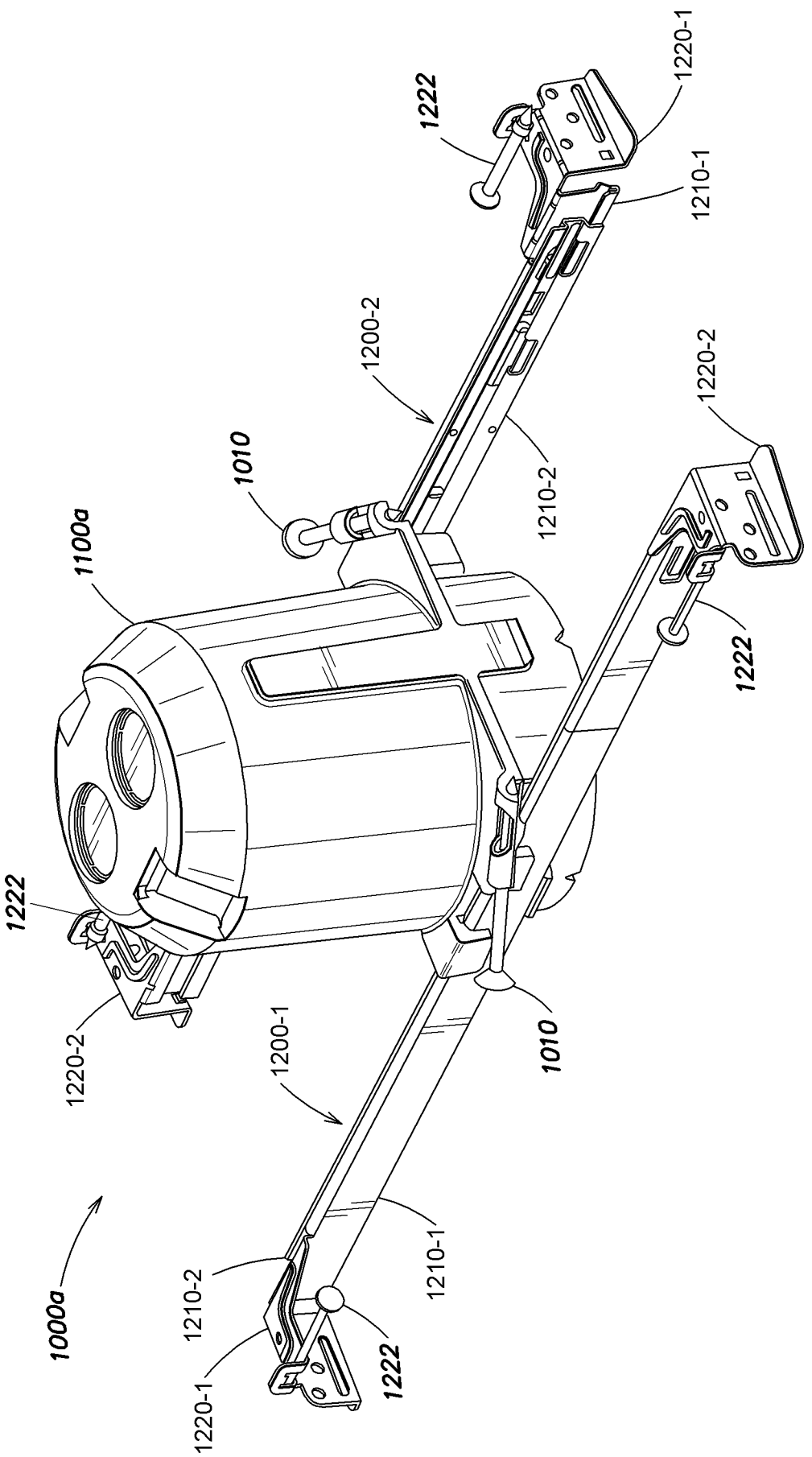
a bent section coupled to the sidewall and disposed outside the housing; and

a push flange joined to the bent section and inserted through the first spring clip opening; and

when the housing assembly is disposed in the ceiling and the push flange of the first spring clip is pushed outwards through the first spring clip opening, the bent section of the first spring clip deflects in an outwards direction causing a portion of the bent section to physically contact a top surface of the ceiling panel such that the portion of the bent section and the flange for a clamp to securely couple the housing assembly to the ceiling.



Date Reçue/Date Received 2021-07-16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1222
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1210-2
1220-1
1222
1010
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1200-2
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1220-1
1222
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1210-2
1220-2
1222

FIG. 1A

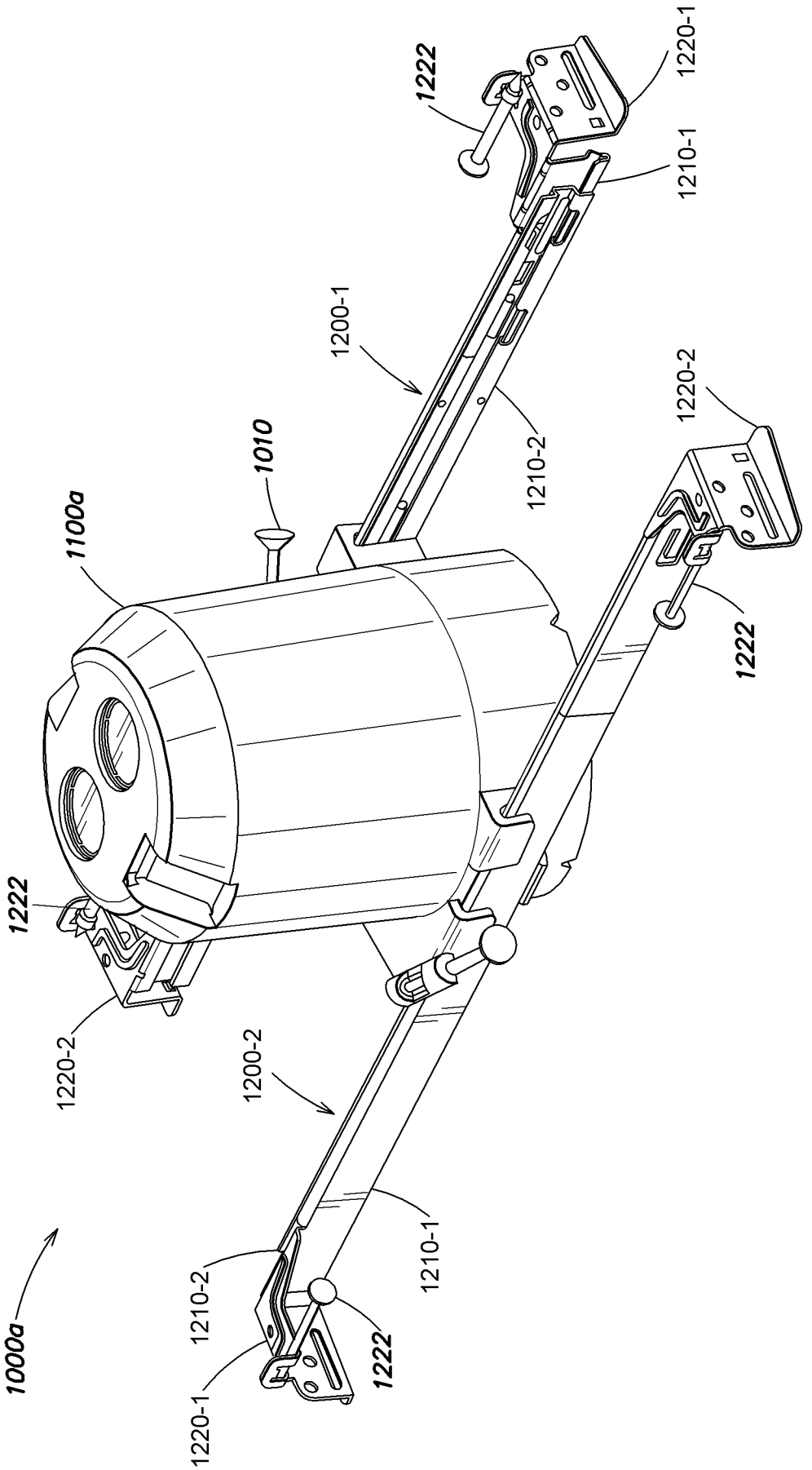



FIG. 1B

Date Reçue/Date Received 2021-07-16

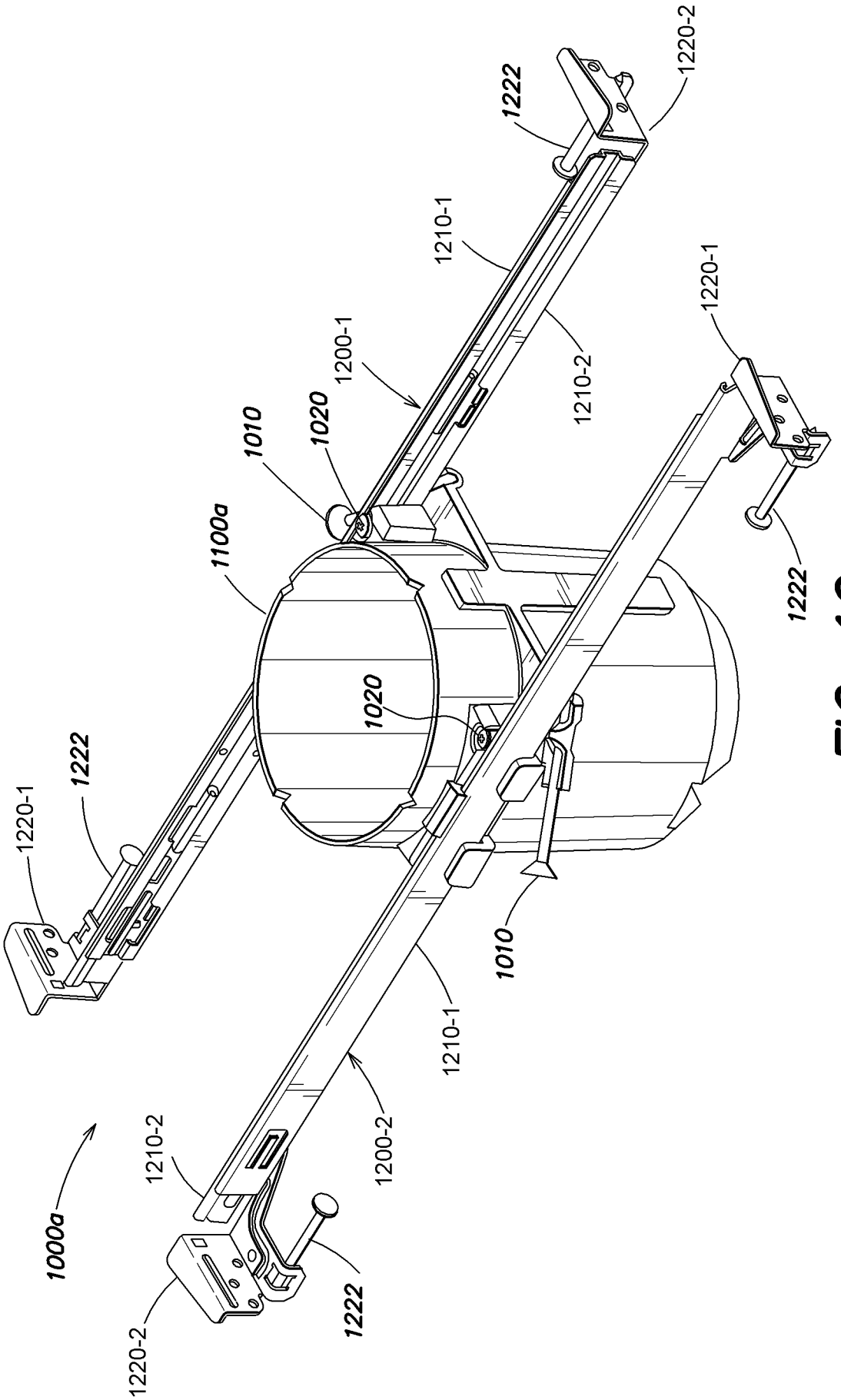



FIG. 1C

Date Reçue/Date Received 2021-07-16

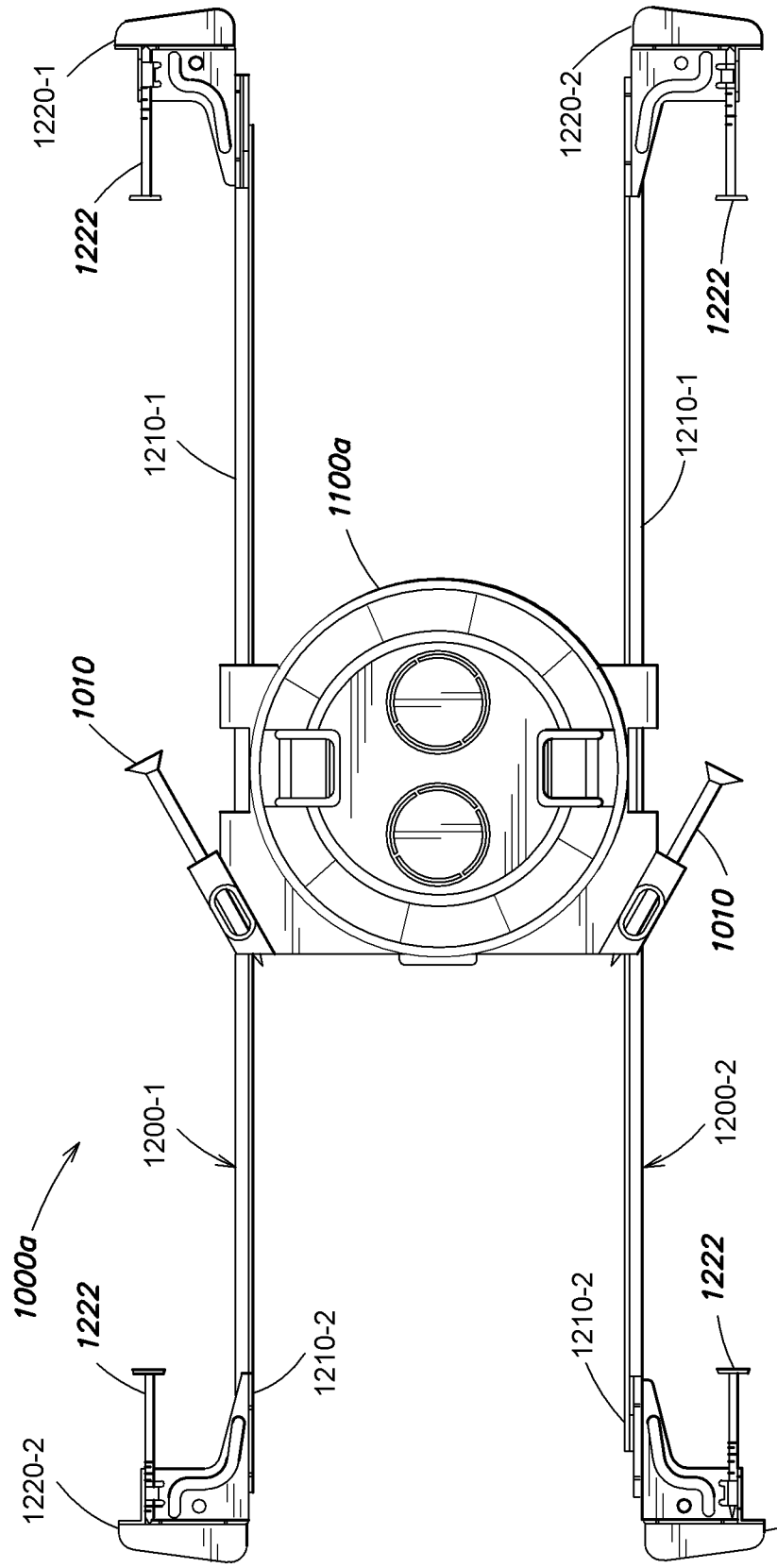

1220-1
1222
1210-1
1100a
1220-2
1222
1210-1
1010
1010
1200-1
1200-2
1000a
1222
1210-2
1210-2
1222
1220-2
1220-1

FIG. 1D

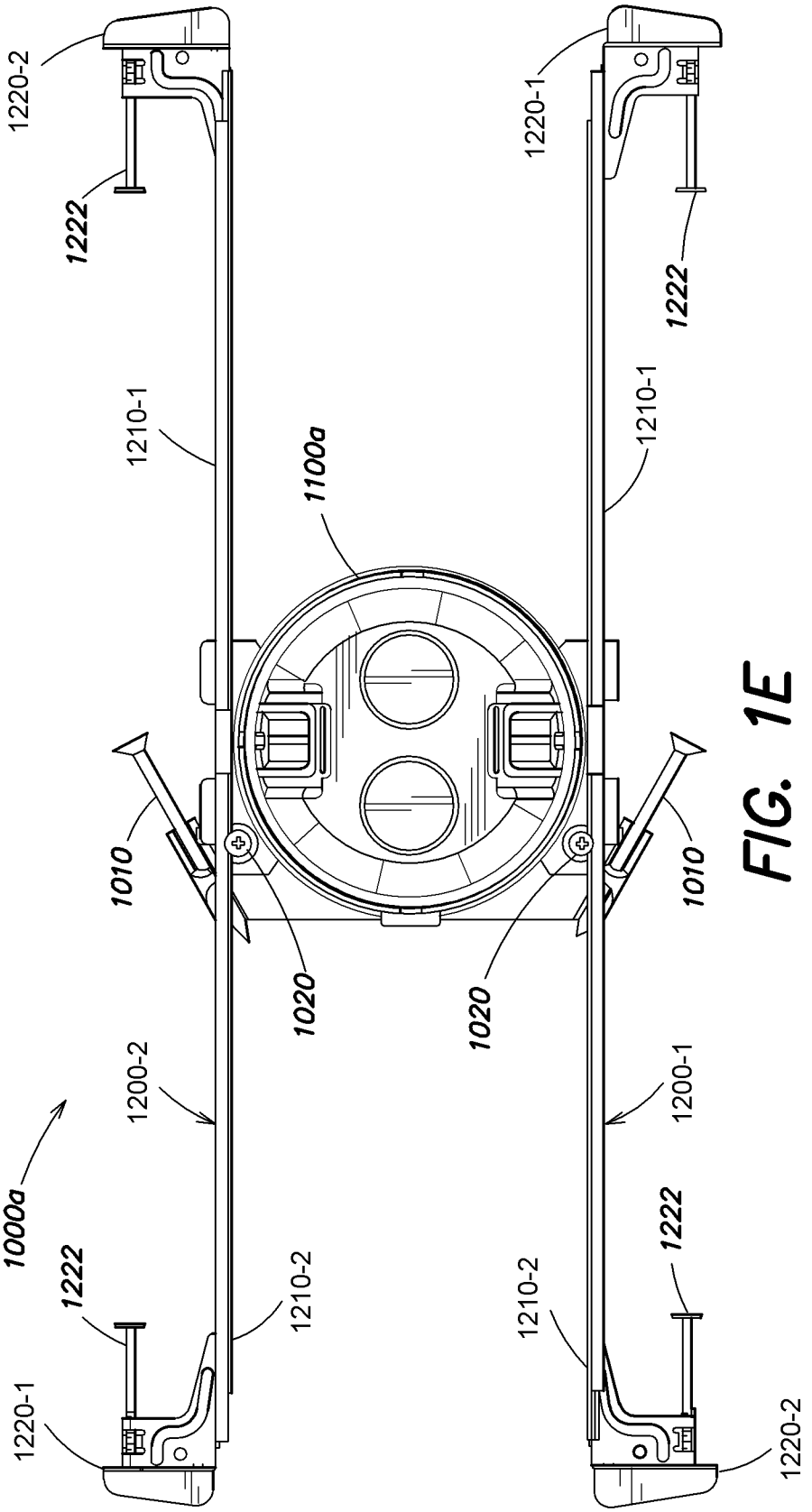



FIG. 1E

Date Reçue/Date Received 2021-07-16

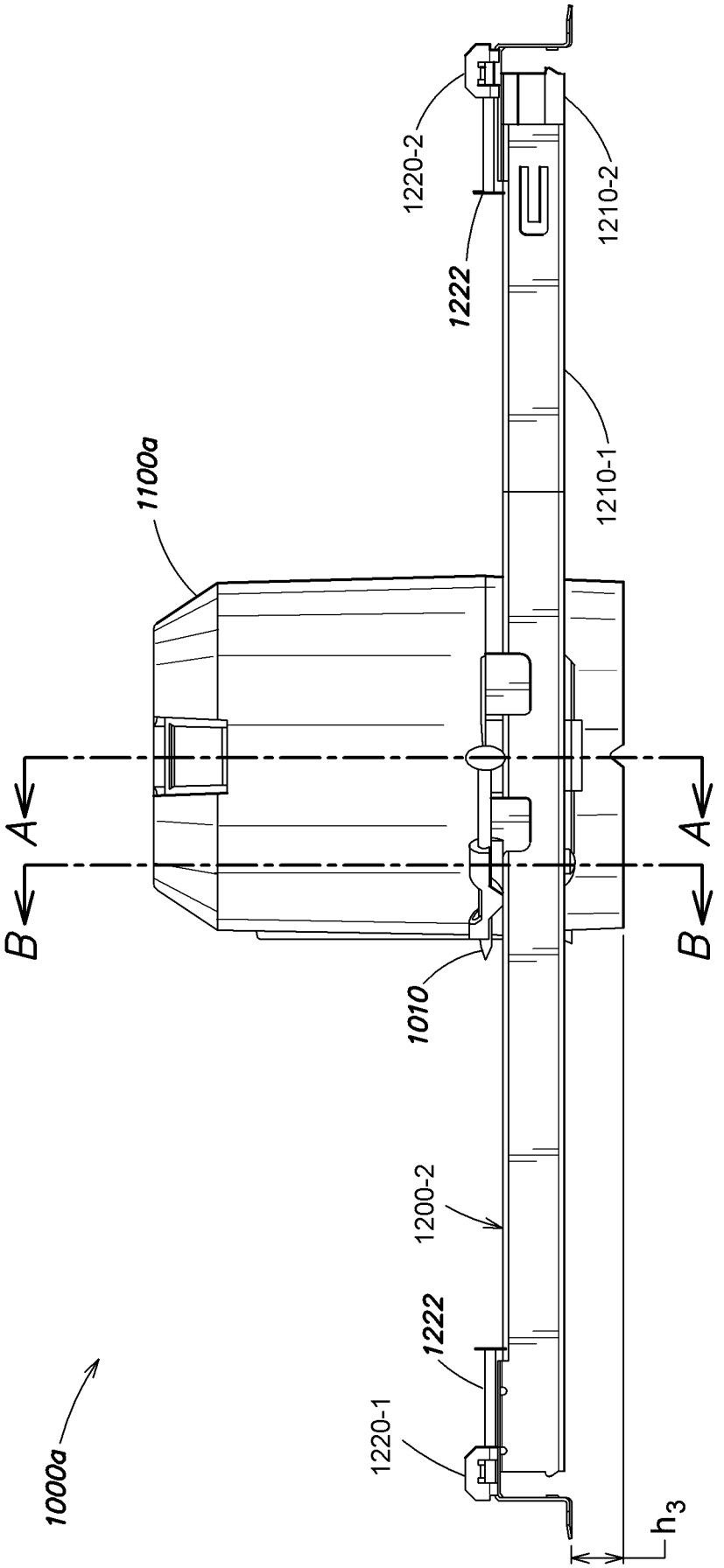



FIG. 1F

Date Reçue/Date Received 2021-07-16

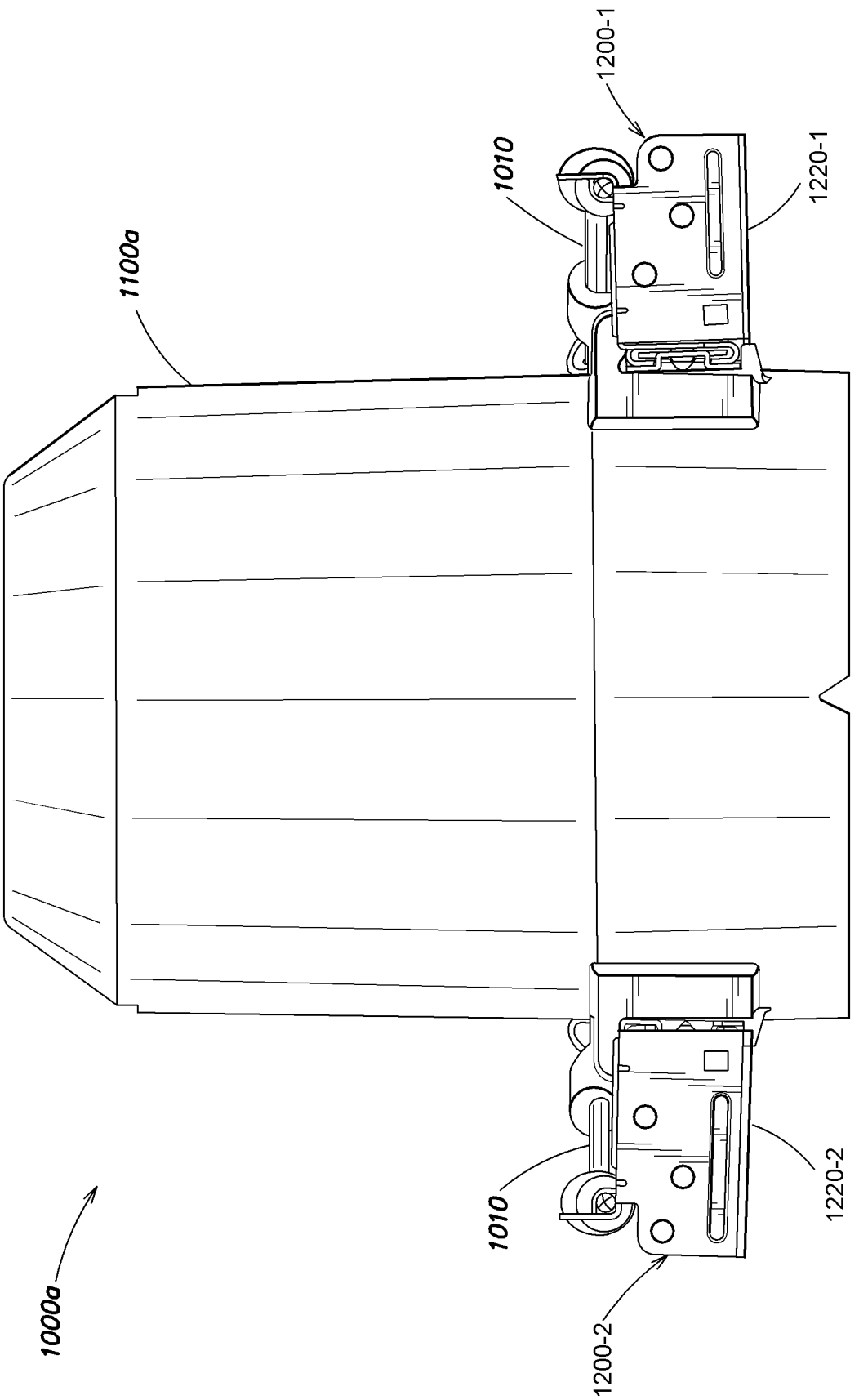



FIG. 1G

Date Reçue/Date Received 2021-07-16

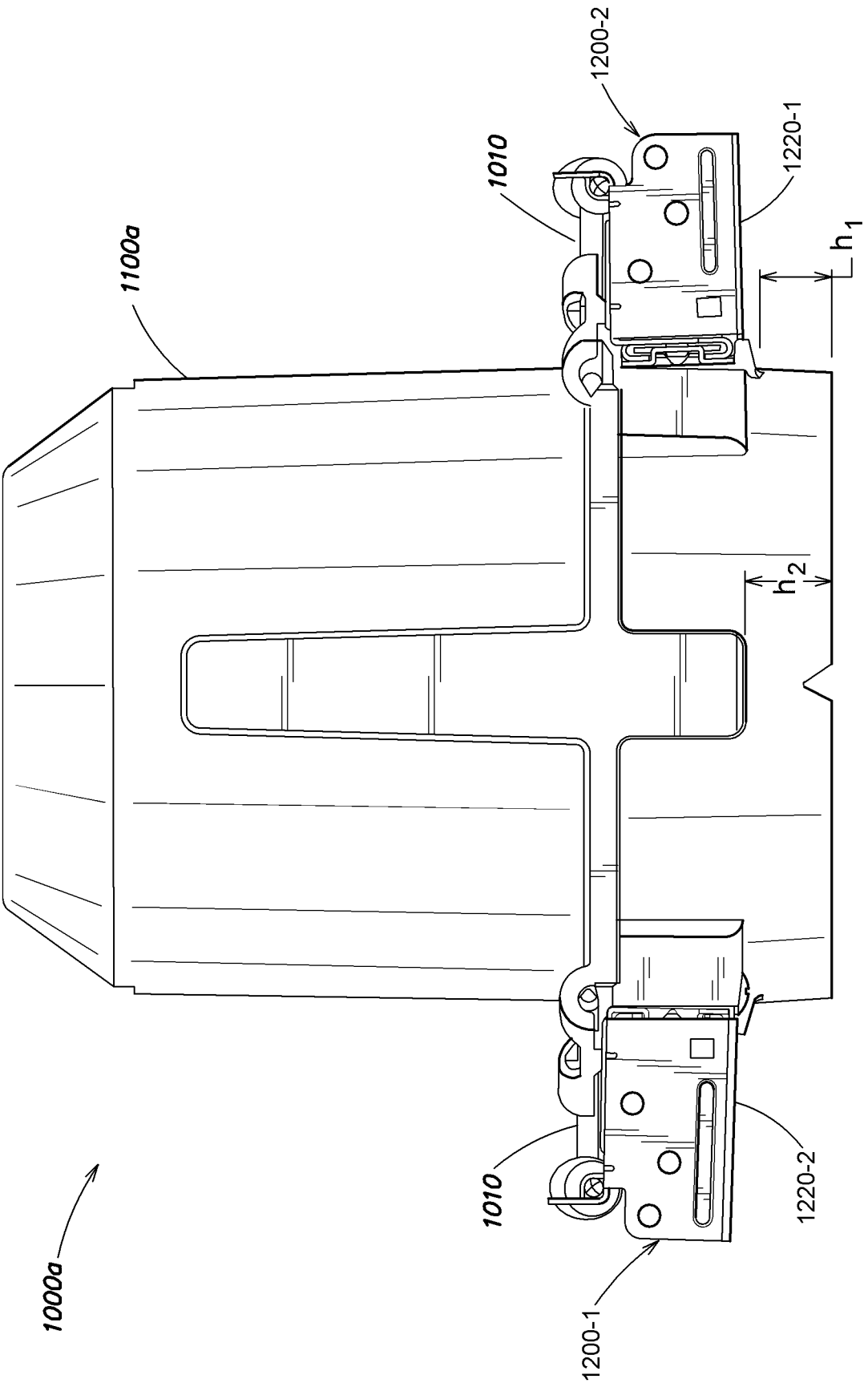



FIG. 1H

Date Reçue/Date Received 2021-07-16

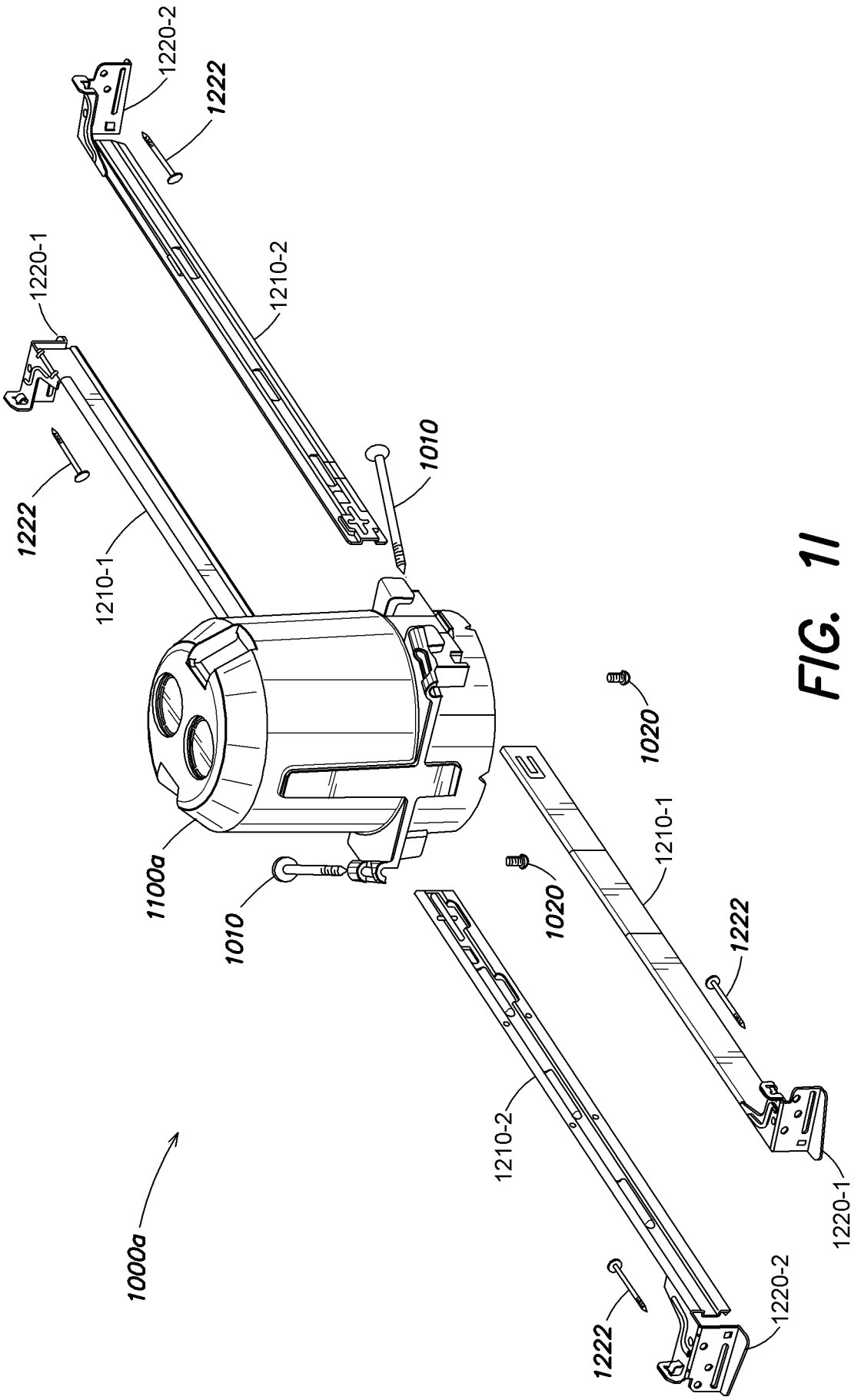



FIG. 1I

Date Reçue/Date Received 2021-07-16

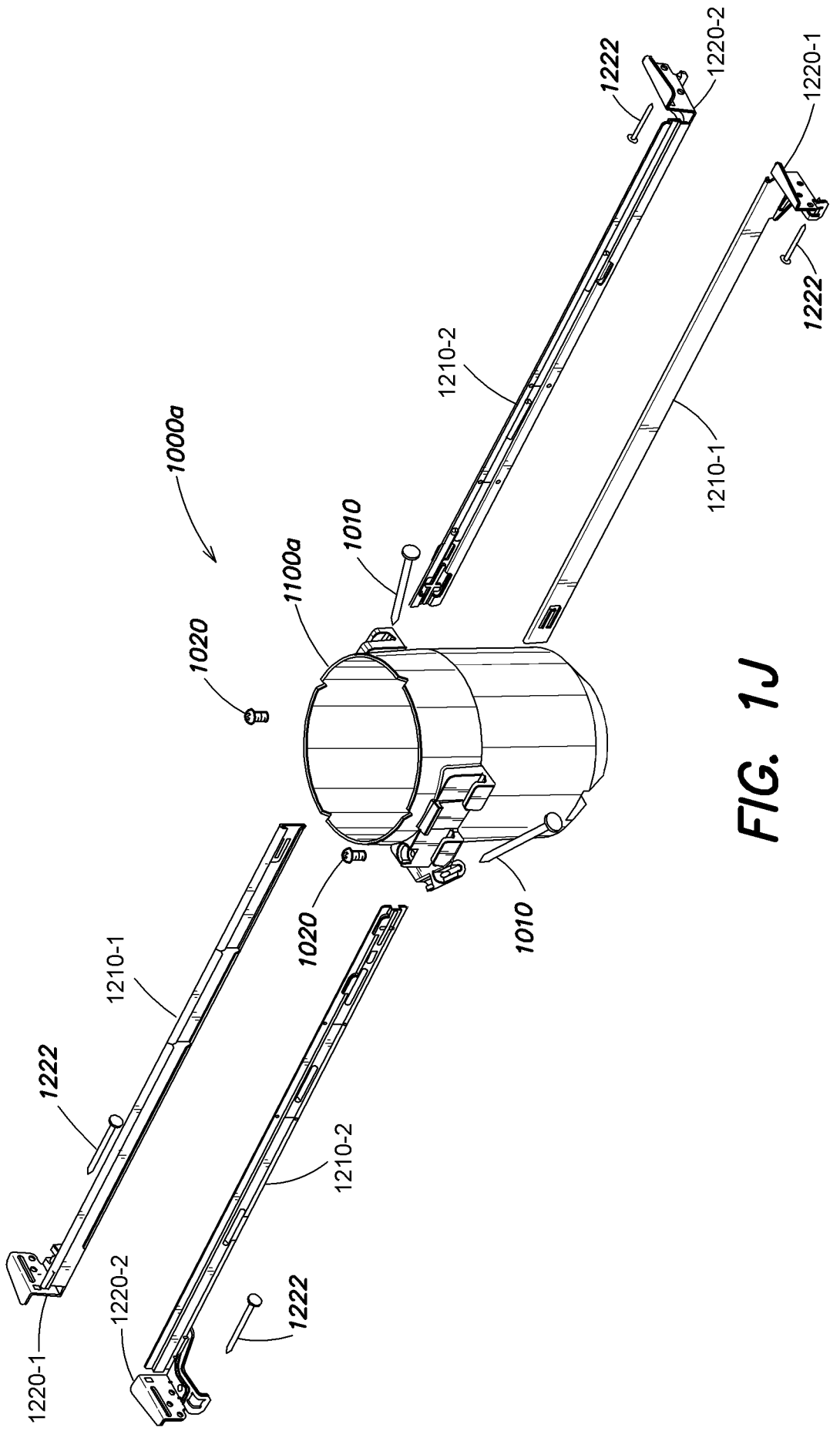

1000a
1100a
1010
1020
1020
1010
1210-2
1210-1
1222
1220-2
1220-1
1222
1210-1
1210-2
1222
1220-2
1220-1

FIG. 1J

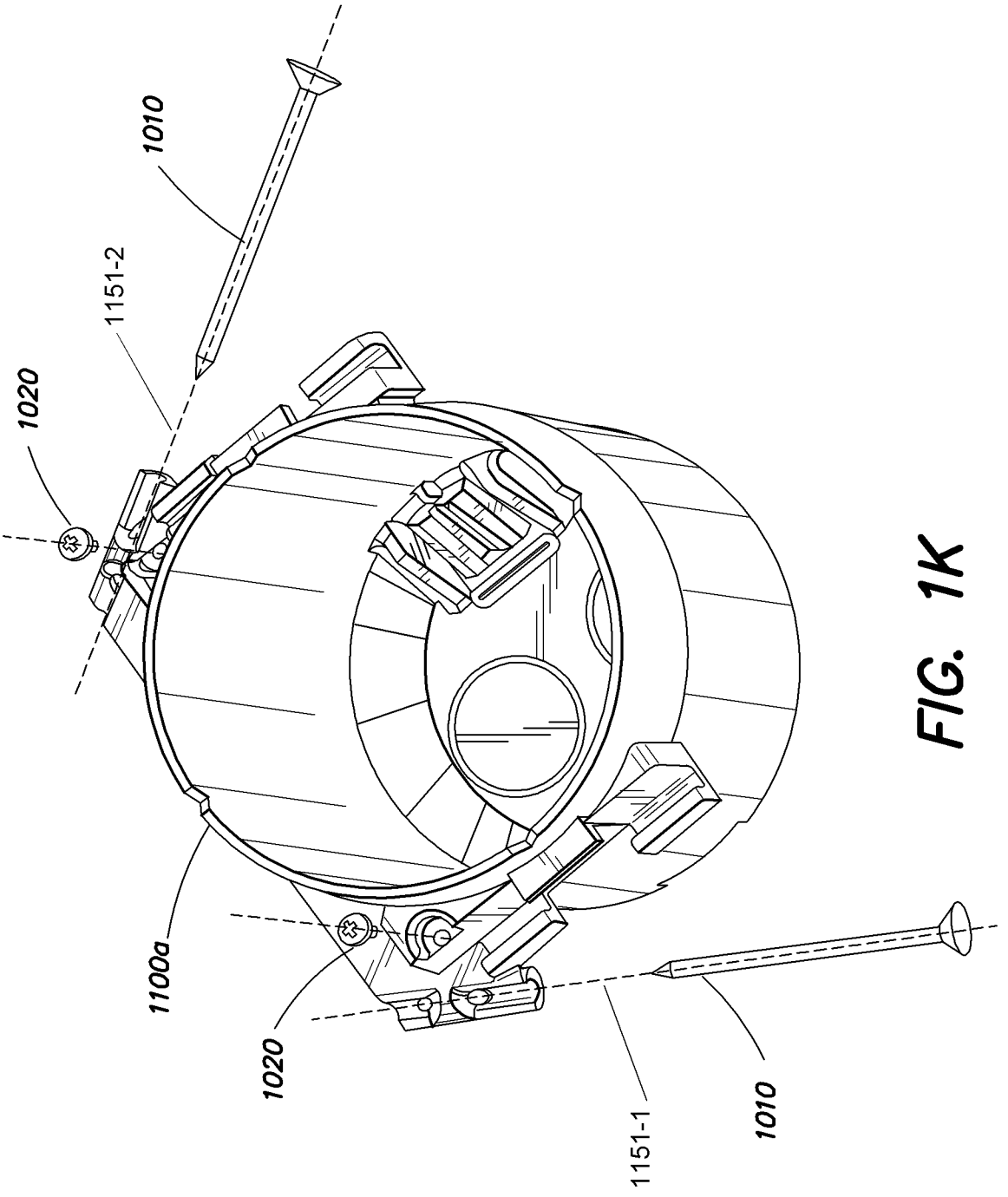



FIG. 1K

Date Reçue/Date Received 2021-07-16

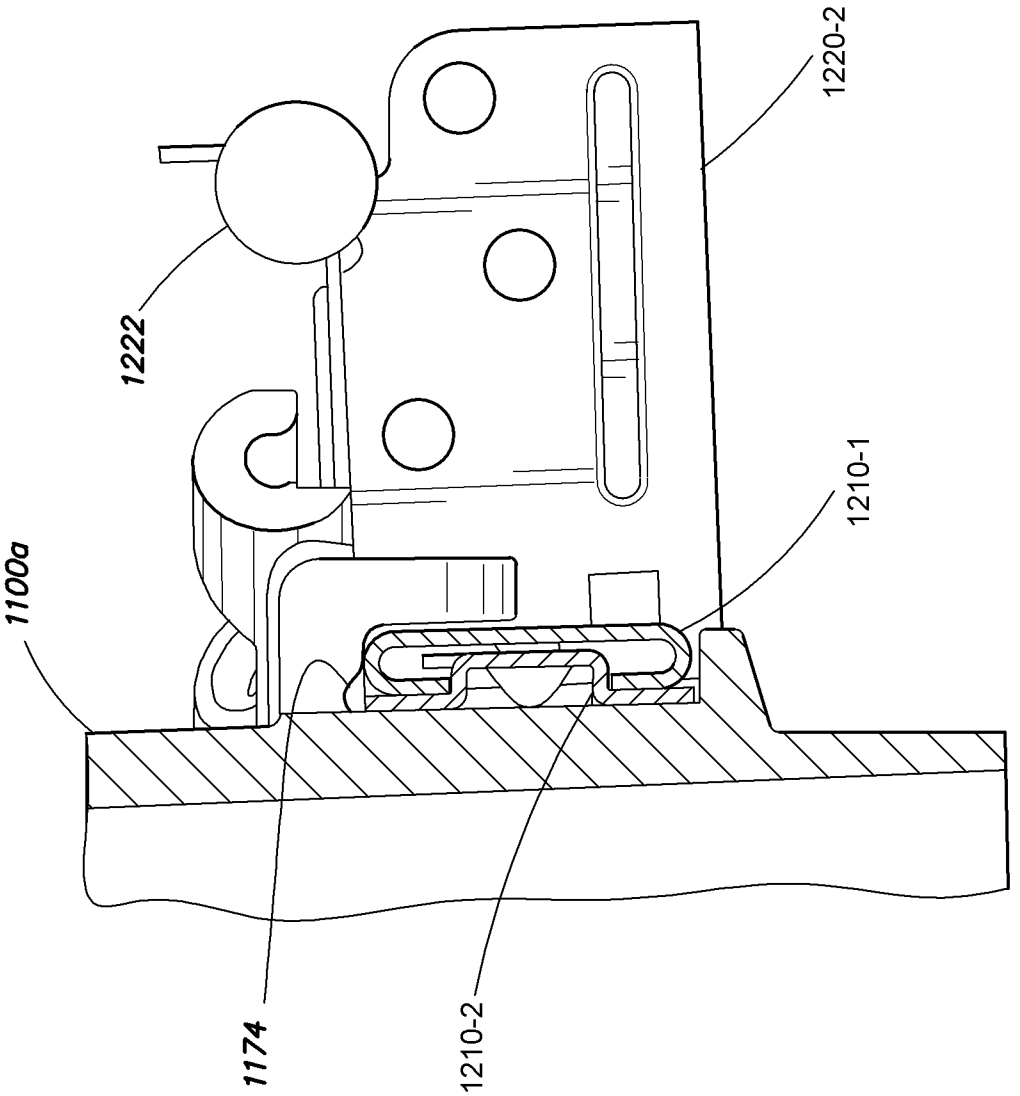



FIG. 1L

Date Reçue/Date Received 2021-07-16

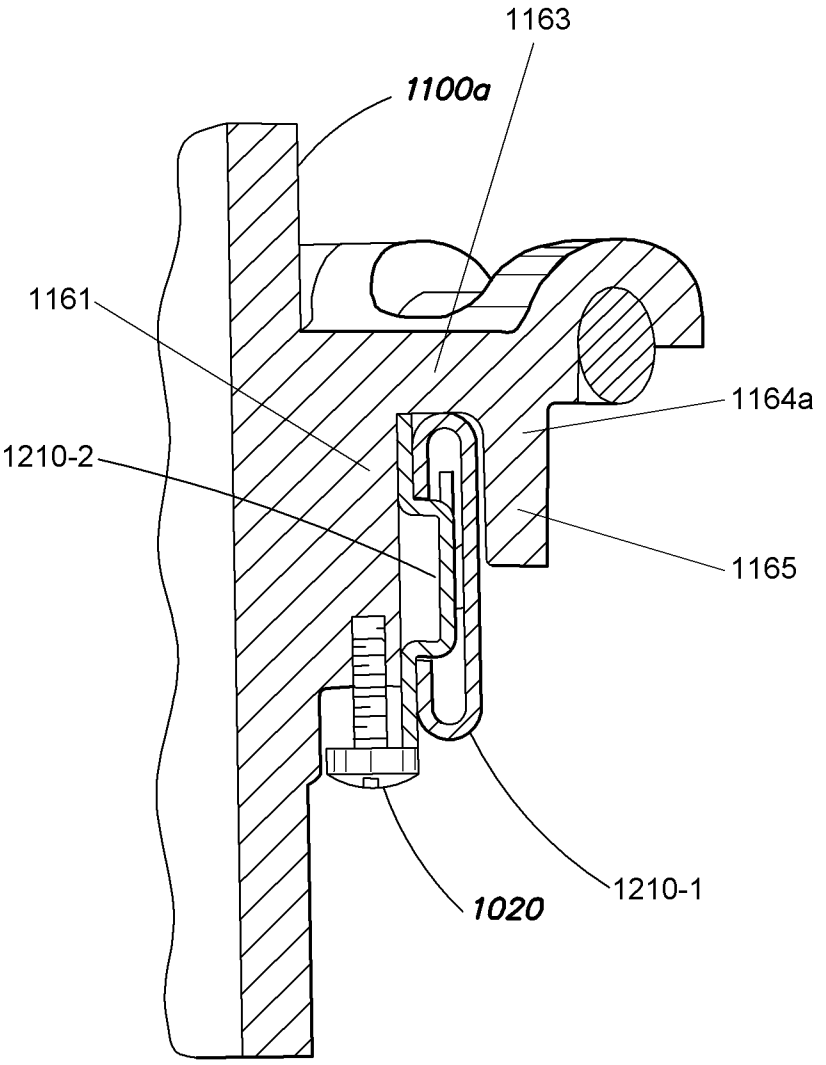



FIG. 1M

Date Reçue/Date Received 2021-07-16

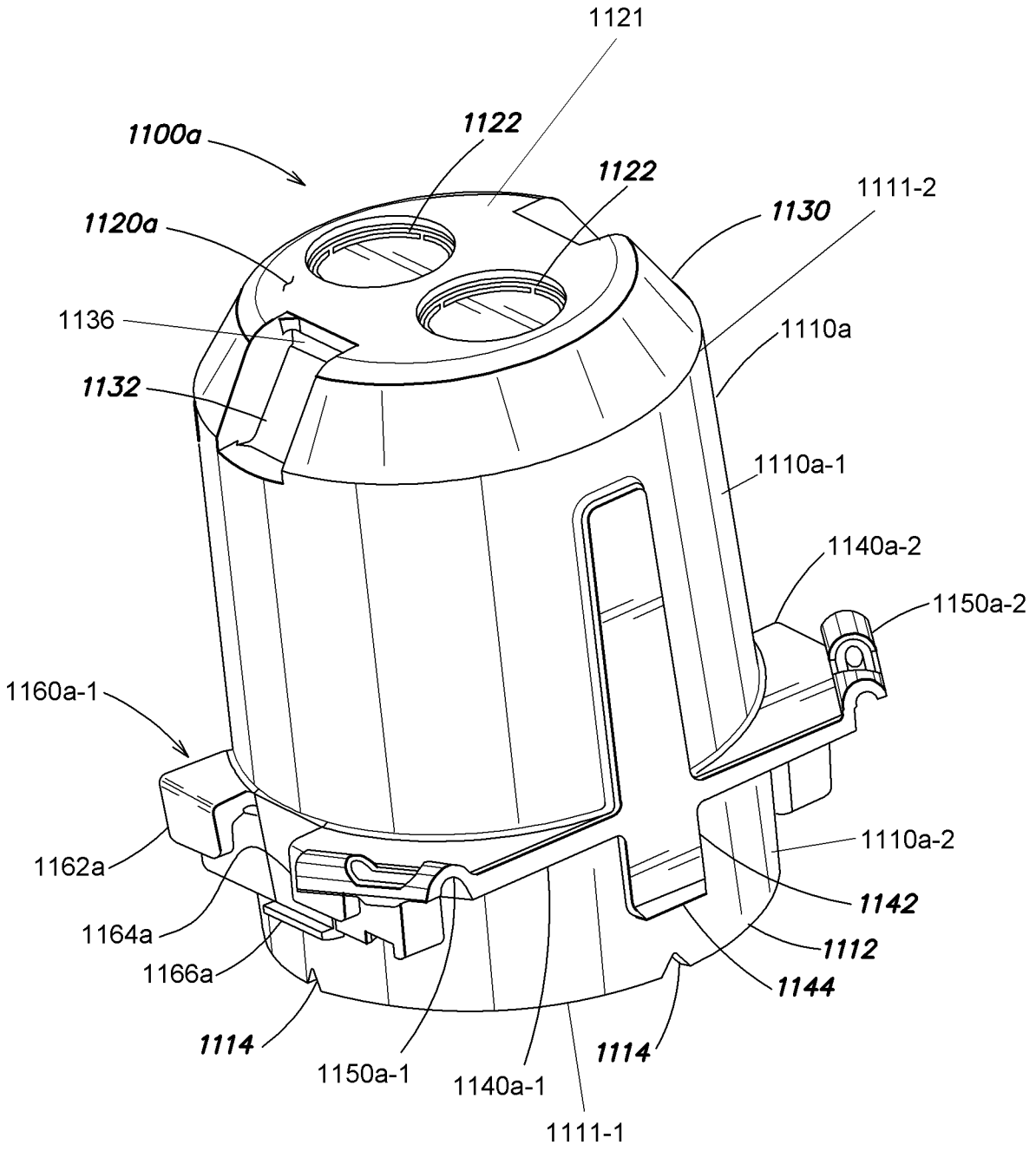



FIG. 2A

Date Reçue/Date Received 2021-07-16

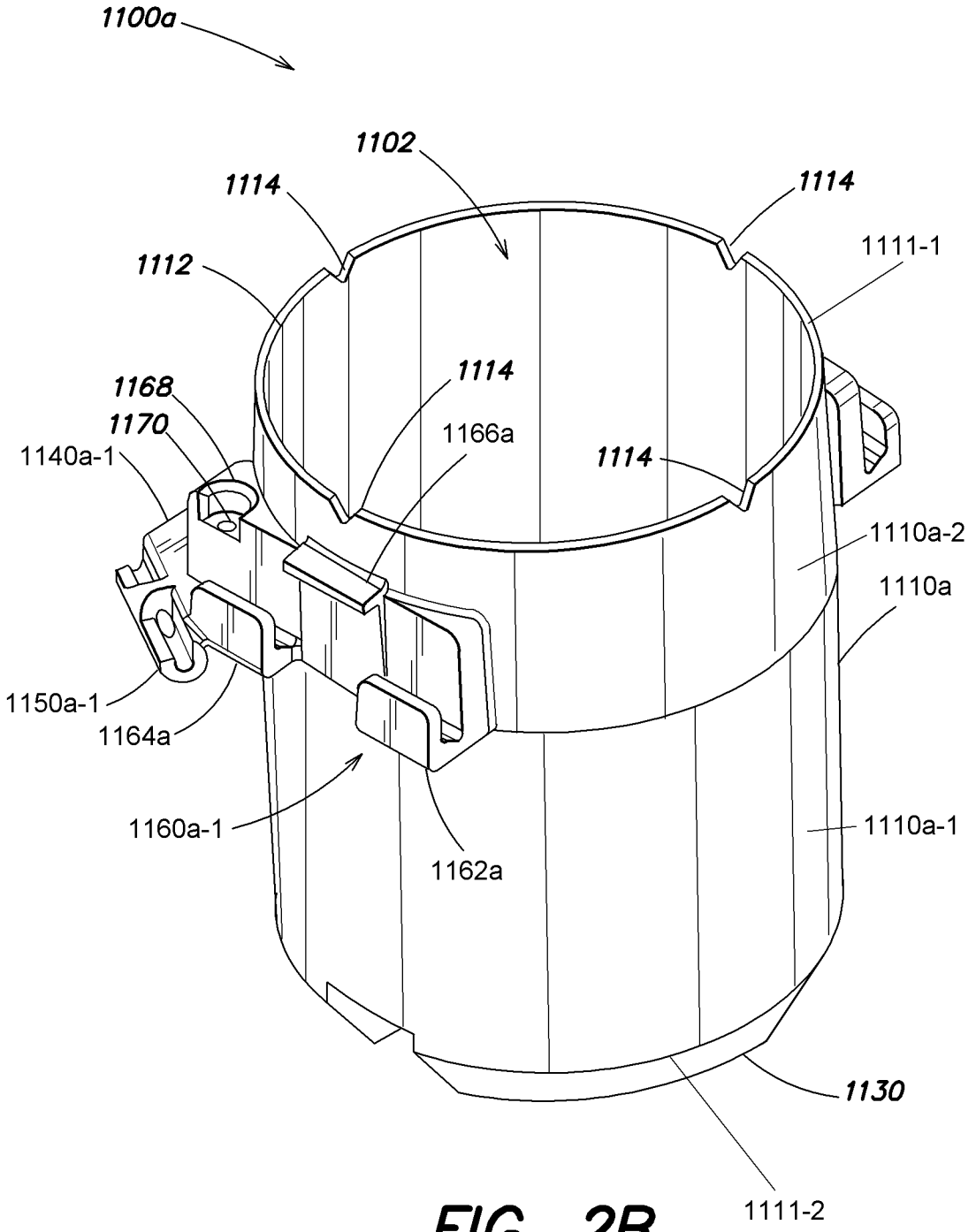



FIG. 2B

Date Reçue/Date Received 2021-07-16

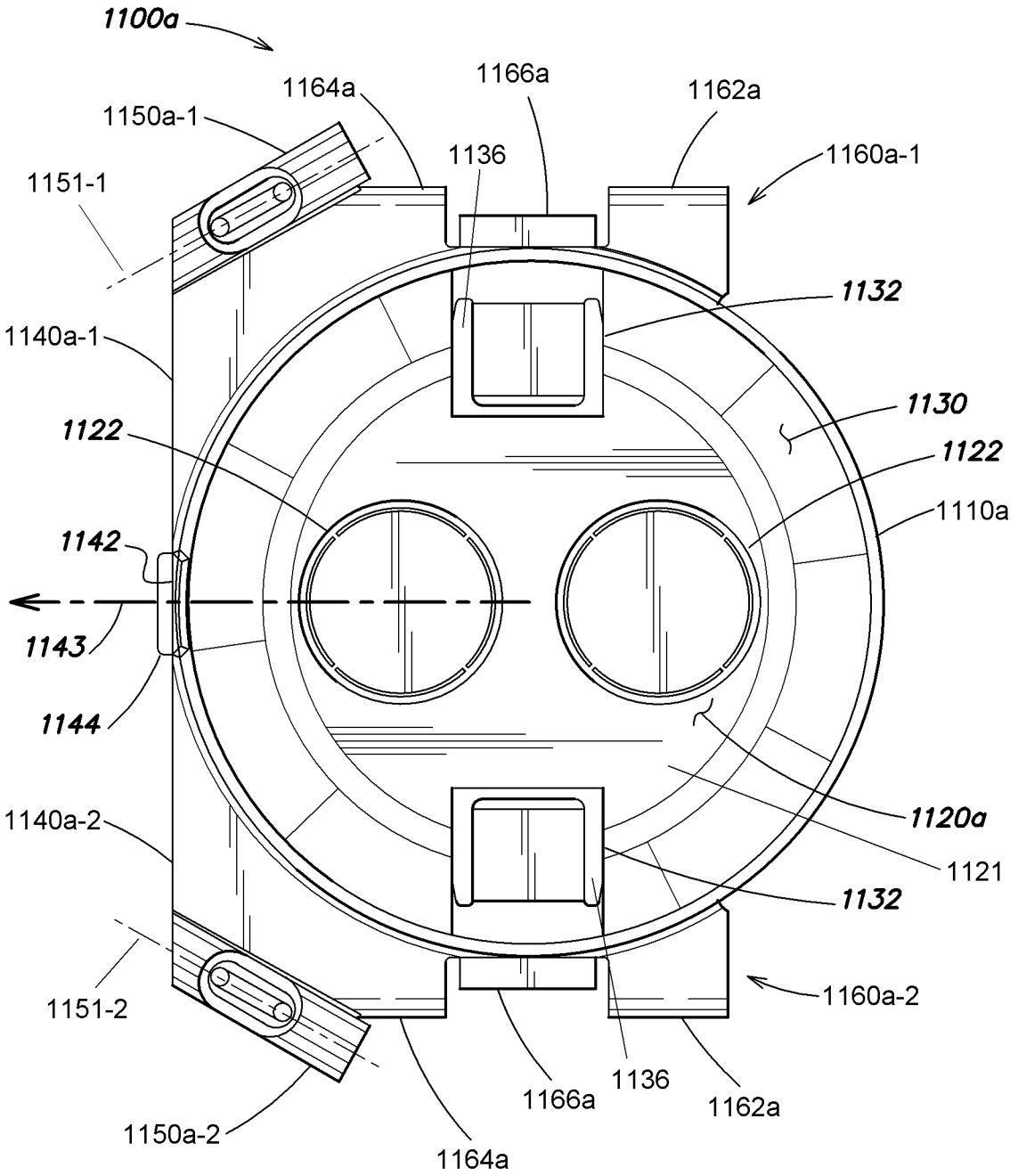



FIG. 2C

Date Reçue/Date Received 2021-07-16

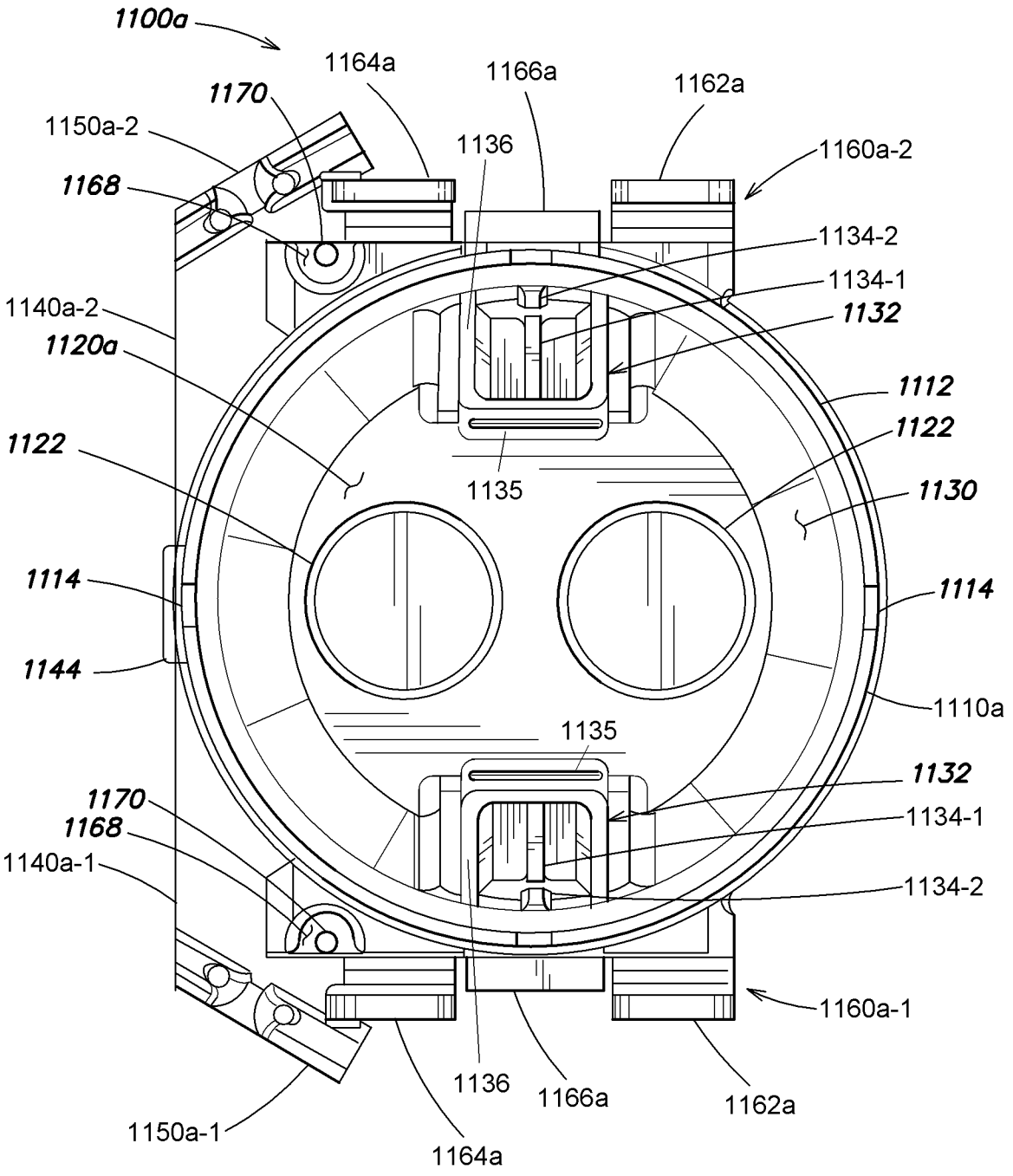



FIG. 2D

Date Reçue/Date Received 2021-07-16

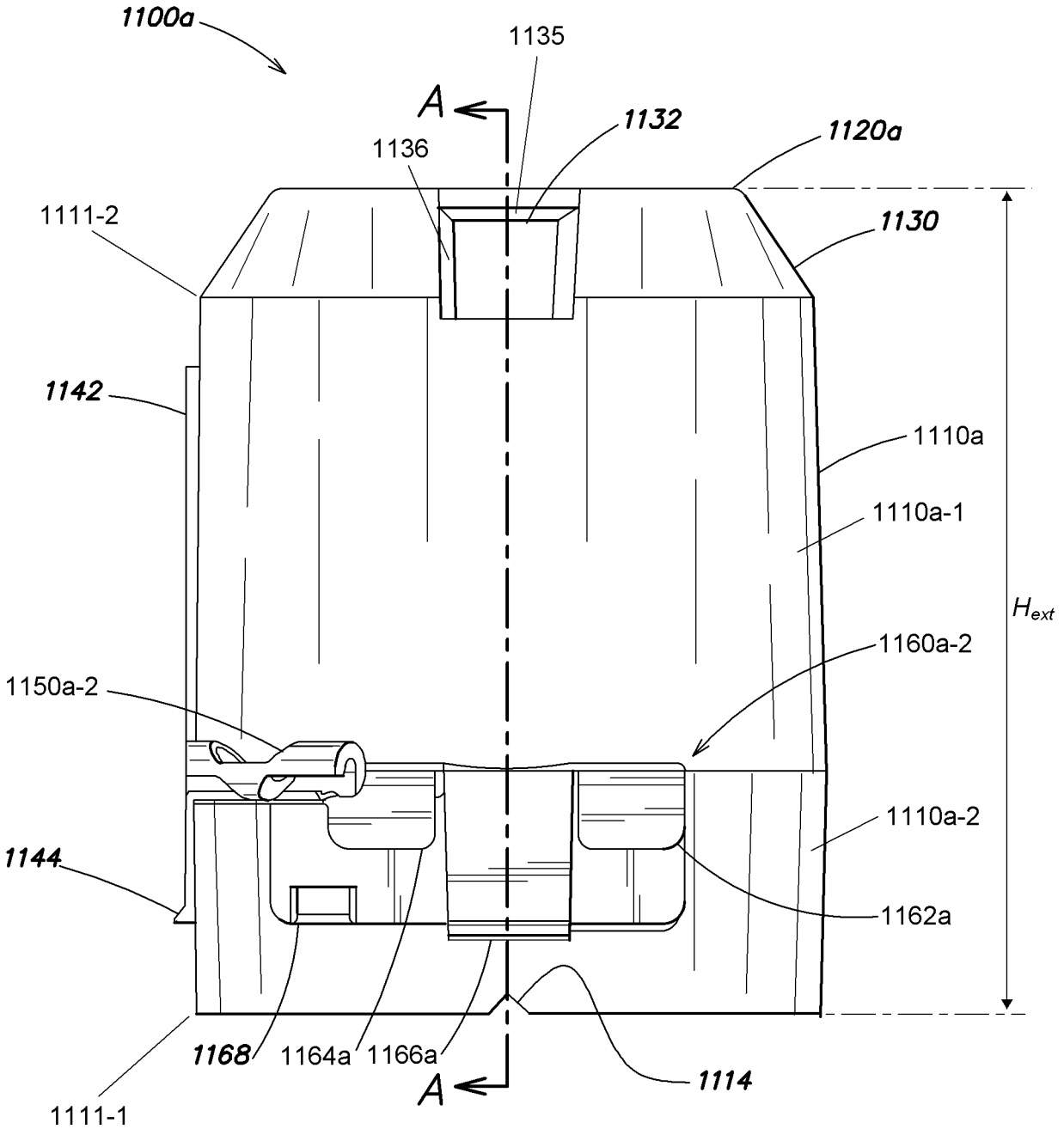



FIG. 2E

Date Reçue/Date Received 2021-07-16

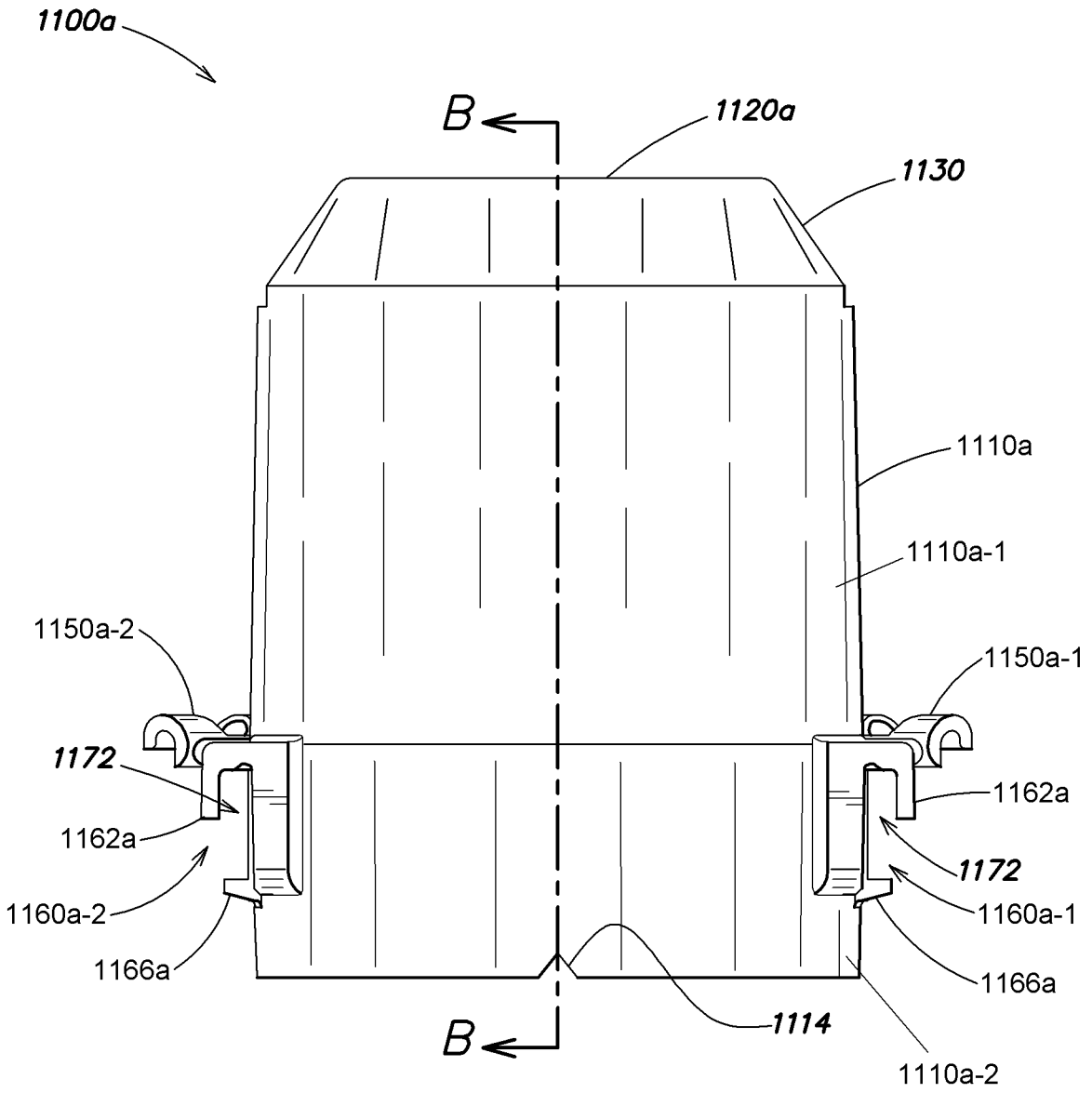



FIG. 2F

Date Reçue/Date Received 2021-07-16

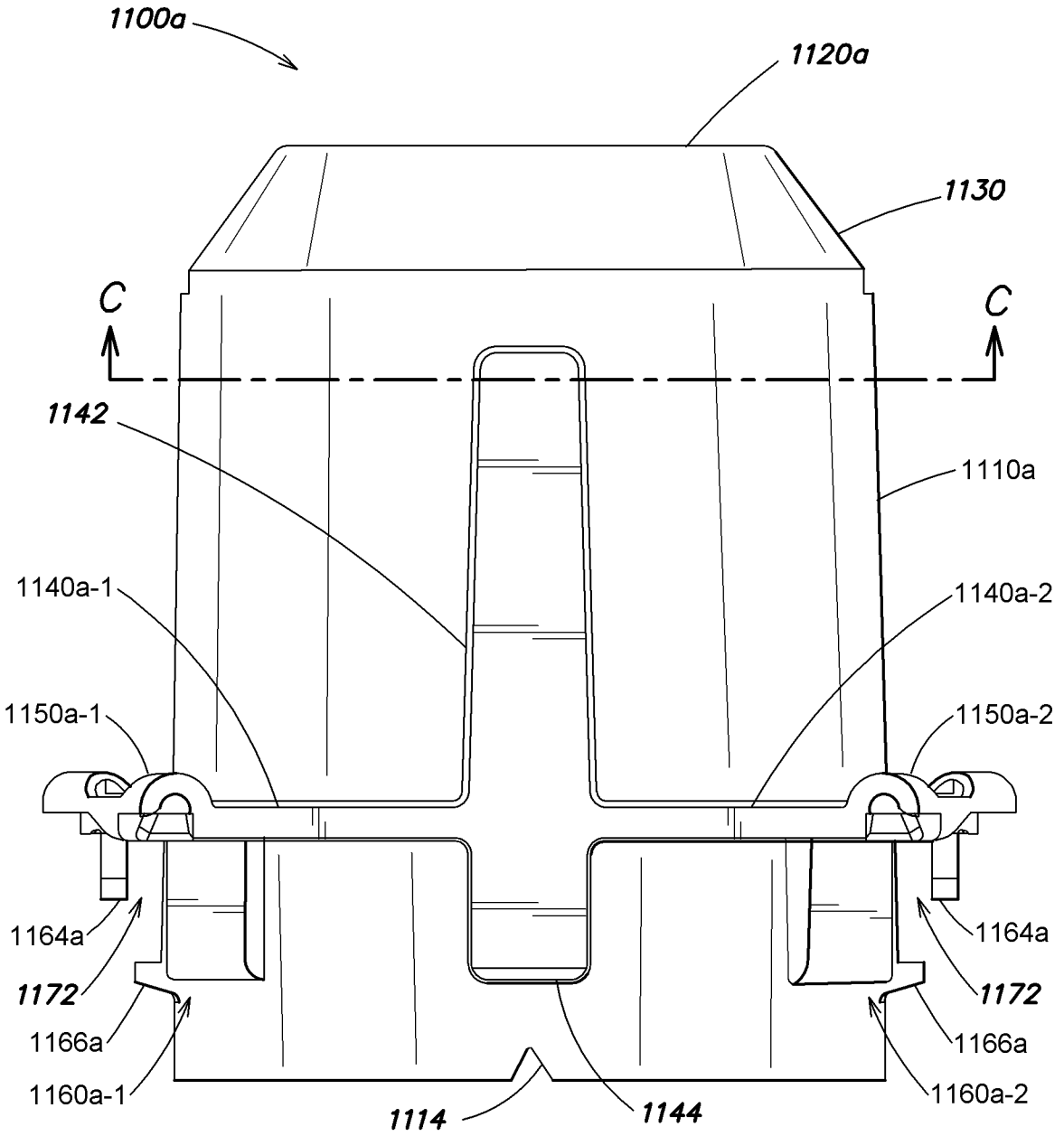



FIG. 2G

Date Reçue/Date Received 2021-07-16

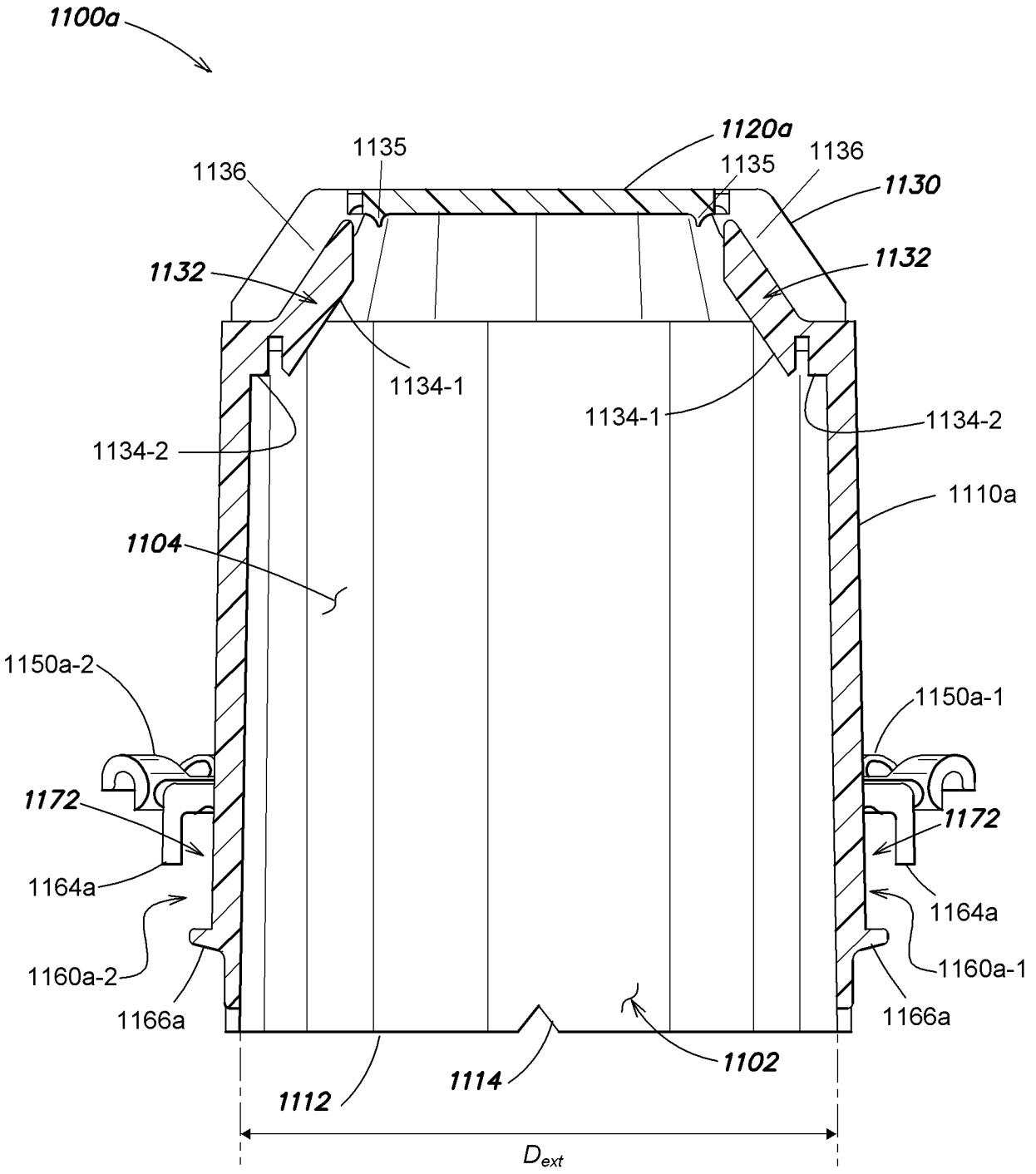



FIG. 2H

Date Reçue/Date Received 2021-07-16

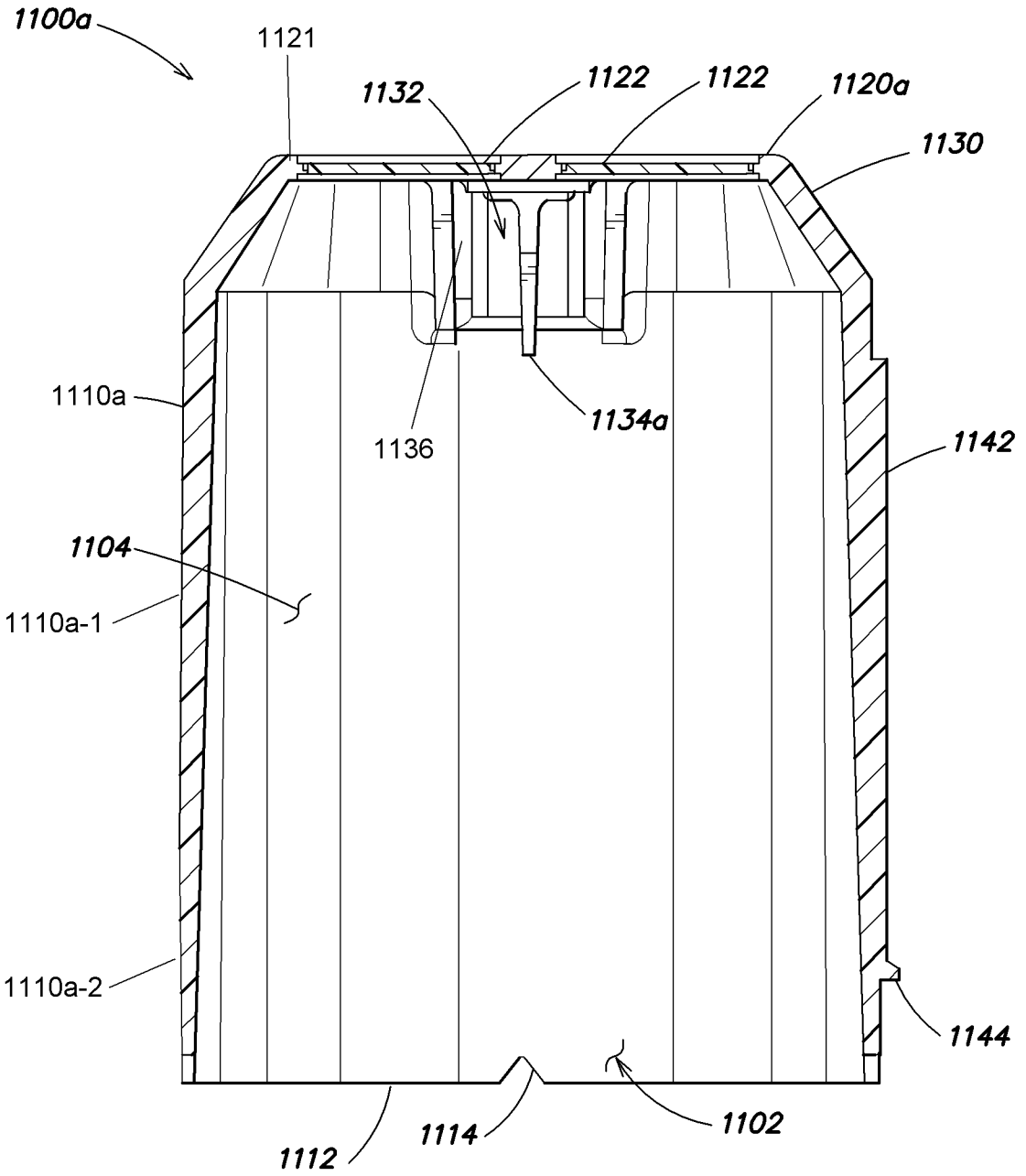



FIG. 2I

Date Reçue/Date Received 2021-07-16

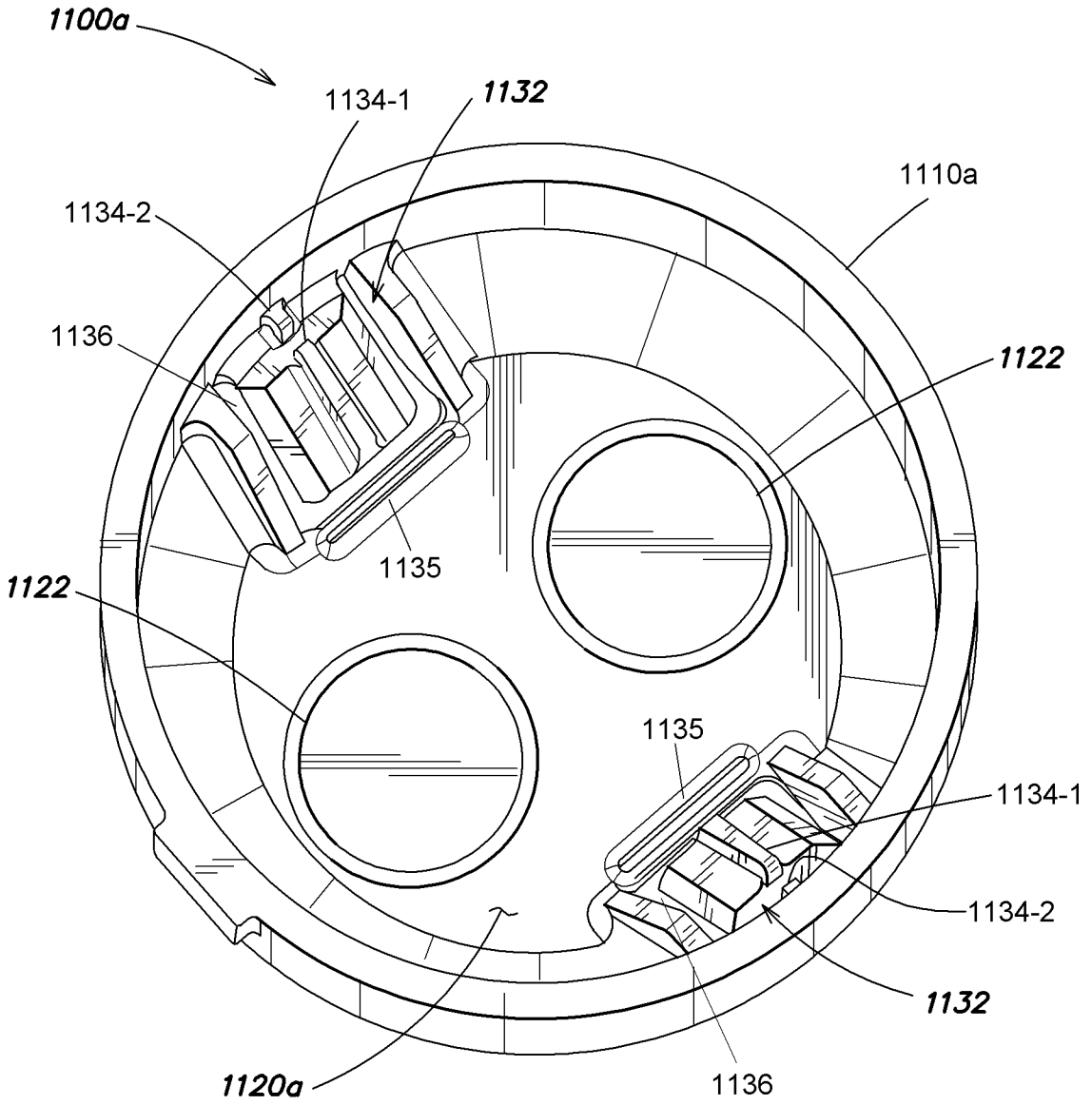



FIG. 2J

Date Reçue/Date Received 2021-07-16

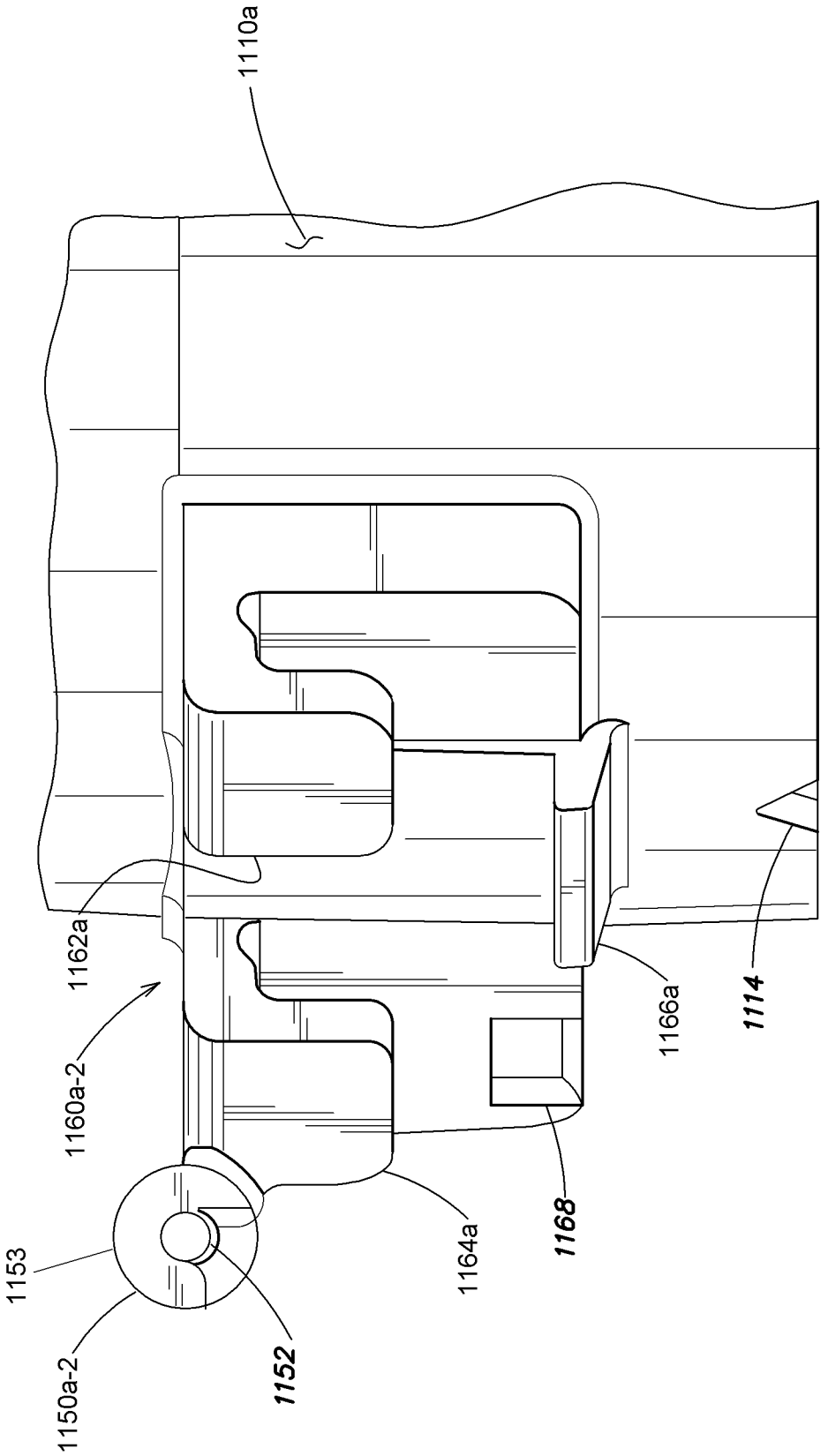



FIG. 3A

Date Reçue/Date Received 2021-07-16

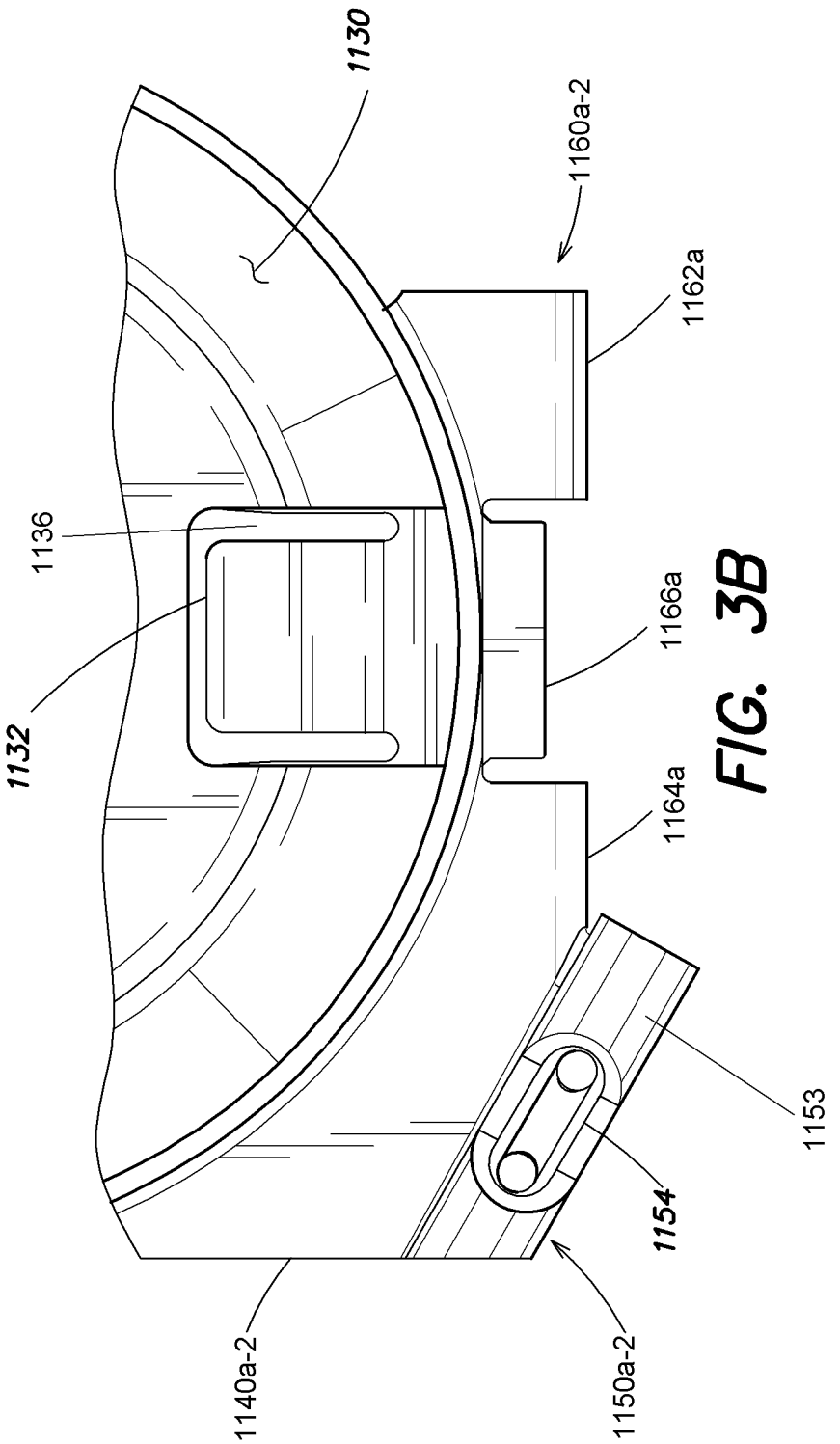



FIG. 3B

Date Reçue/Date Received 2021-07-16

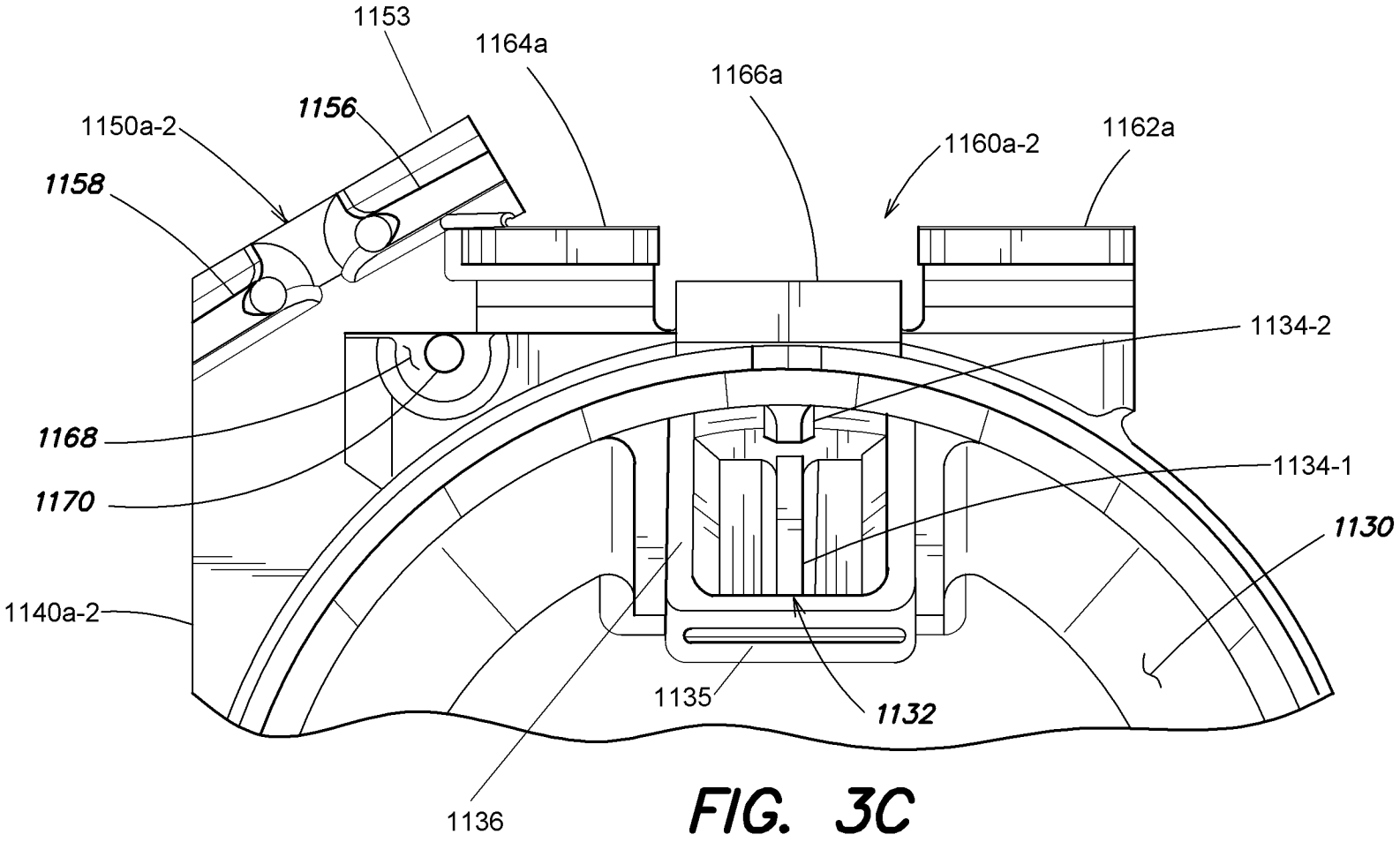



FIG. 3C

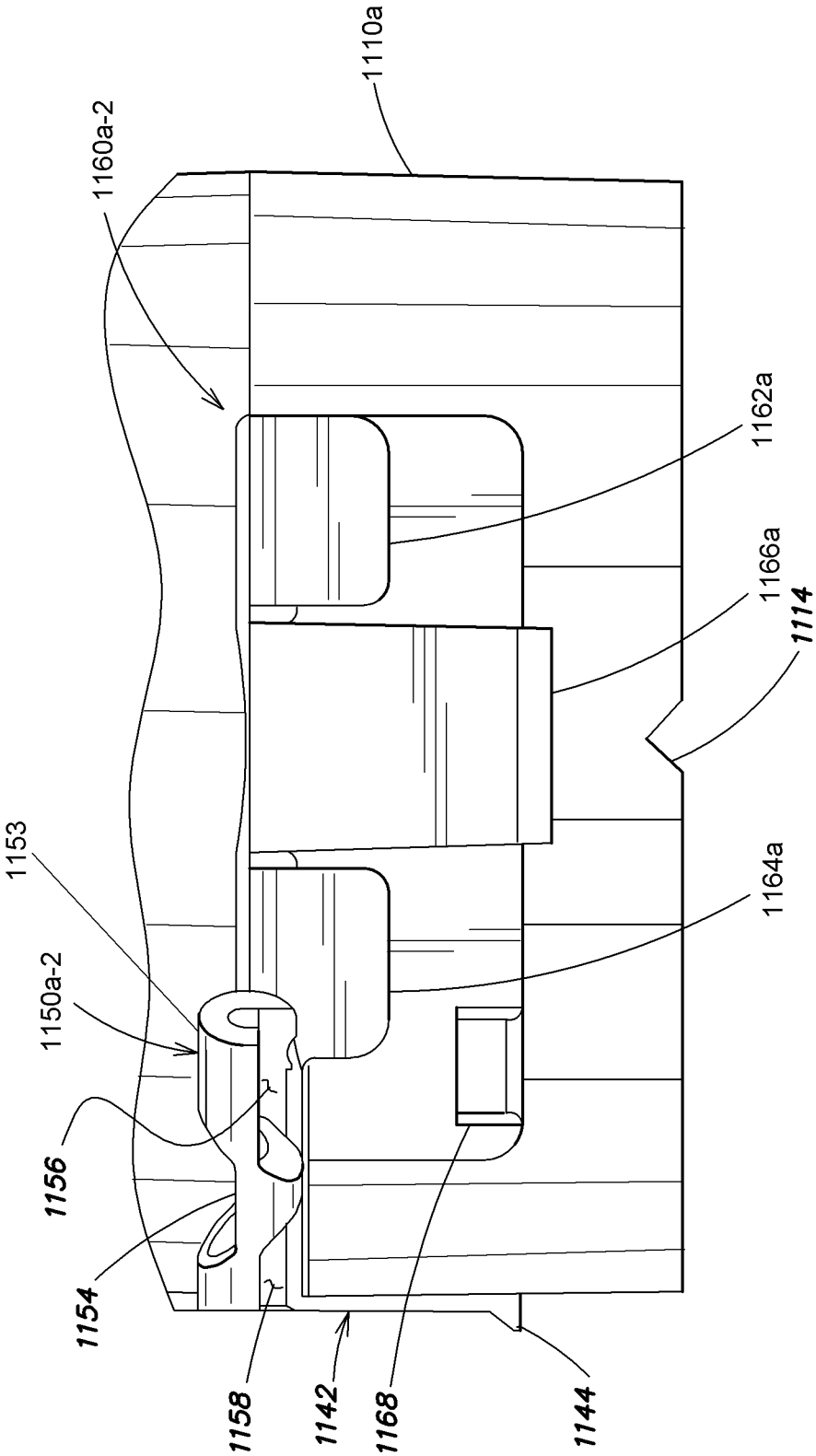



FIG. 3D

Date Reçue/Date Received 2021-07-16

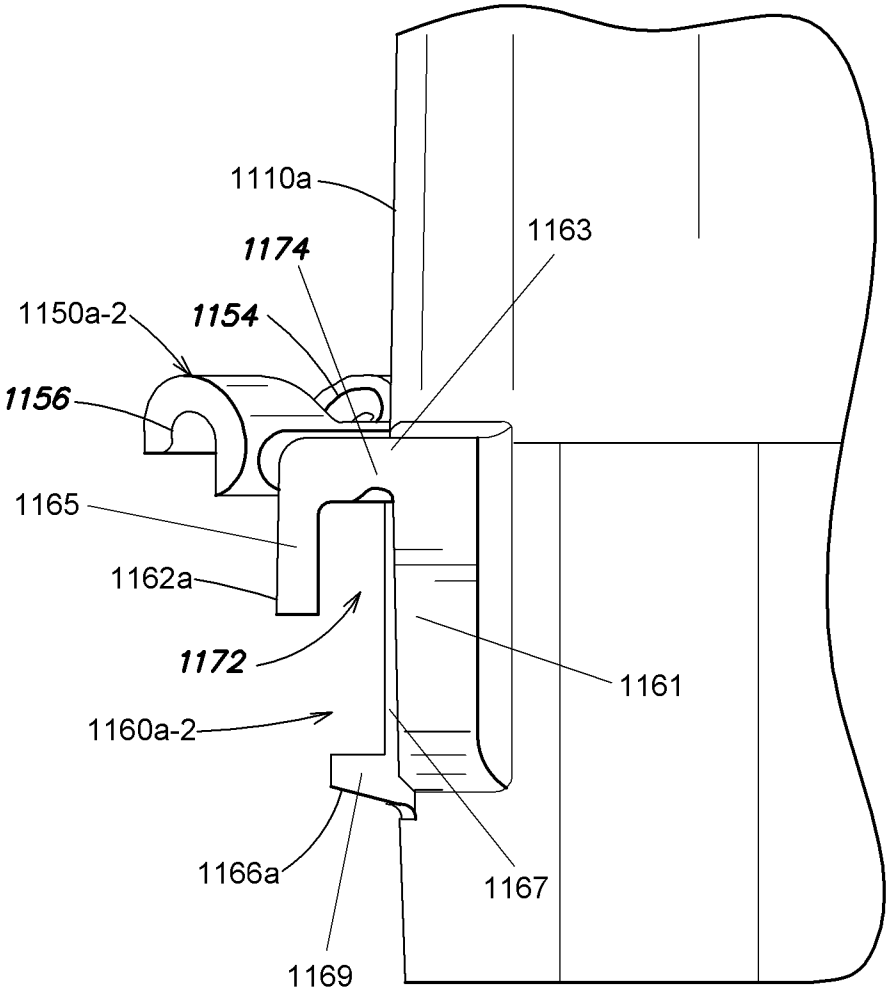



FIG. 3E

Date Reçue/Date Received 2021-07-16

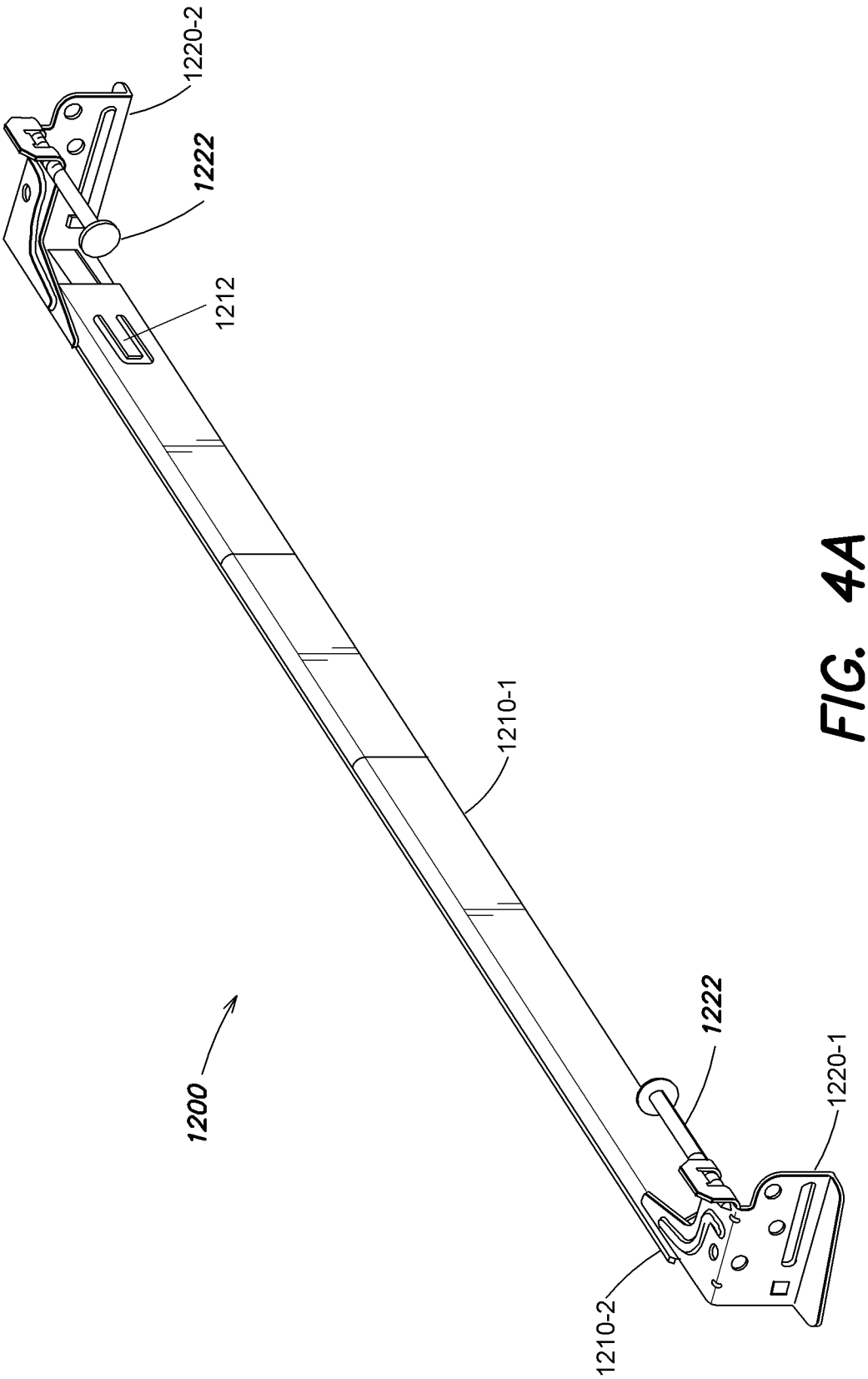



FIG. 4A

Date Reçue/Date Received 2021-07-16

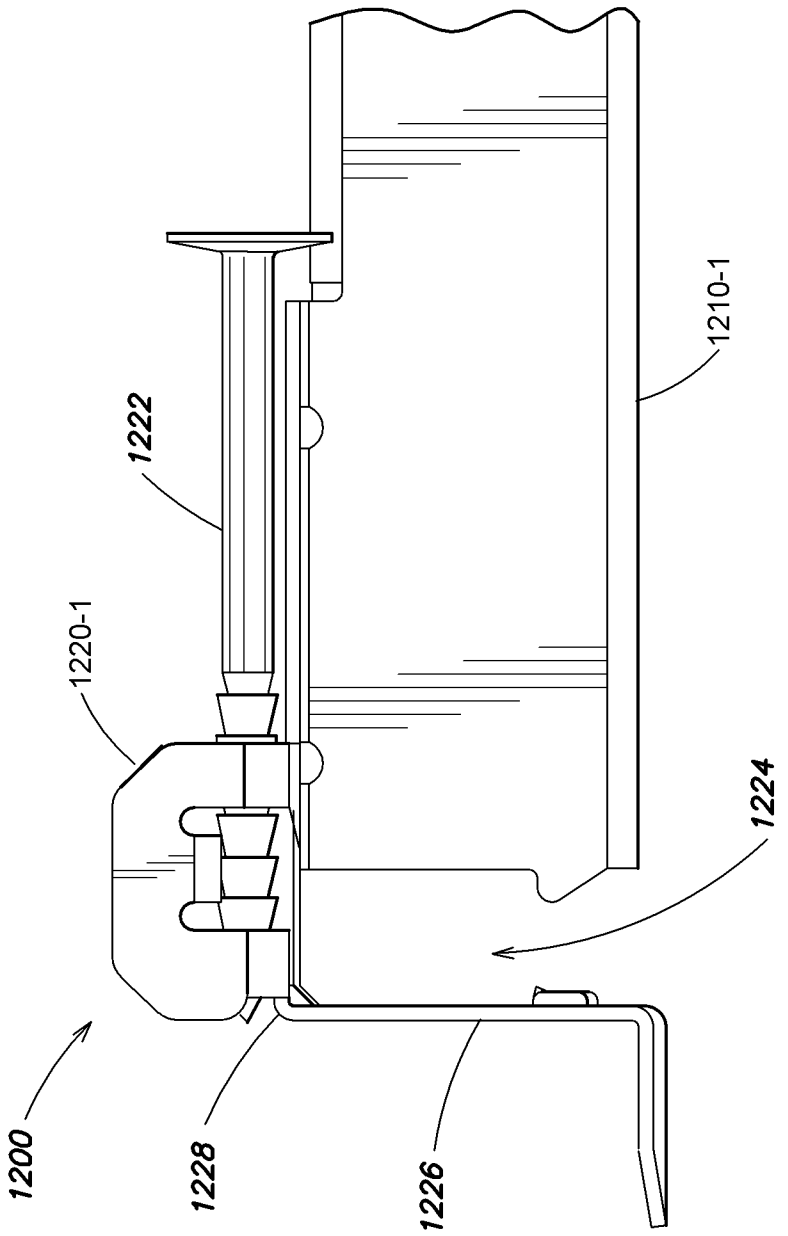



FIG. 4B

Date Reçue/Date Received 2021-07-16

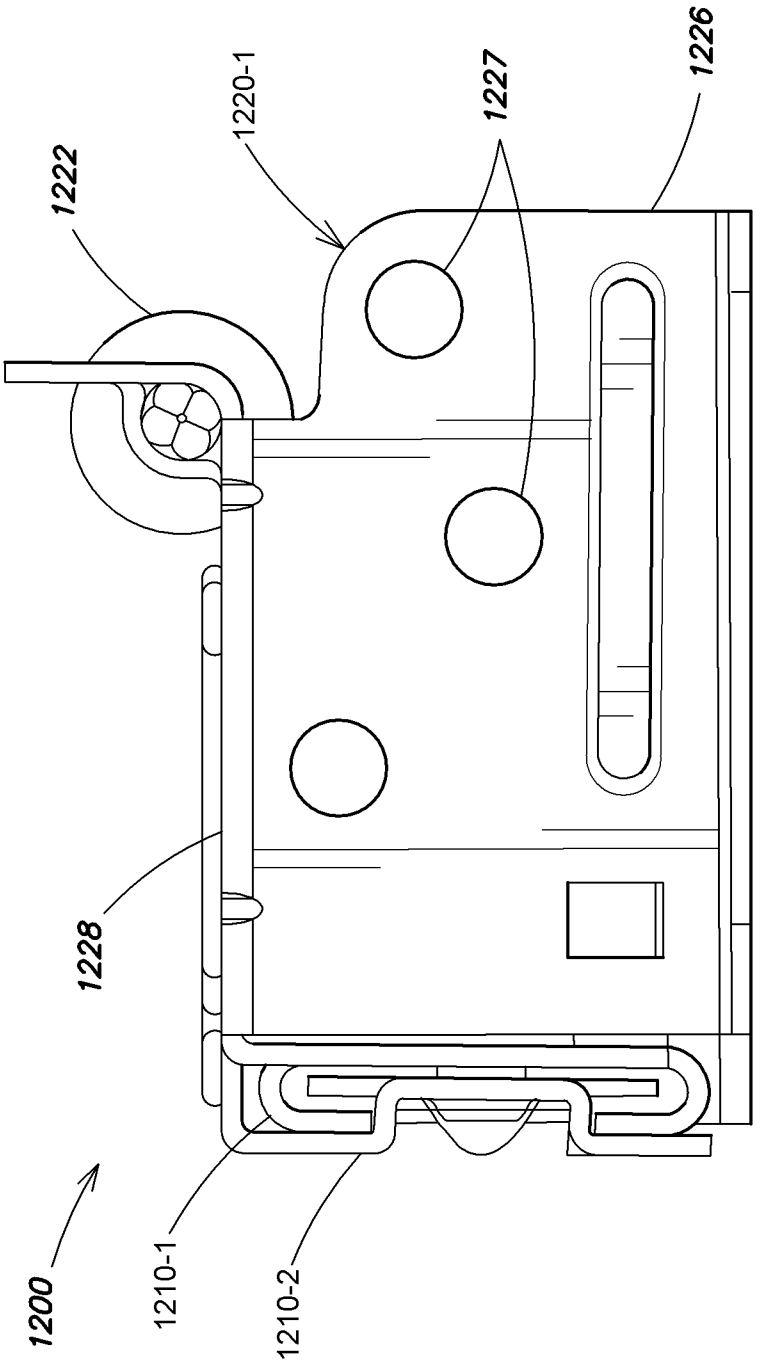



FIG. 4C

Date Reçue/Date Received 2021-07-16

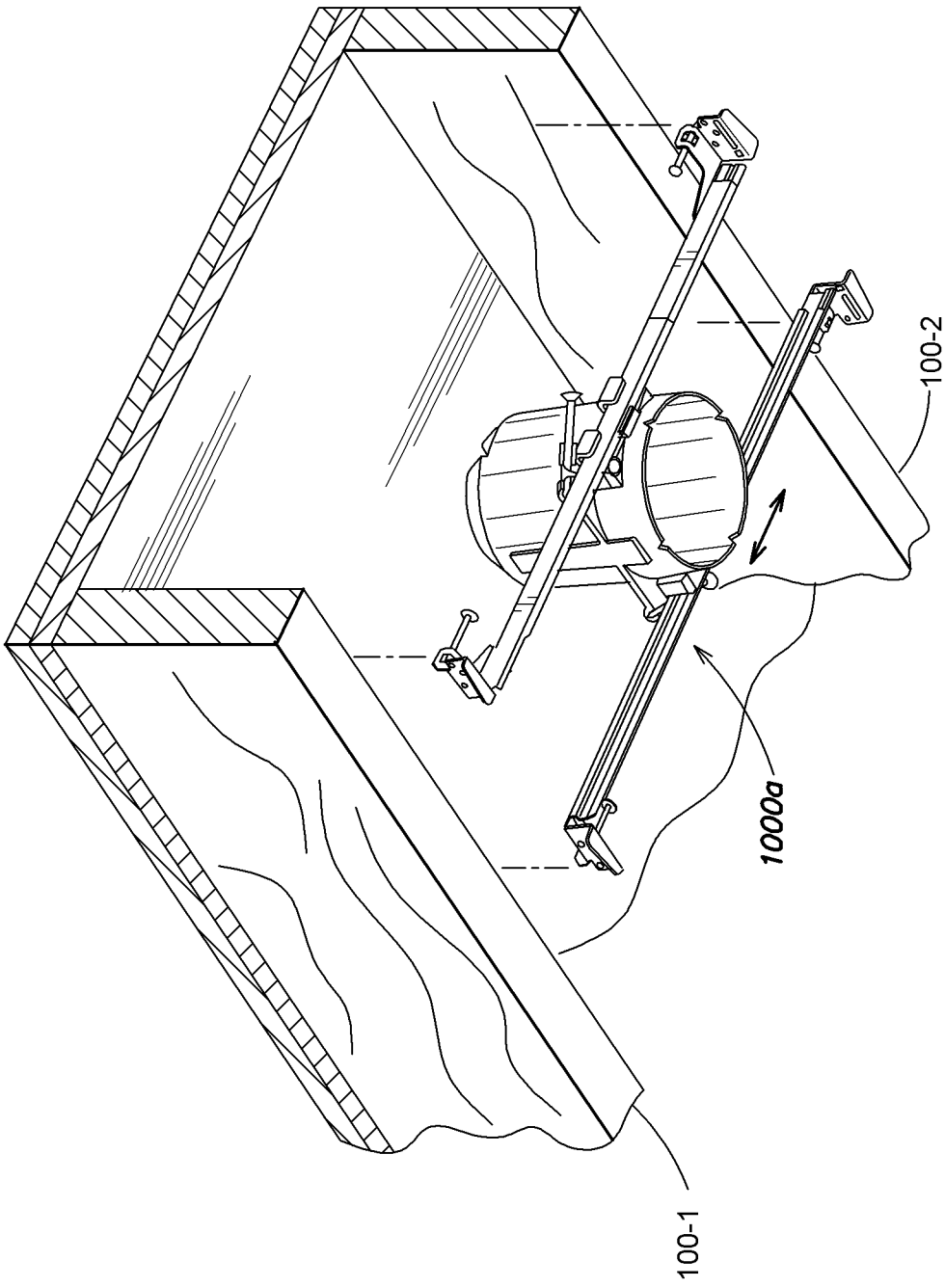



FIG. 5A

Date Reçue/Date Received 2021-07-16

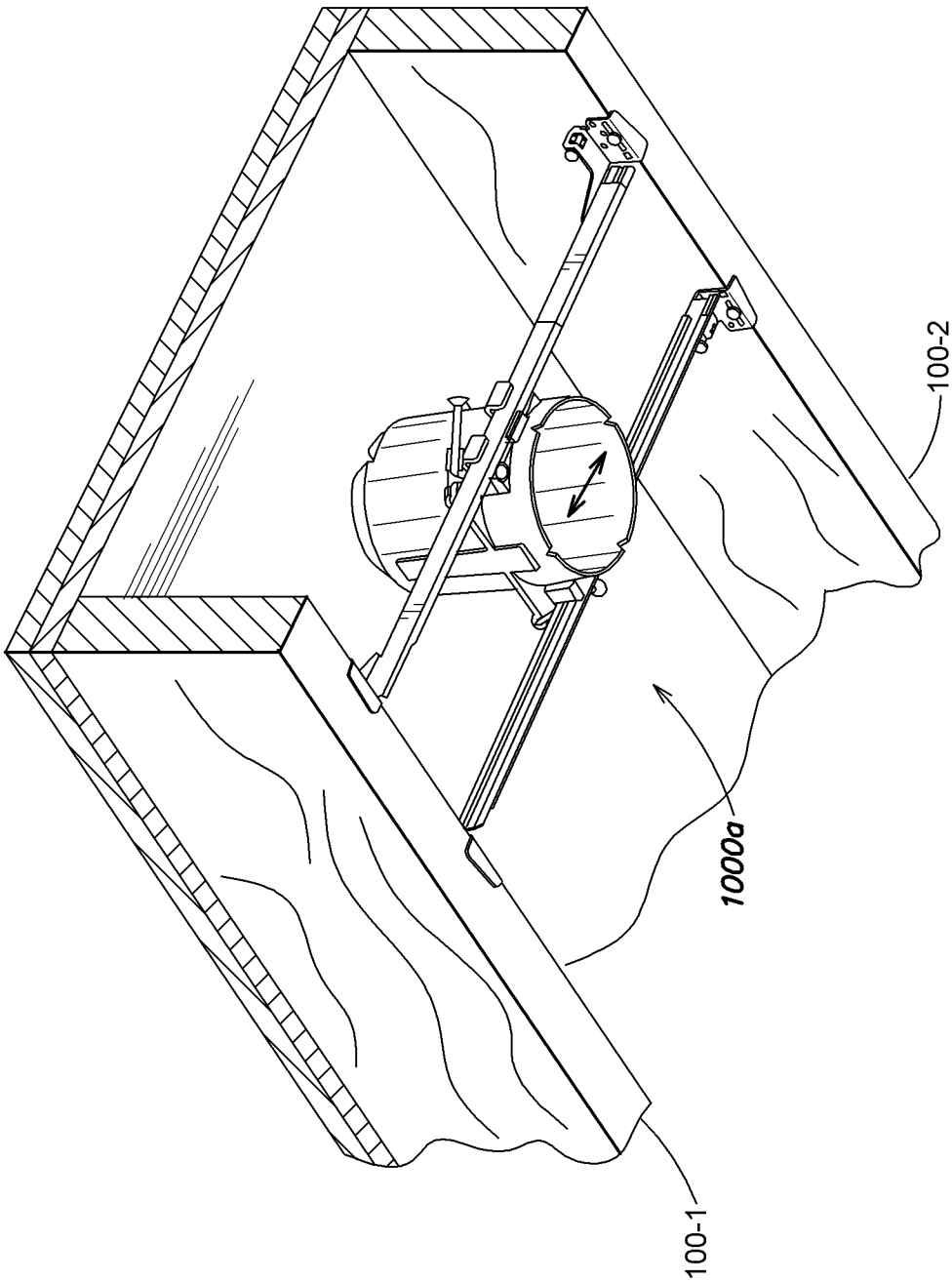



FIG. 5B

Date Reçue/Date Received 2021-07-16

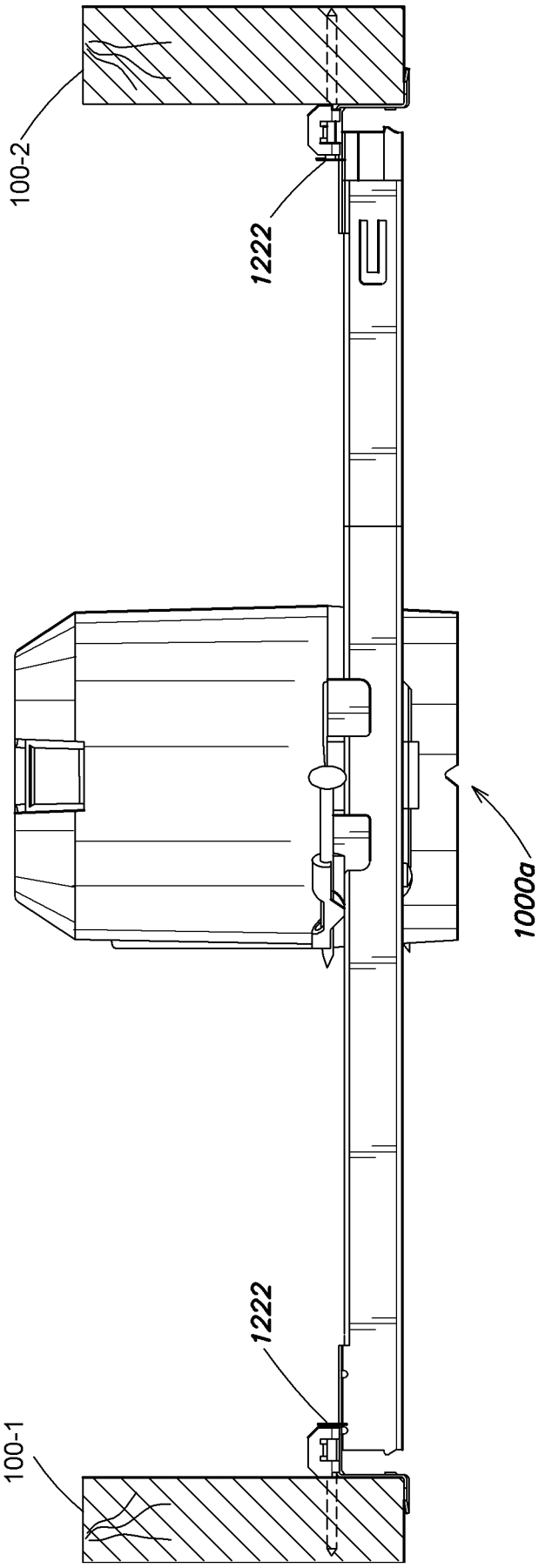



FIG. 5C

Date Reçue/Date Received 2021-07-16

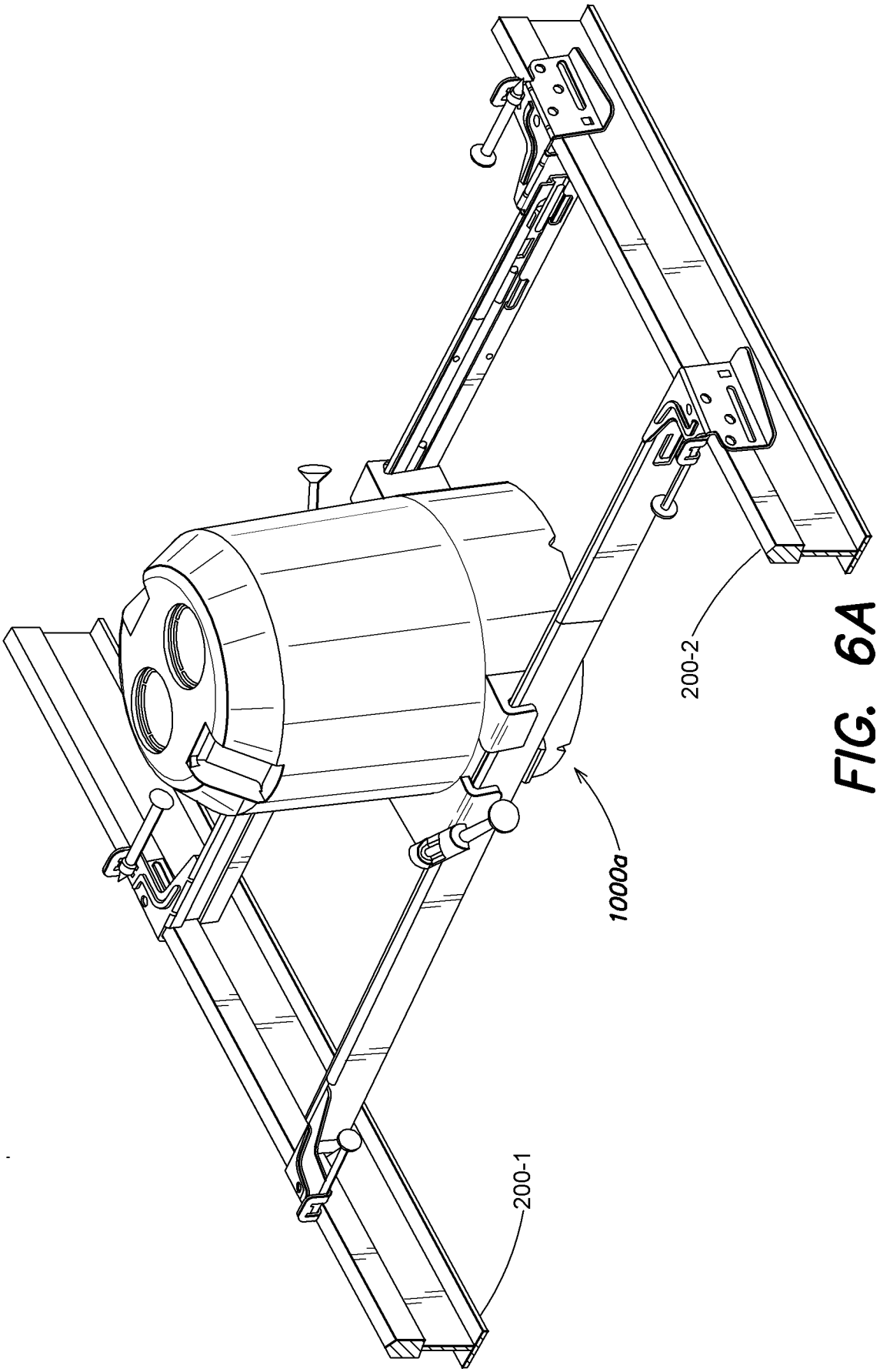



FIG. 6A

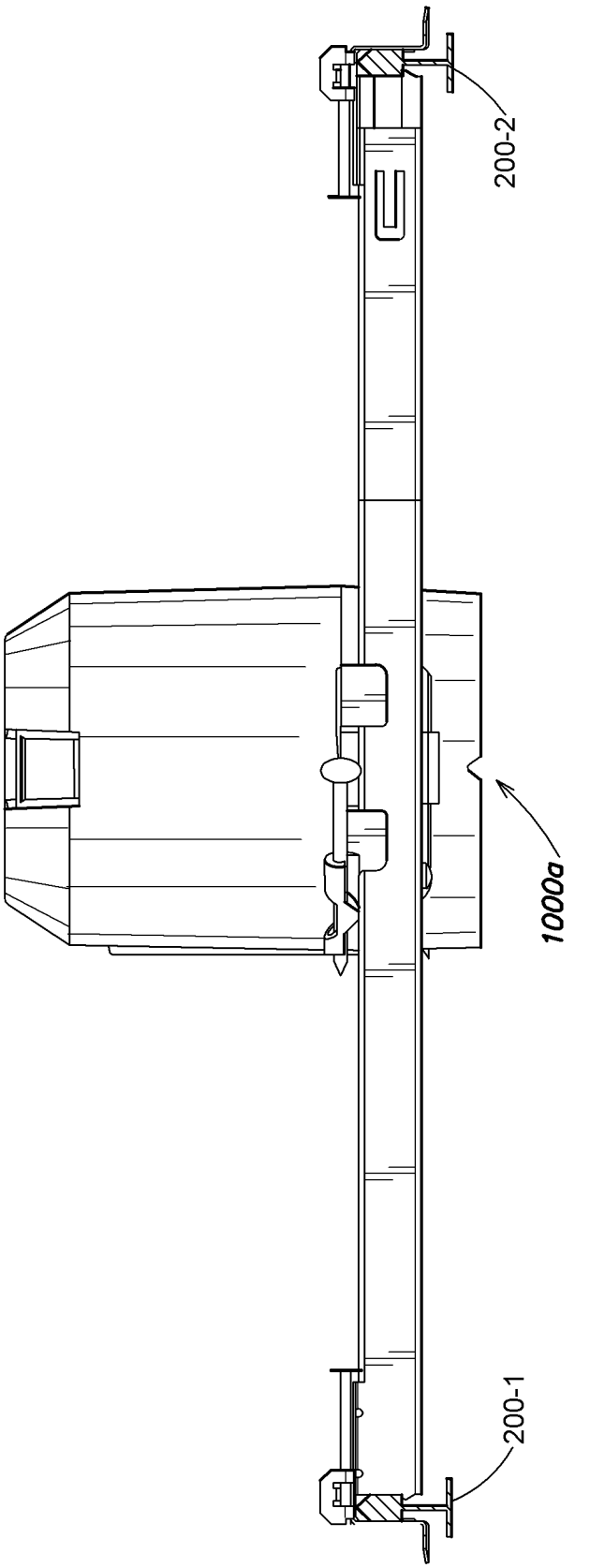



FIG. 6B

Date Reçue/Date Received 2021-07-16

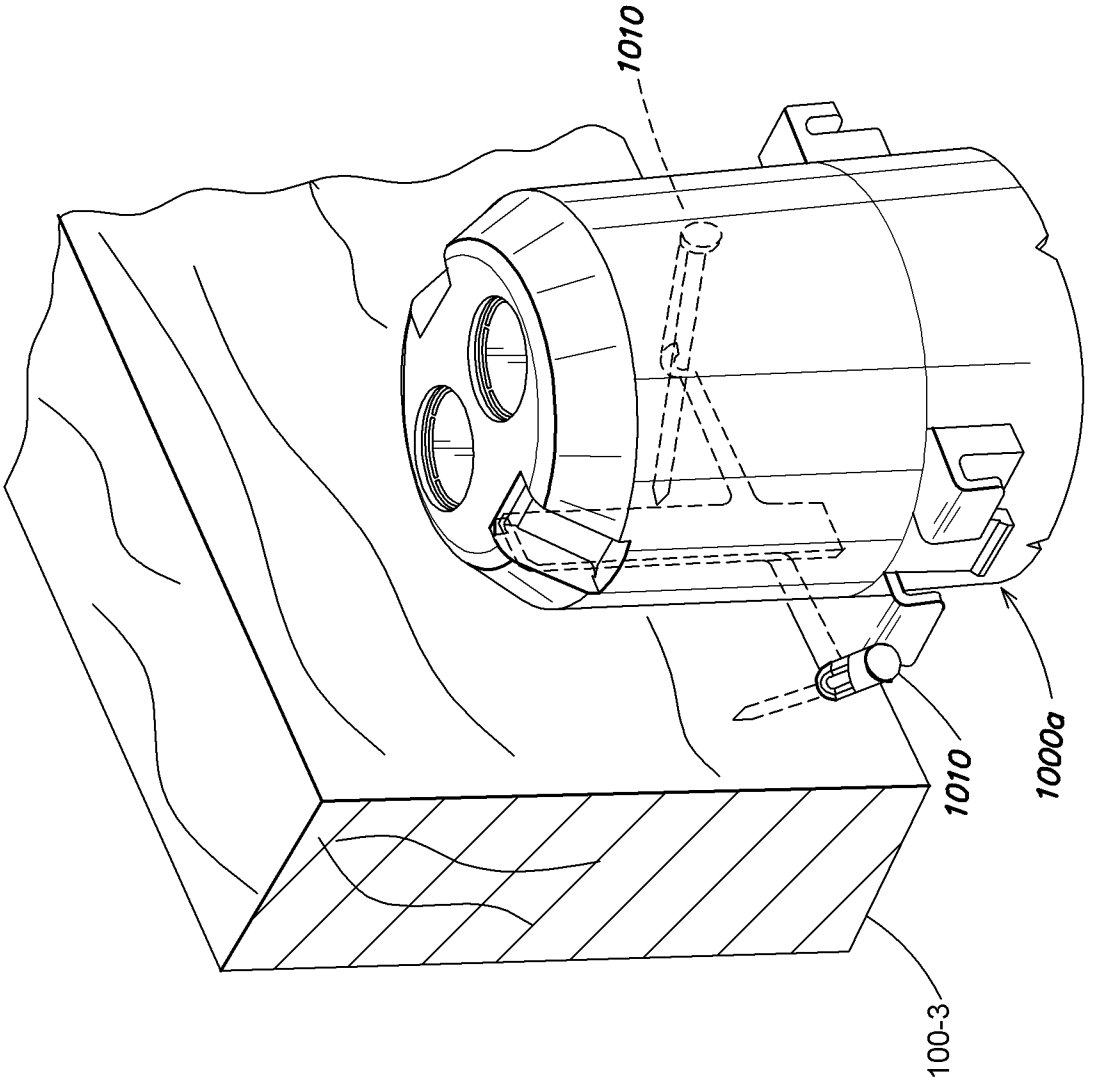



FIG. 7A

Date Reçue/Date Received 2021-07-16

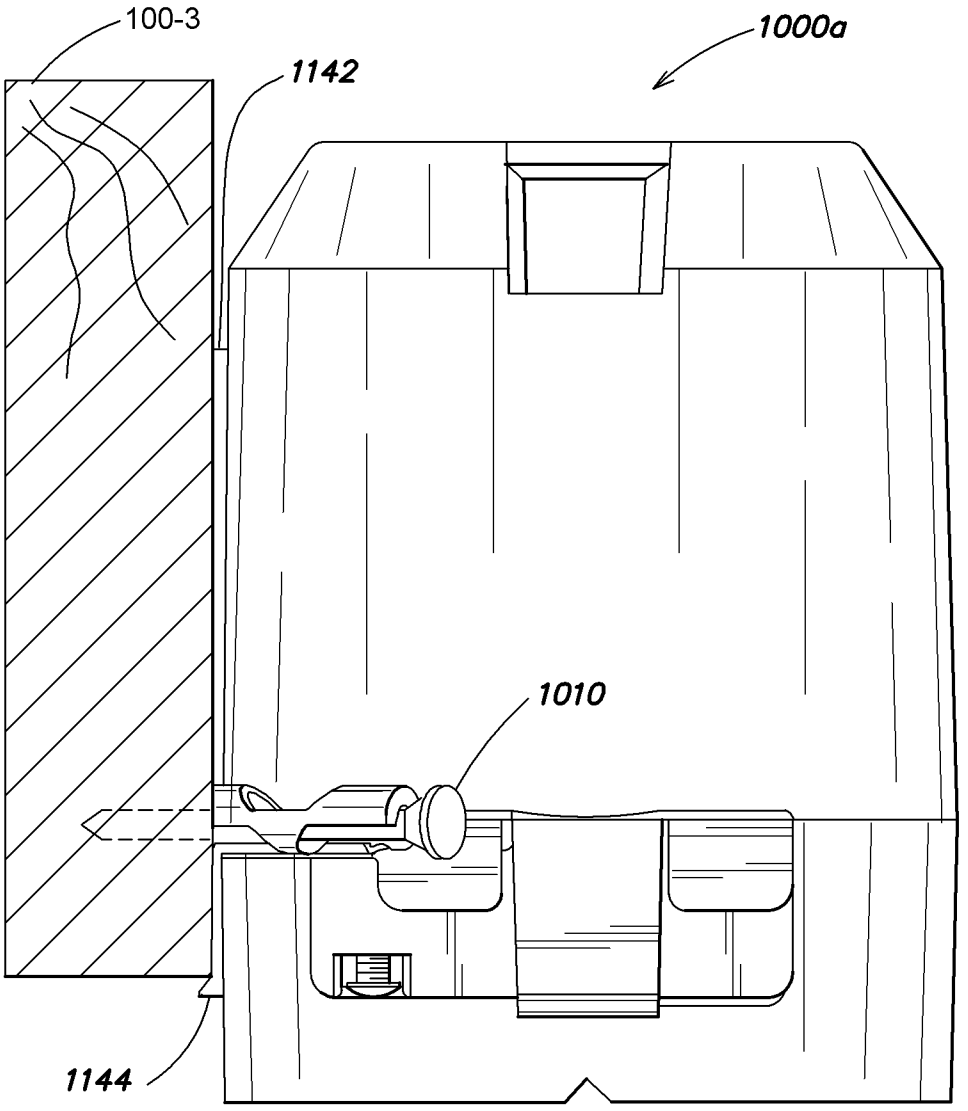



FIG. 7B

Date Reçue/Date Received 2021-07-16

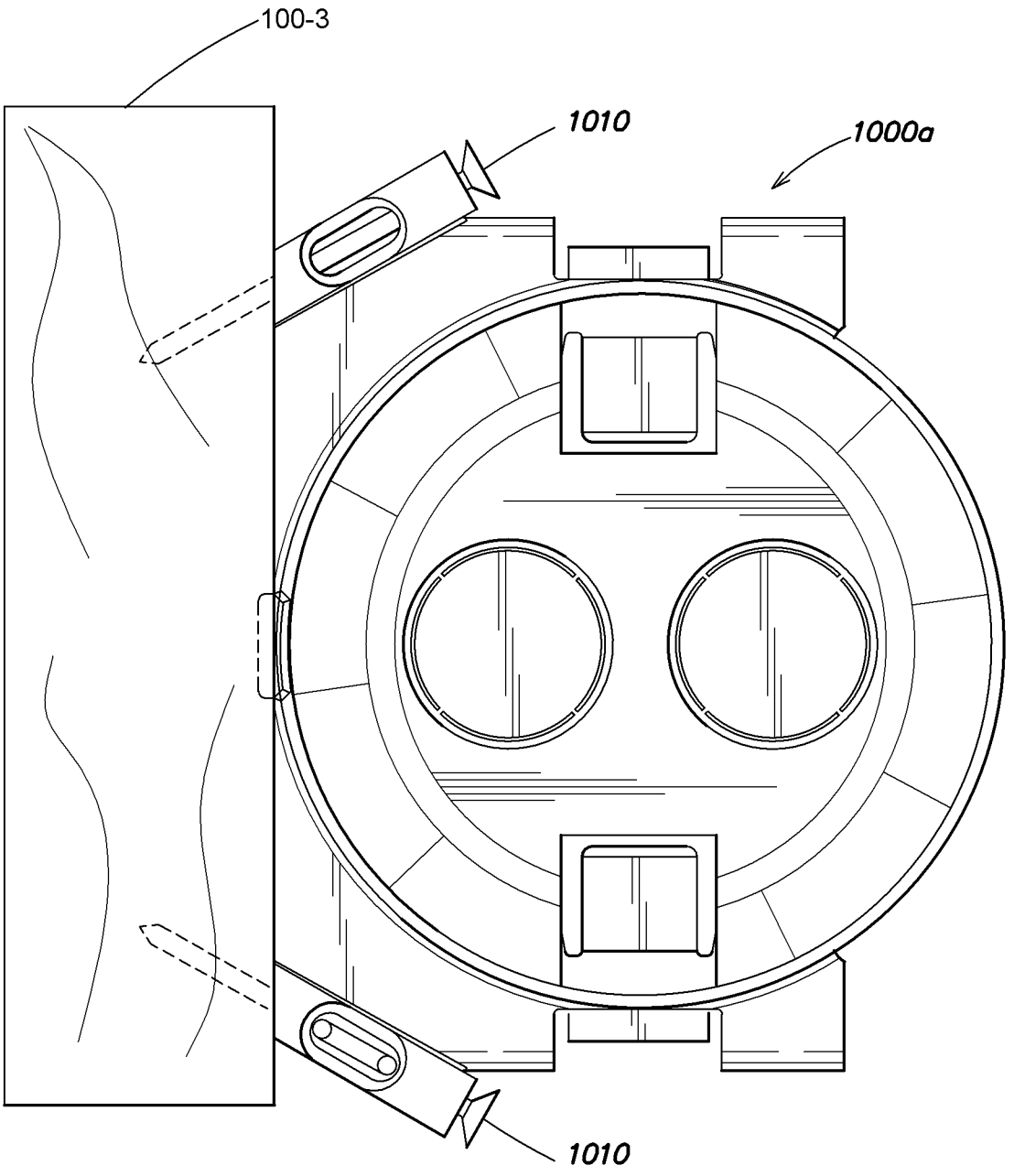



FIG. 7C

Date Reçue/Date Received 2021-07-16

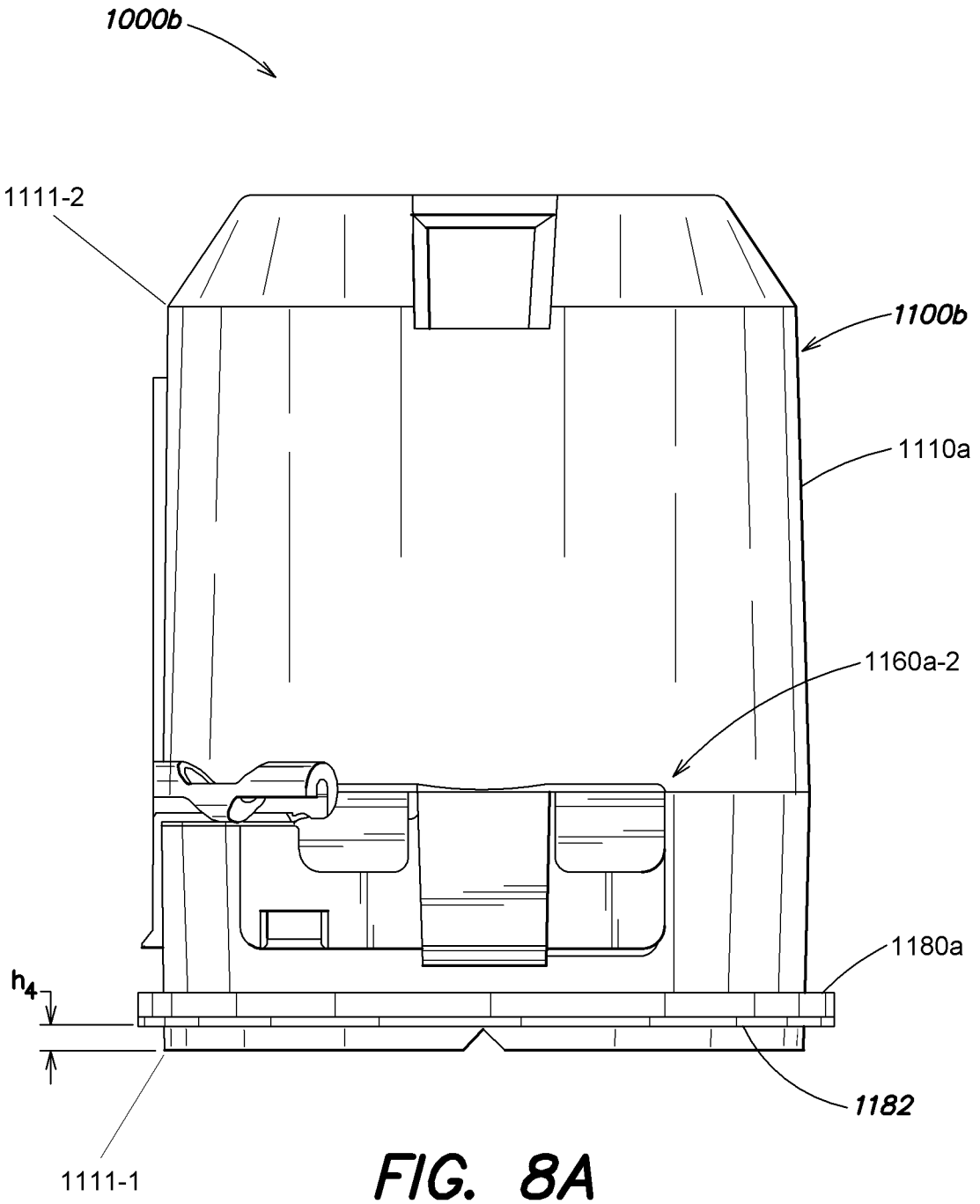



FIG. 8A

Date Reçue/Date Received 2021-07-16

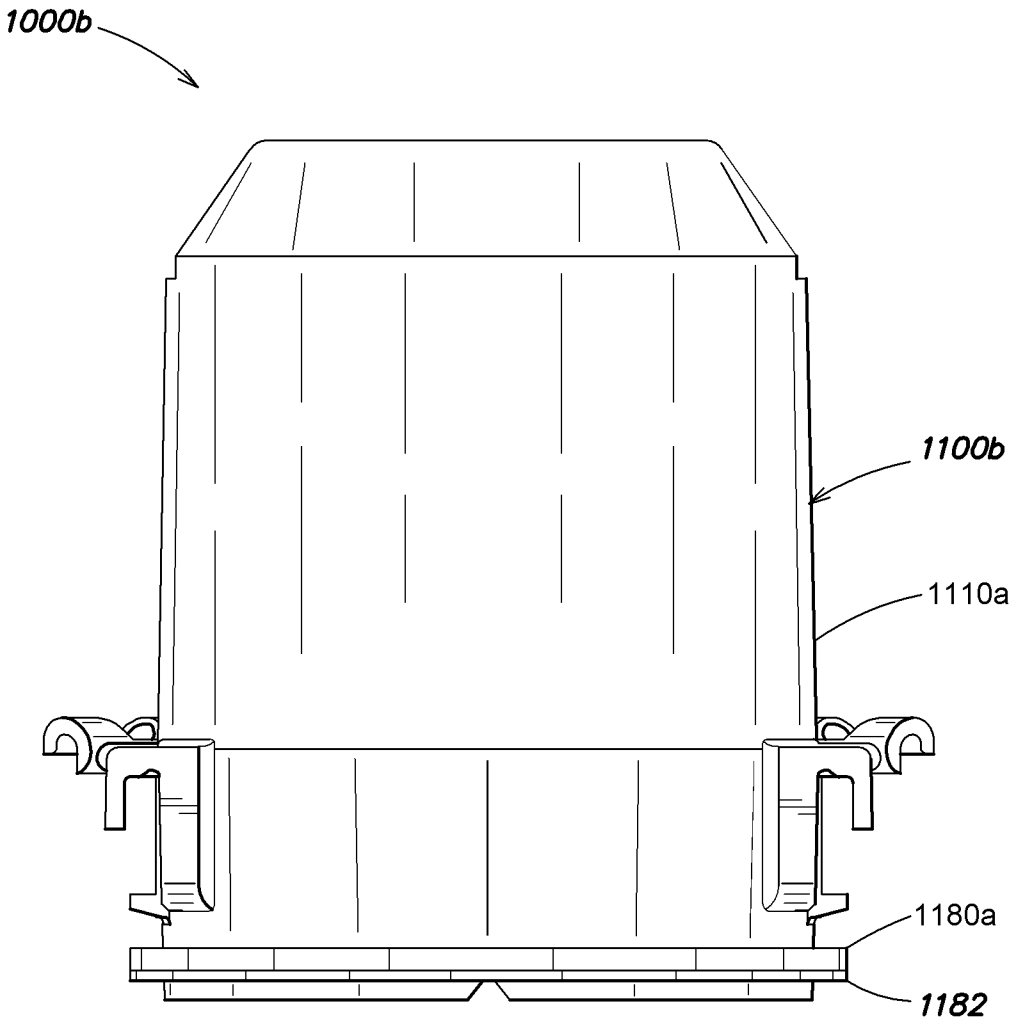



FIG. 8B

Date Reçue/Date Received 2021-07-16

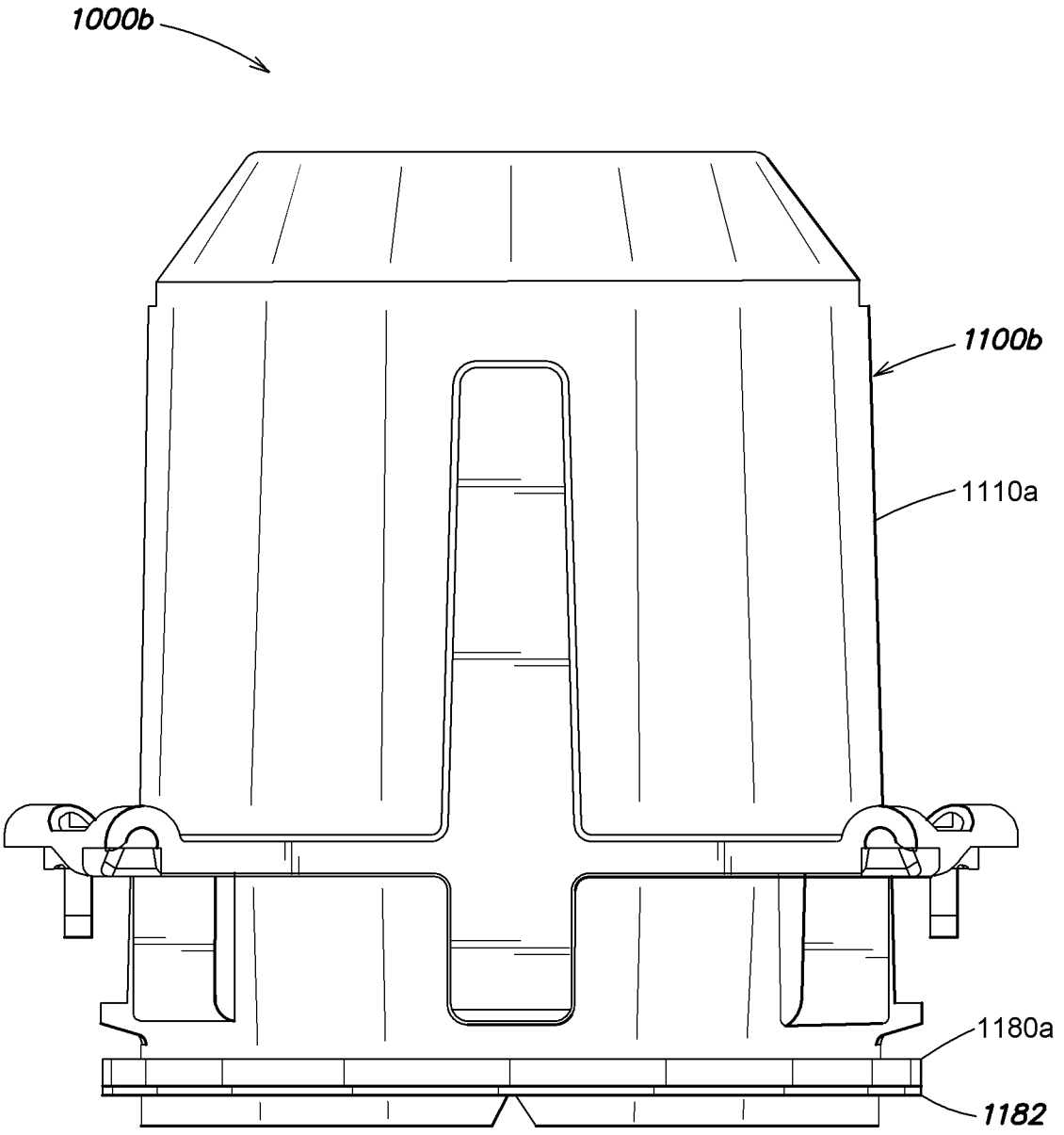



FIG. 8C

Date Reçue/Date Received 2021-07-16

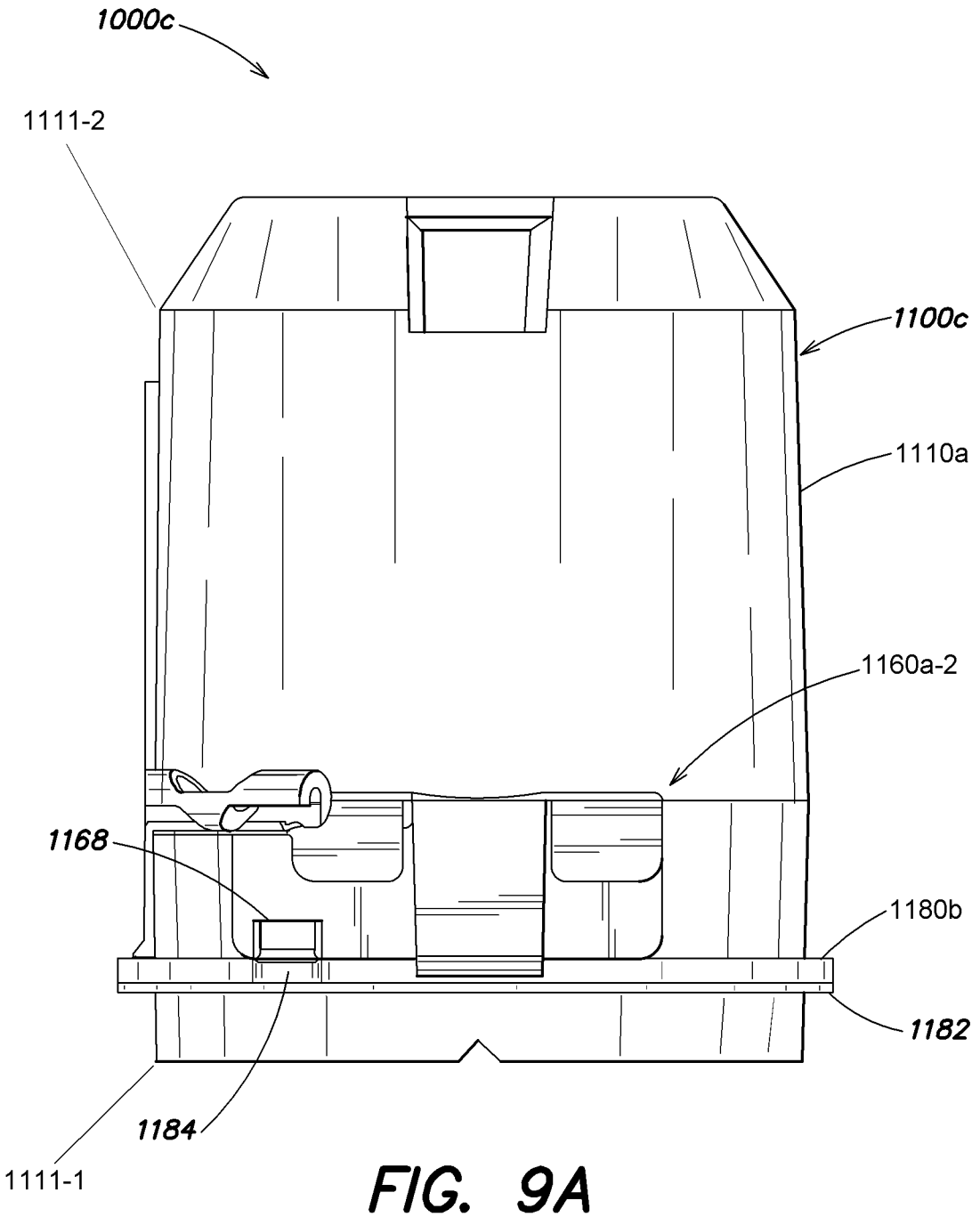



FIG. 9A

Date Reçue/Date Received 2021-07-16

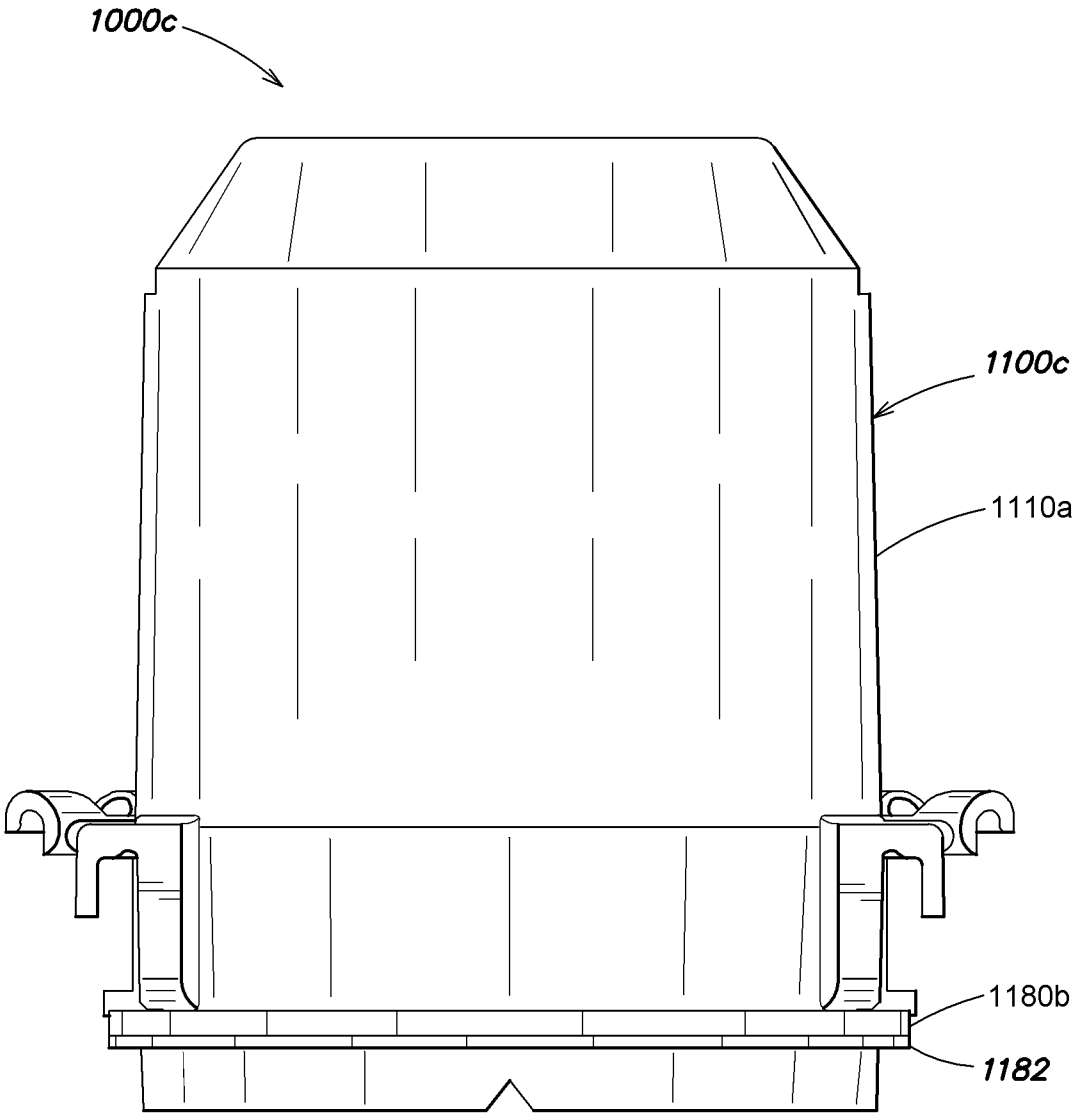



FIG. 9B

Date Reçue/Date Received 2021-07-16

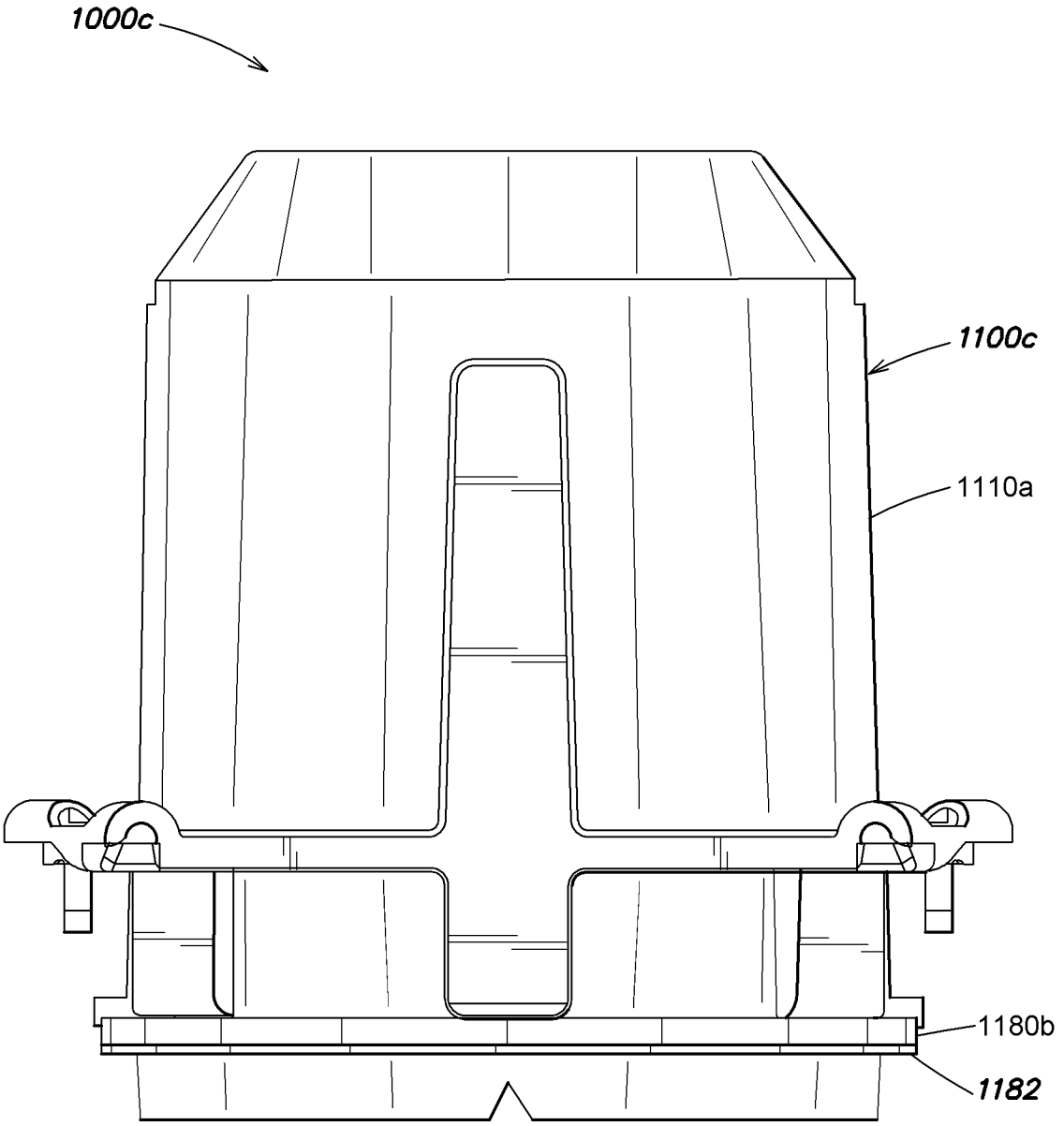



FIG. 9C

Date Reçue/Date Received 2021-07-16

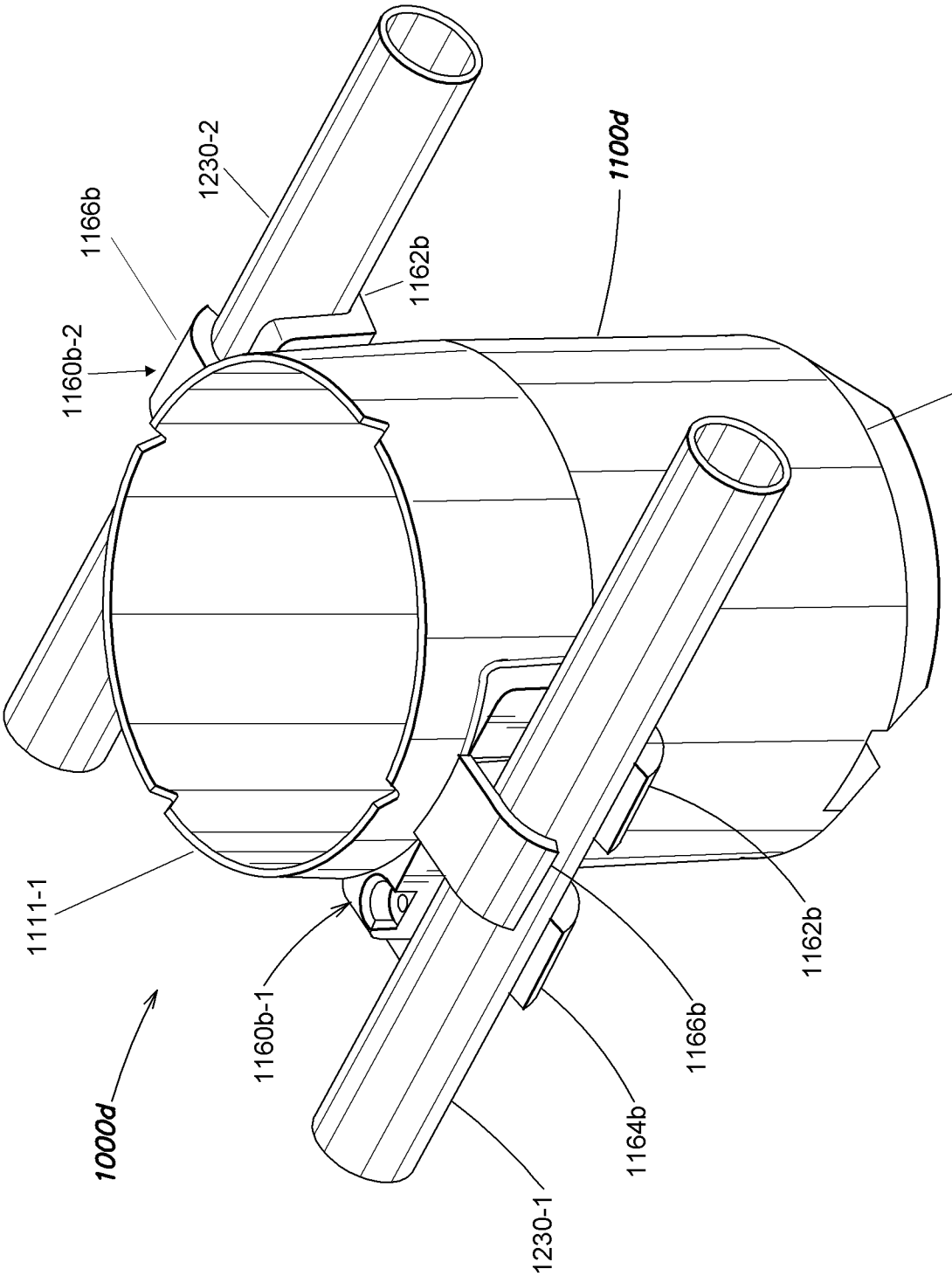

1000d
1100d
1111-1
1111-2
1160b-1
1160b-2
1162b
1162b
1164b
1166b
1166b
1230-1
1230-2

FIG. 10A

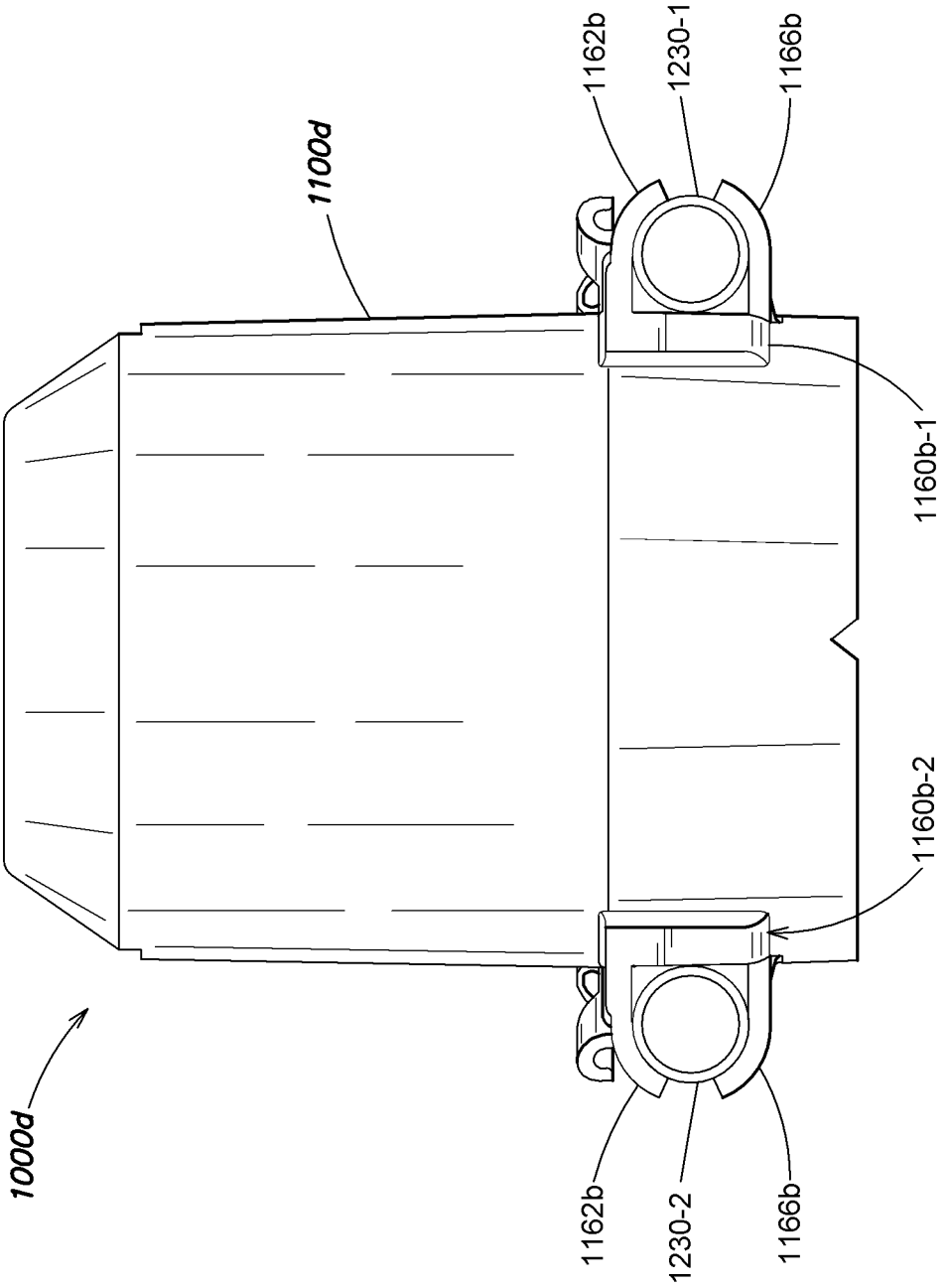



FIG. 10B

Date Reçue/Date Received 2021-07-16

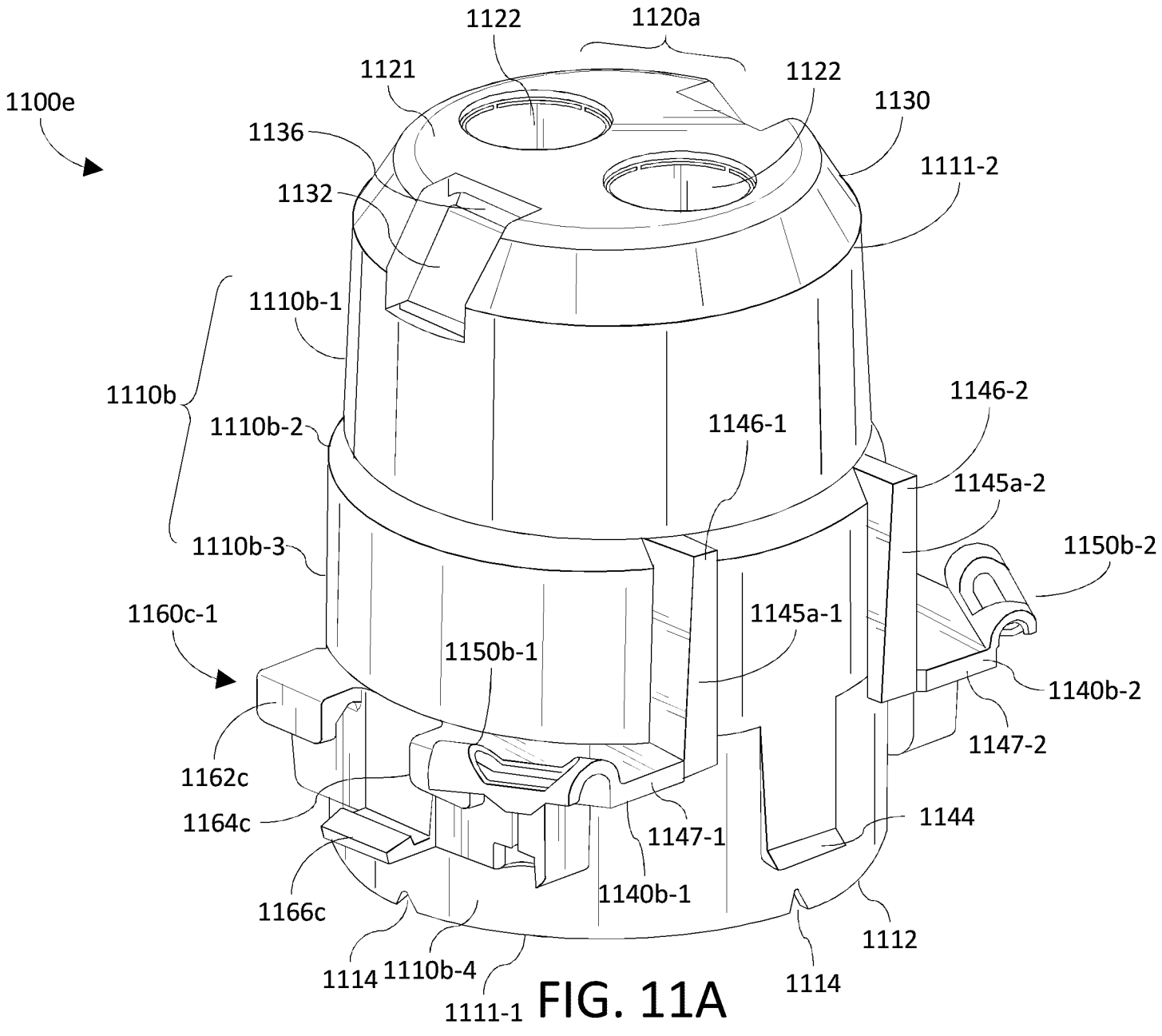



FIG. 11A

Date Reçue/Date Received 2021-07-16

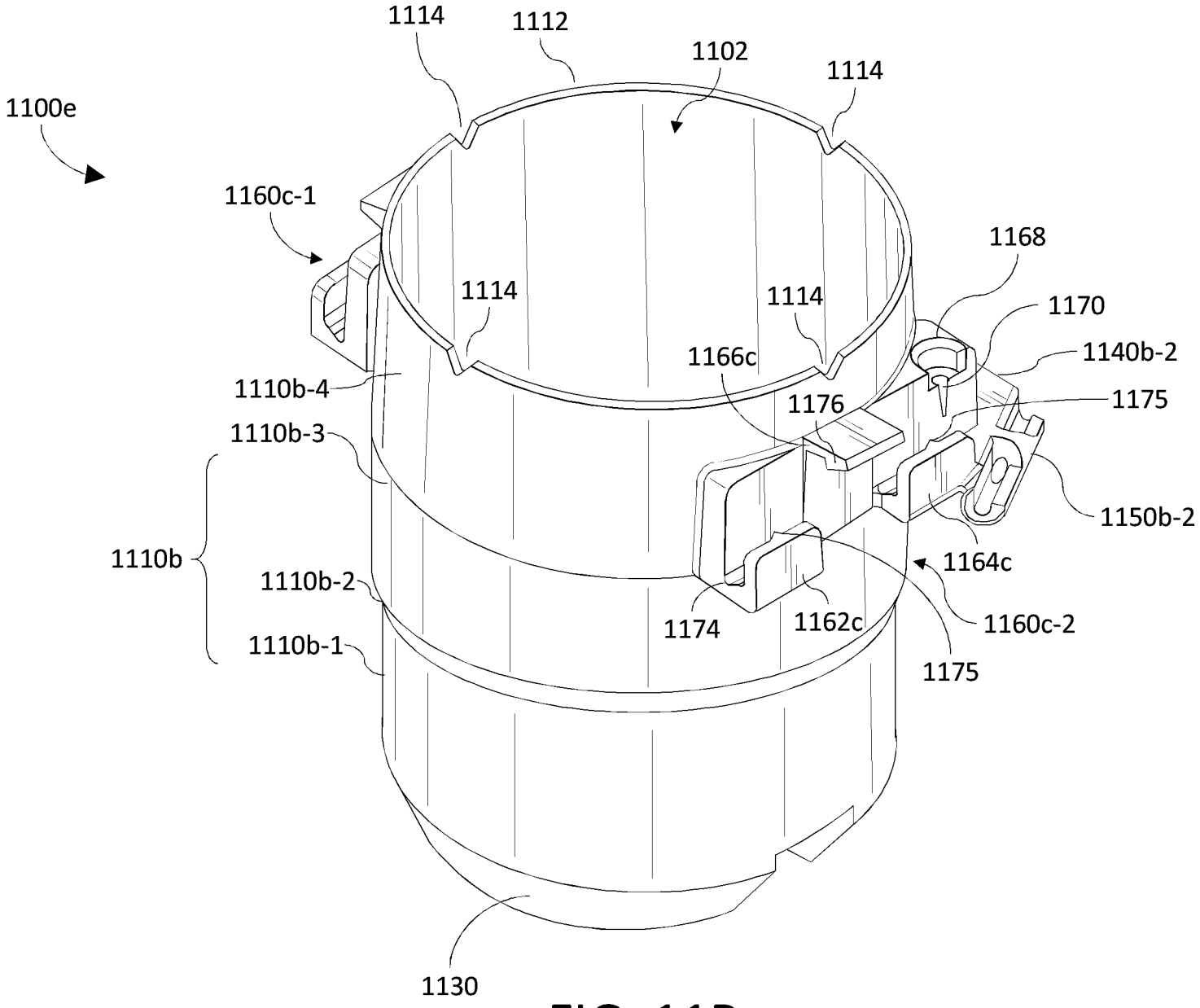



FIG. 11B

Date Reçue/Date Received 2021-07-16

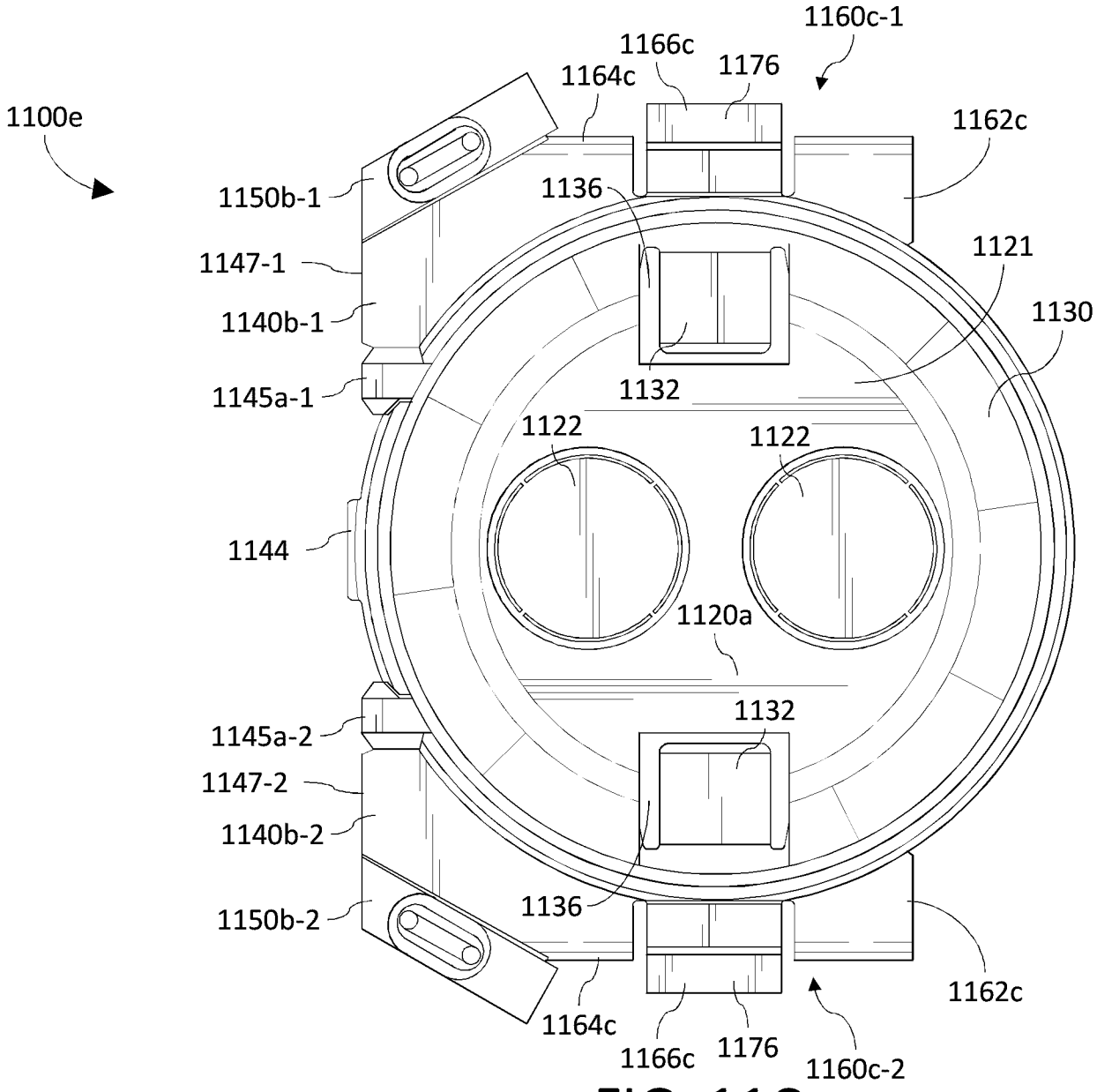



FIG. 11C

Date Reçue/Date Received 2021-07-16

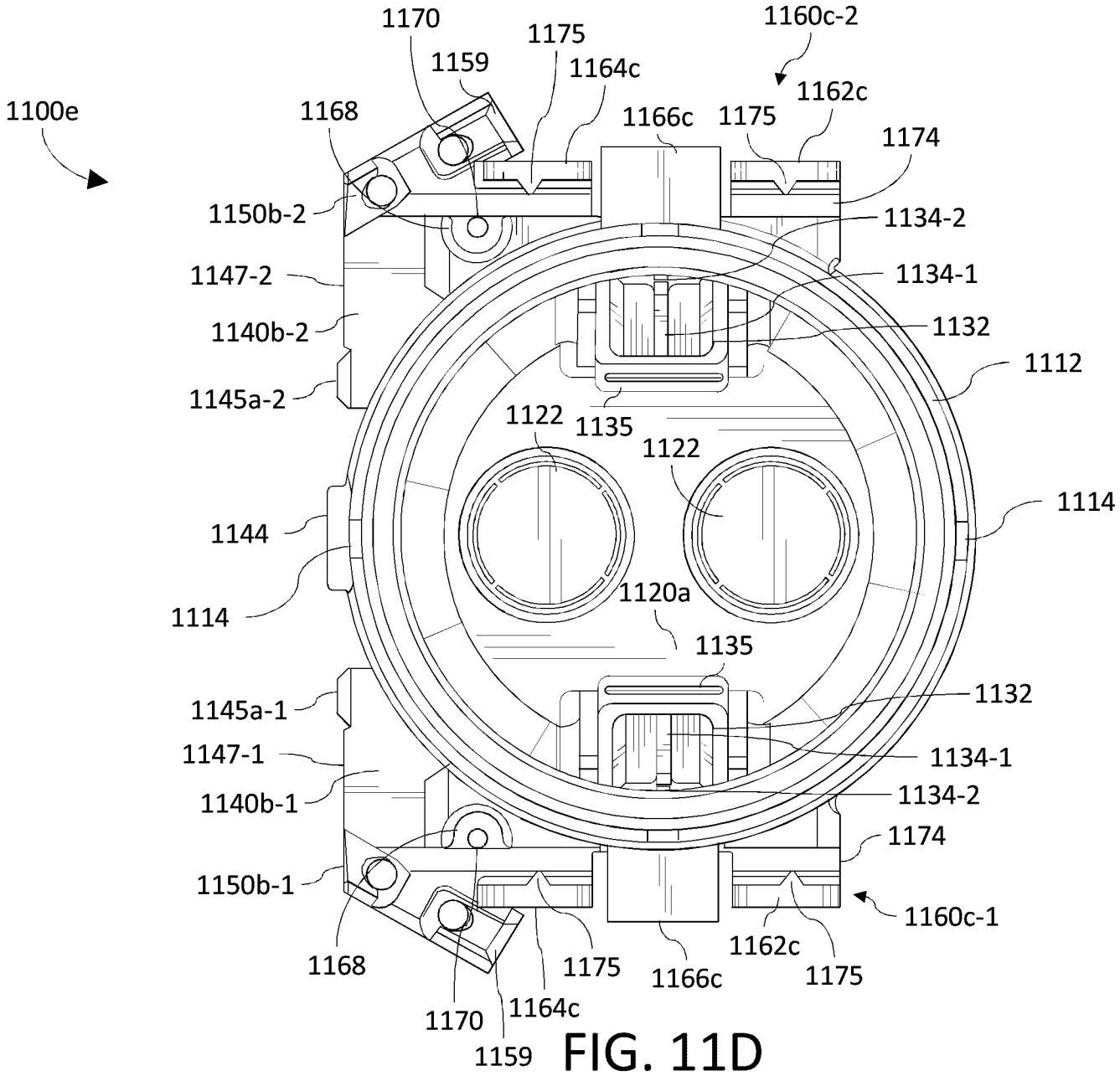



FIG. 11D

Date Reçue/Date Received 2021-07-16

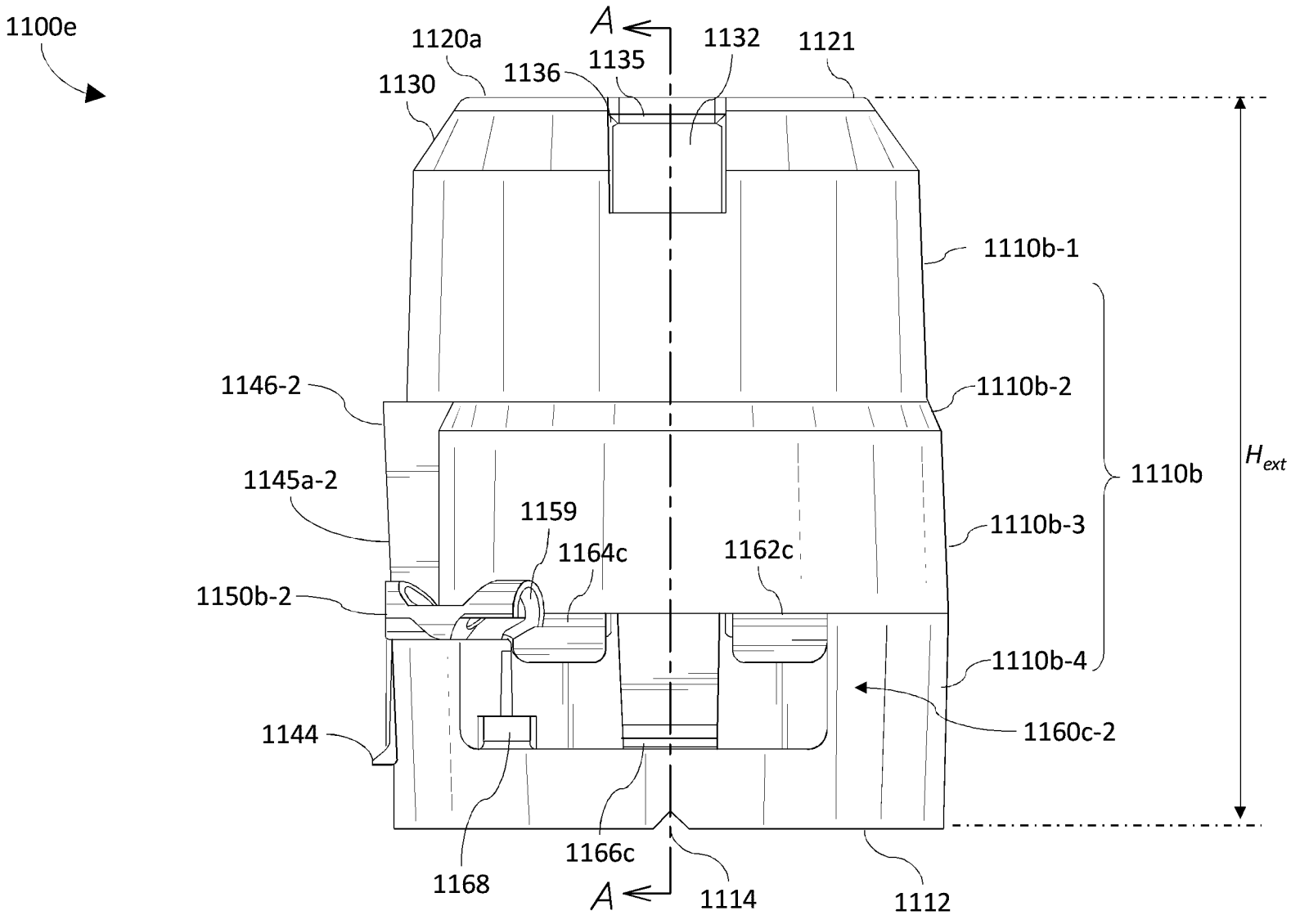



FIG. 11E

Date Reçue/Date Received 2021-07-16

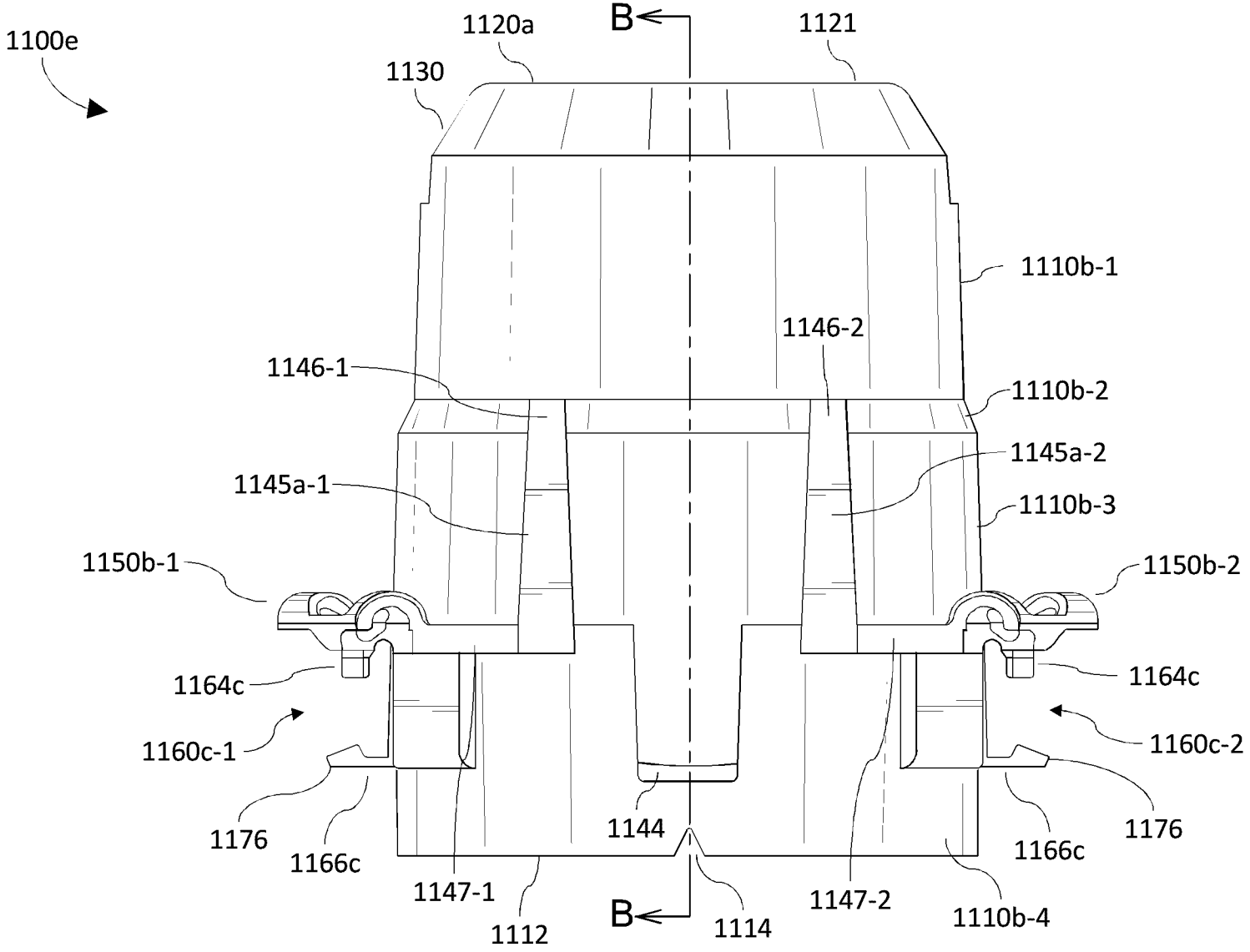



FIG. 11F

Date Reçue/Date Received 2021-07-16

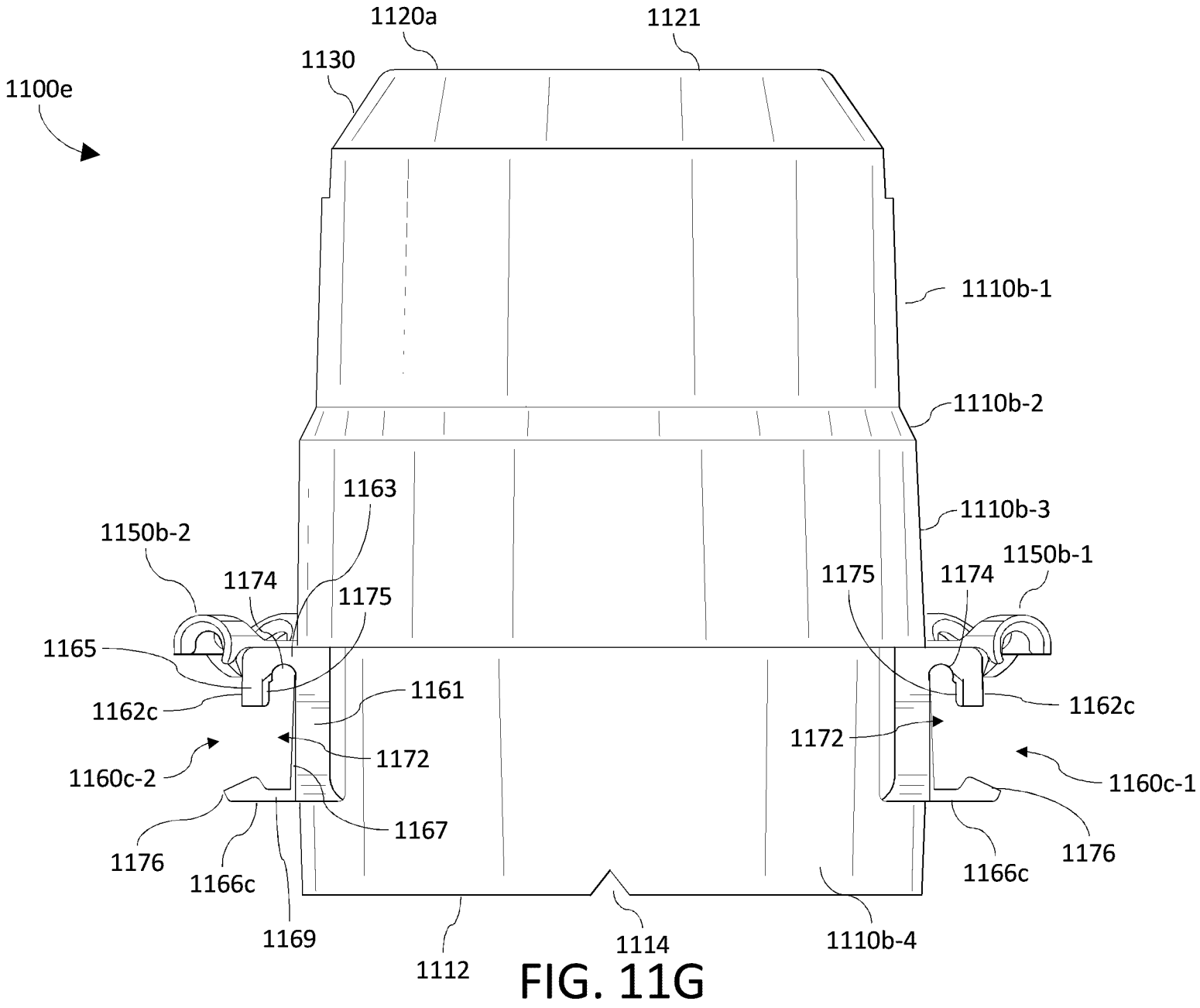



FIG. 11G

Date Reçue/Date Received 2021-07-16

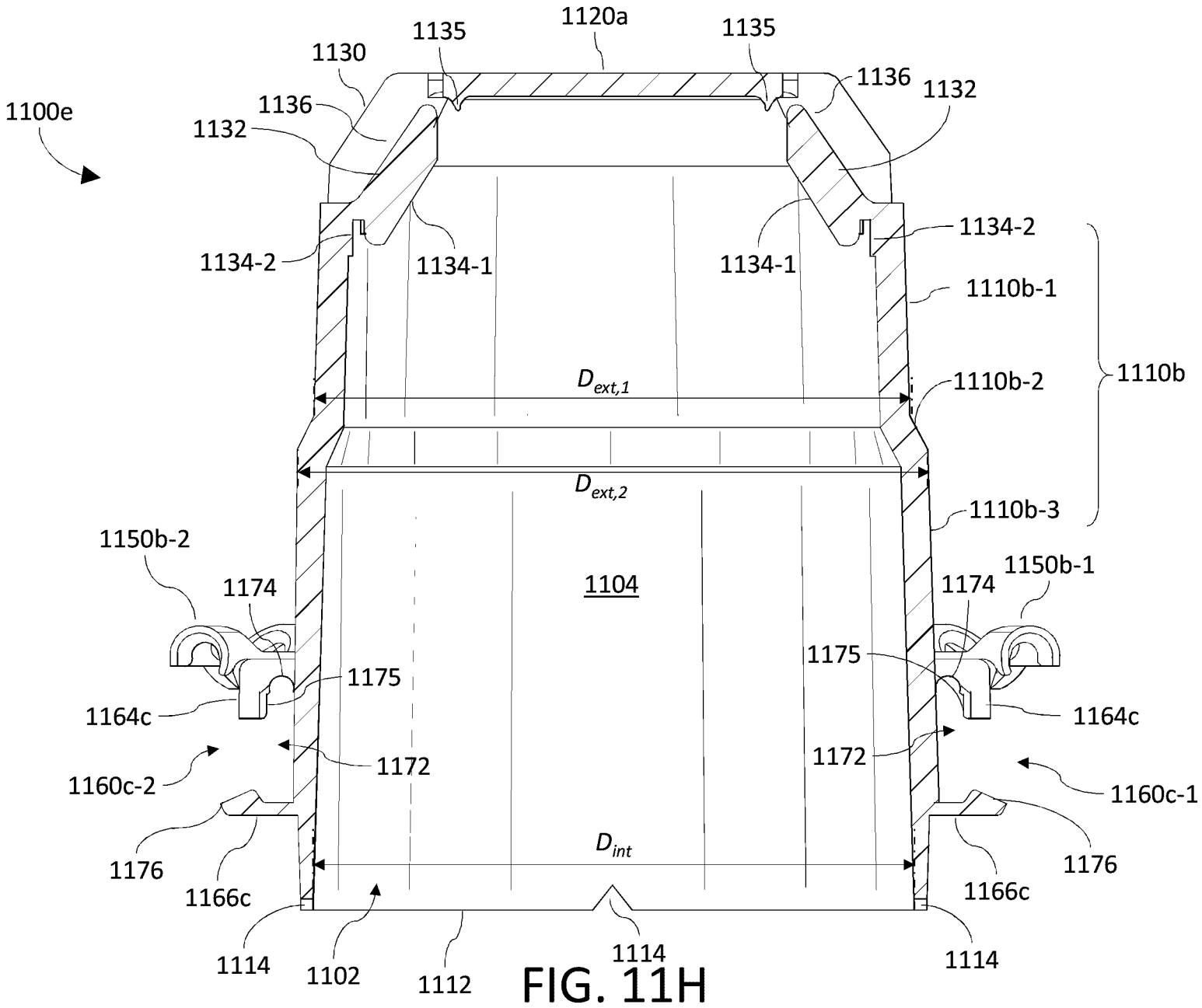



FIG. 11H

Date Reçue/Date Received 2021-07-16

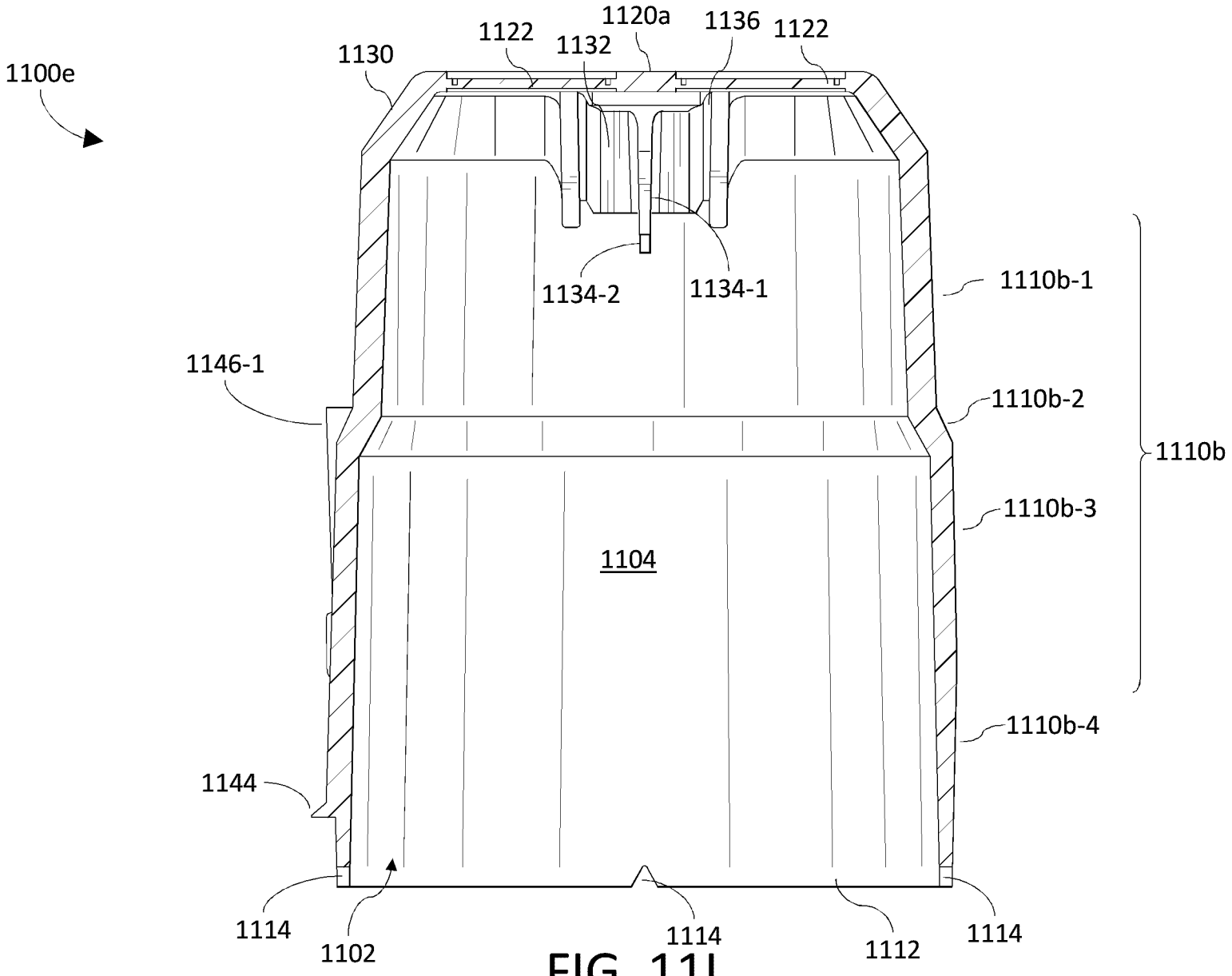



FIG. 11I

Date Reçue/Date Received 2021-07-16

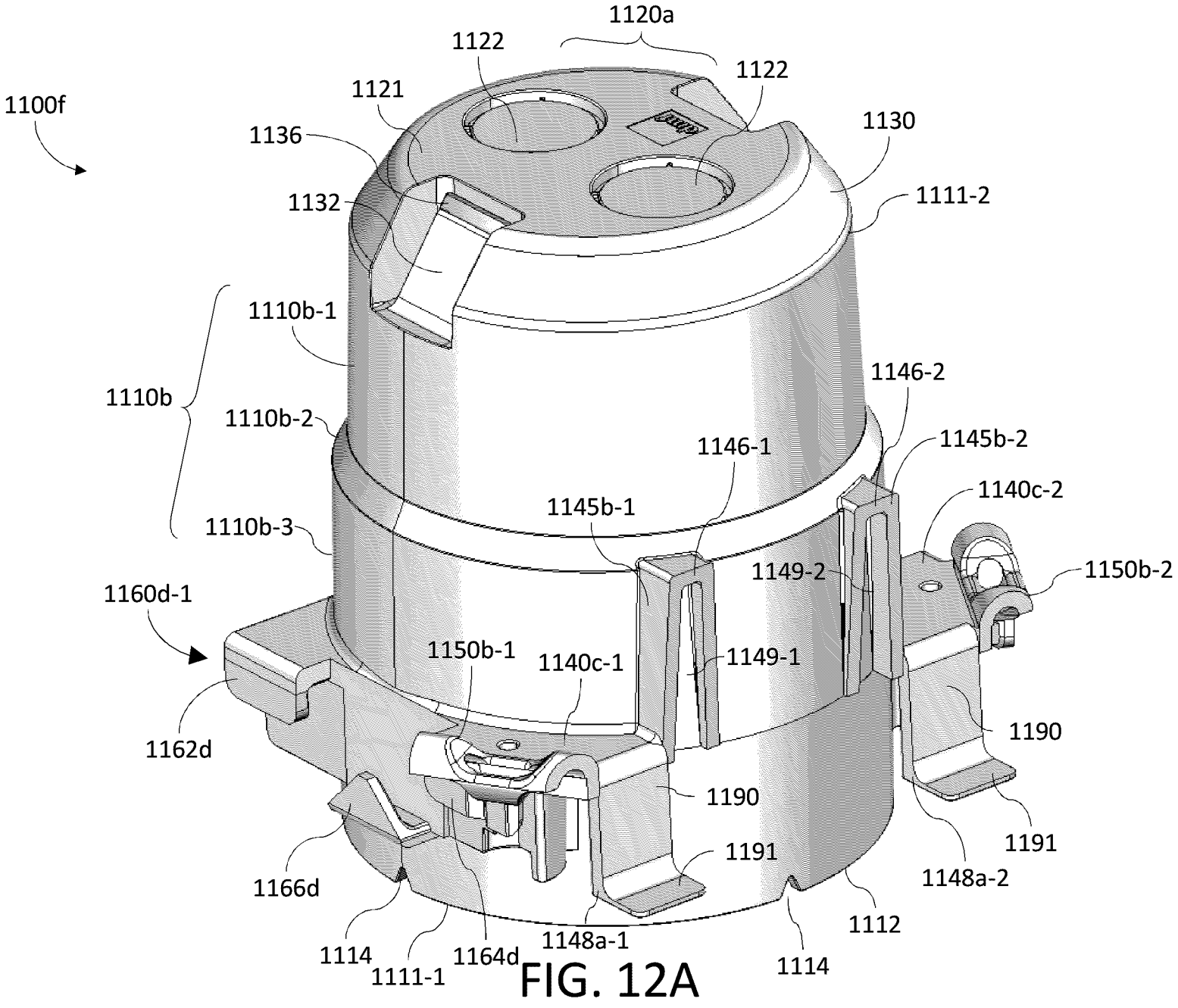



FIG. 12A

Date Reçue/Date Received 2021-07-16

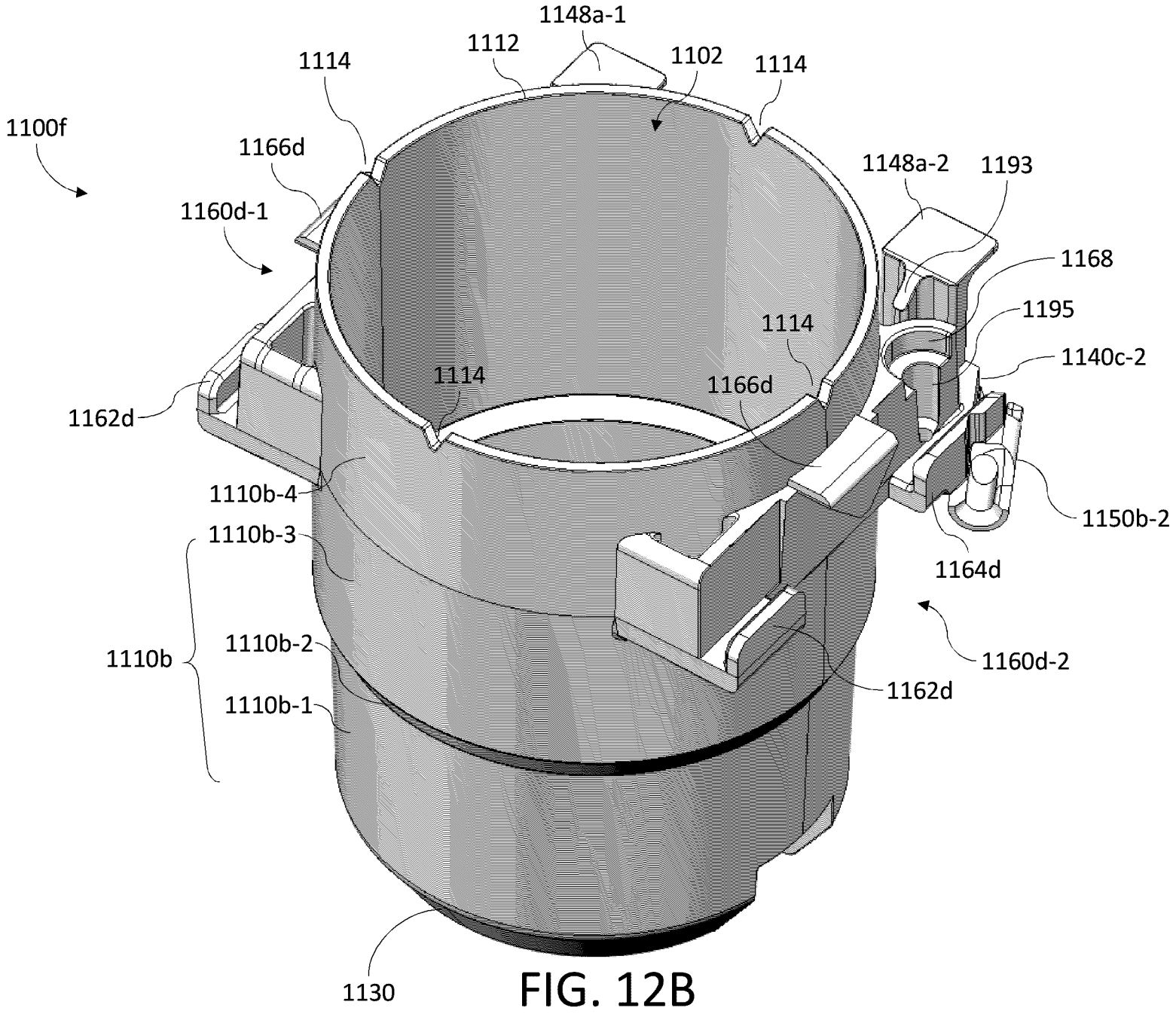



FIG. 12B

Date Reçue/Date Received 2021-07-16

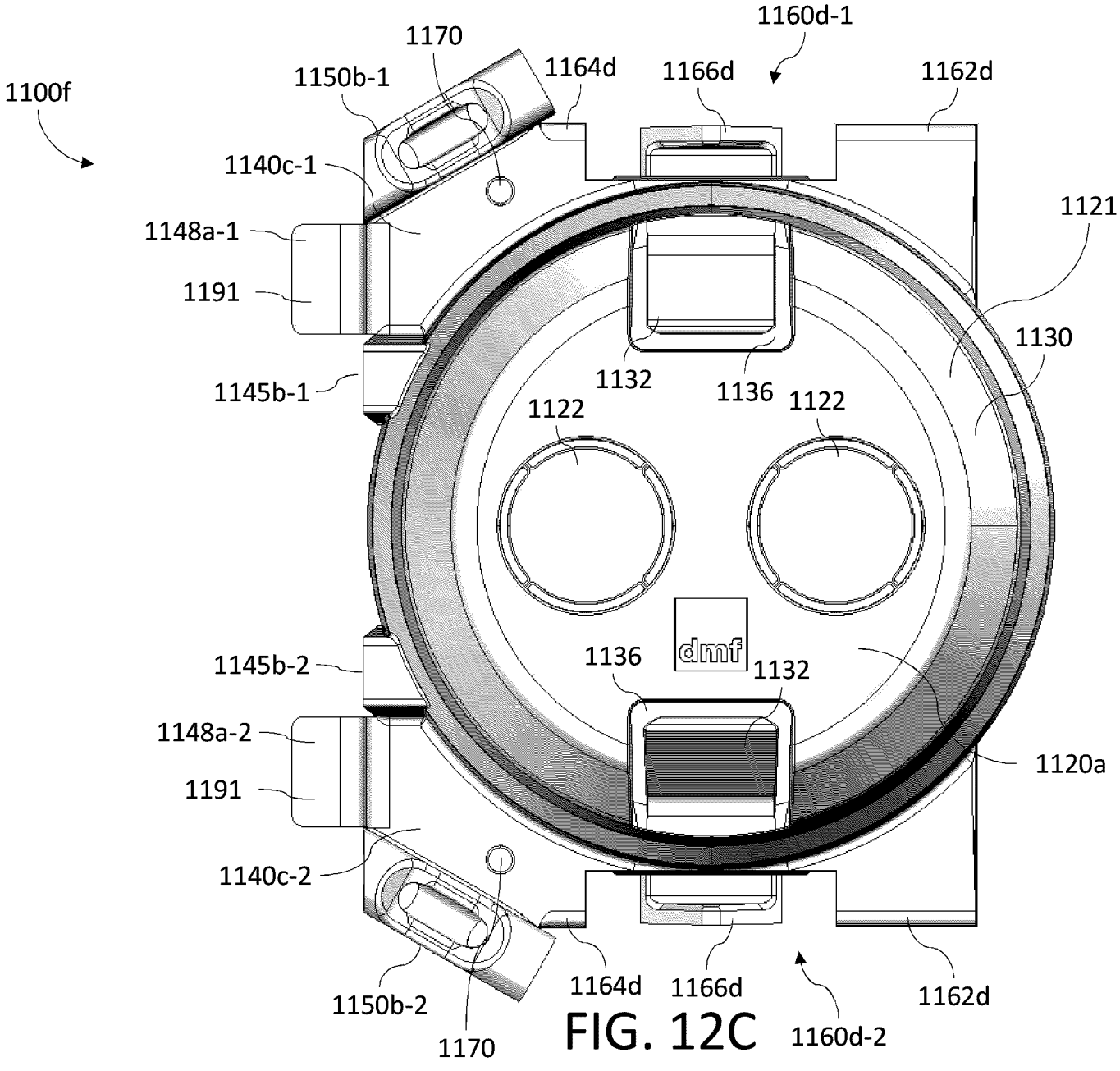



FIG. 12C

Date Reçue/Date Received 2021-07-16

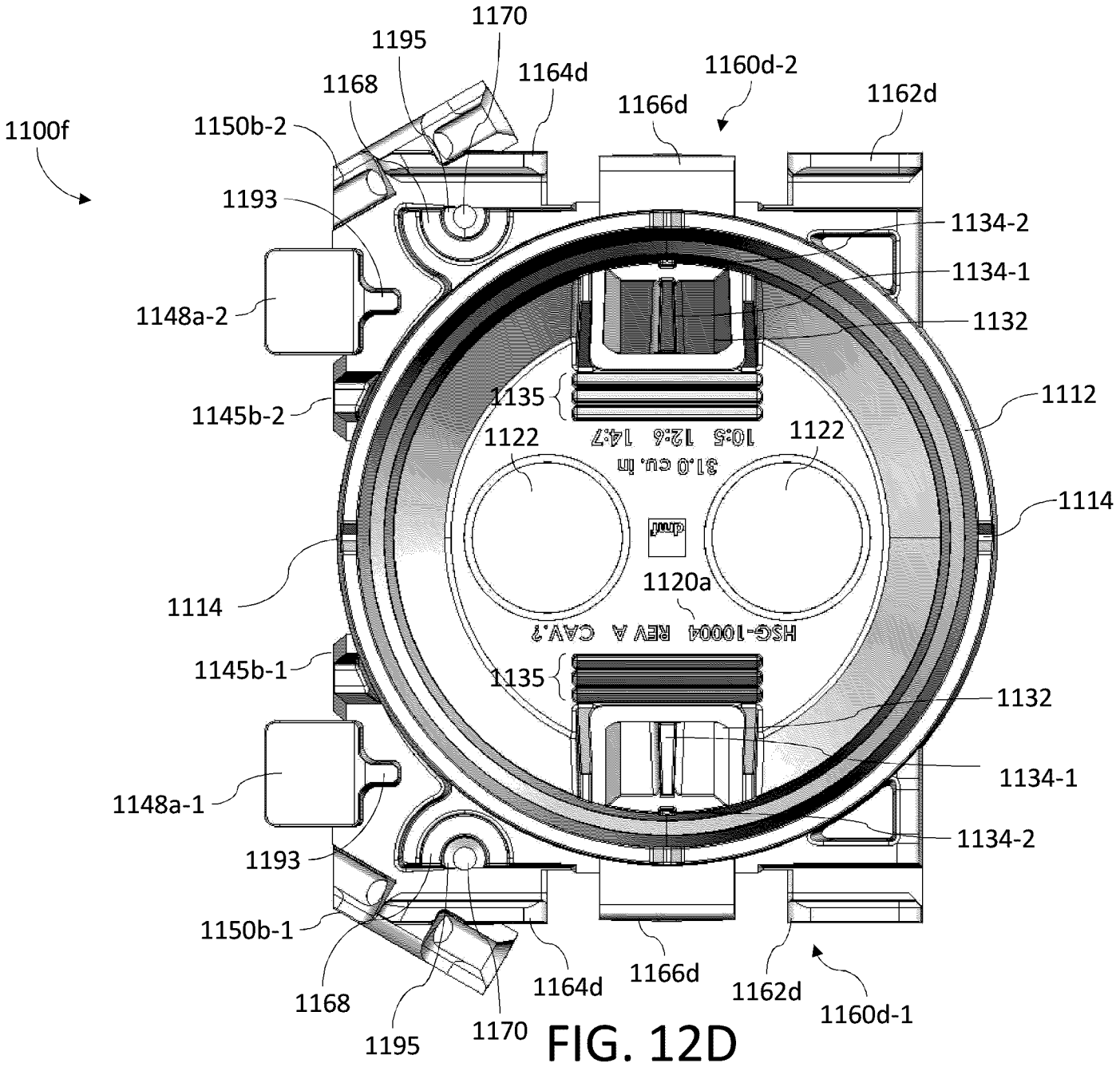



FIG. 12D

Date Reçue/Date Received 2021-07-16

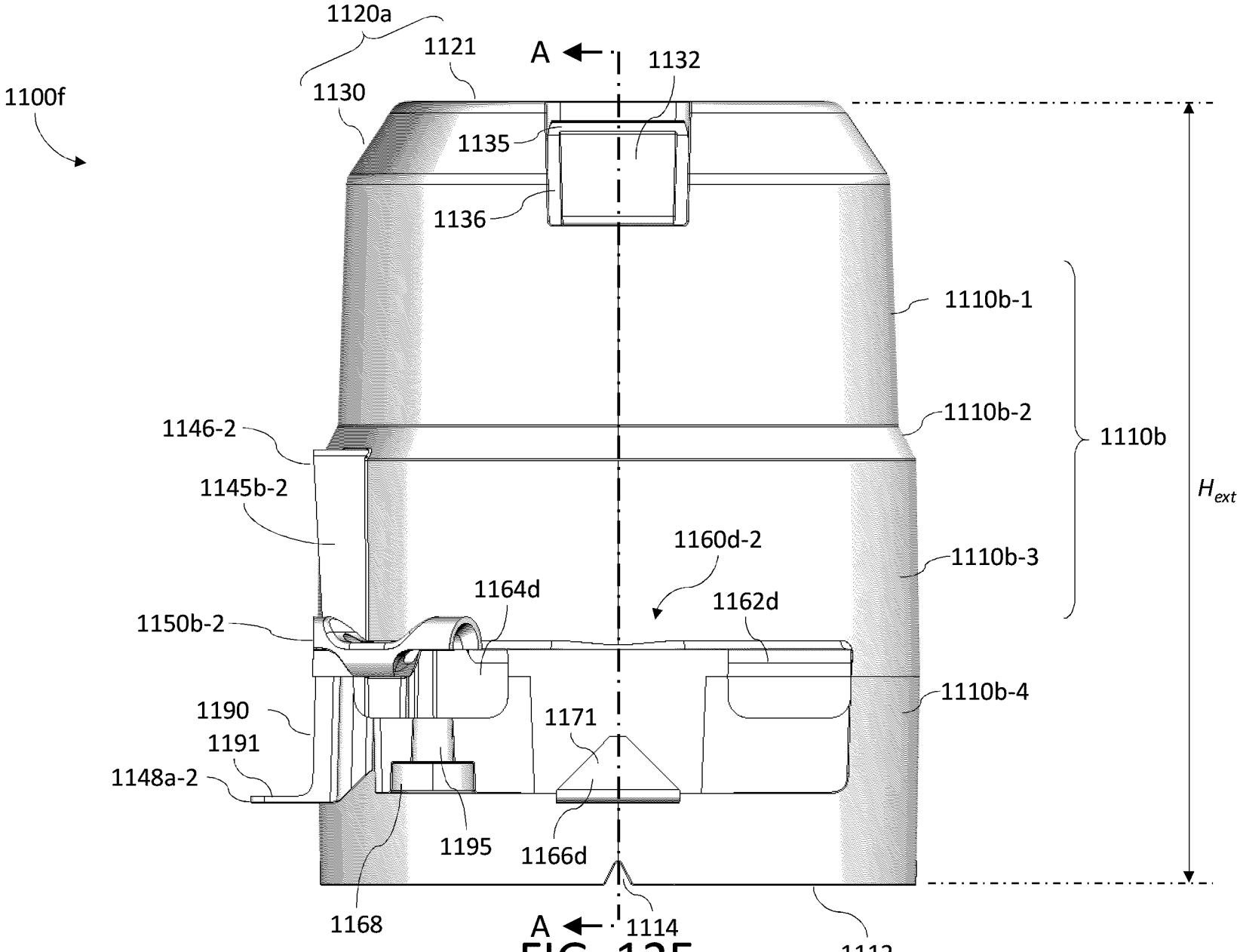



FIG. 12E

Date Reçue/Date Received 2021-07-16

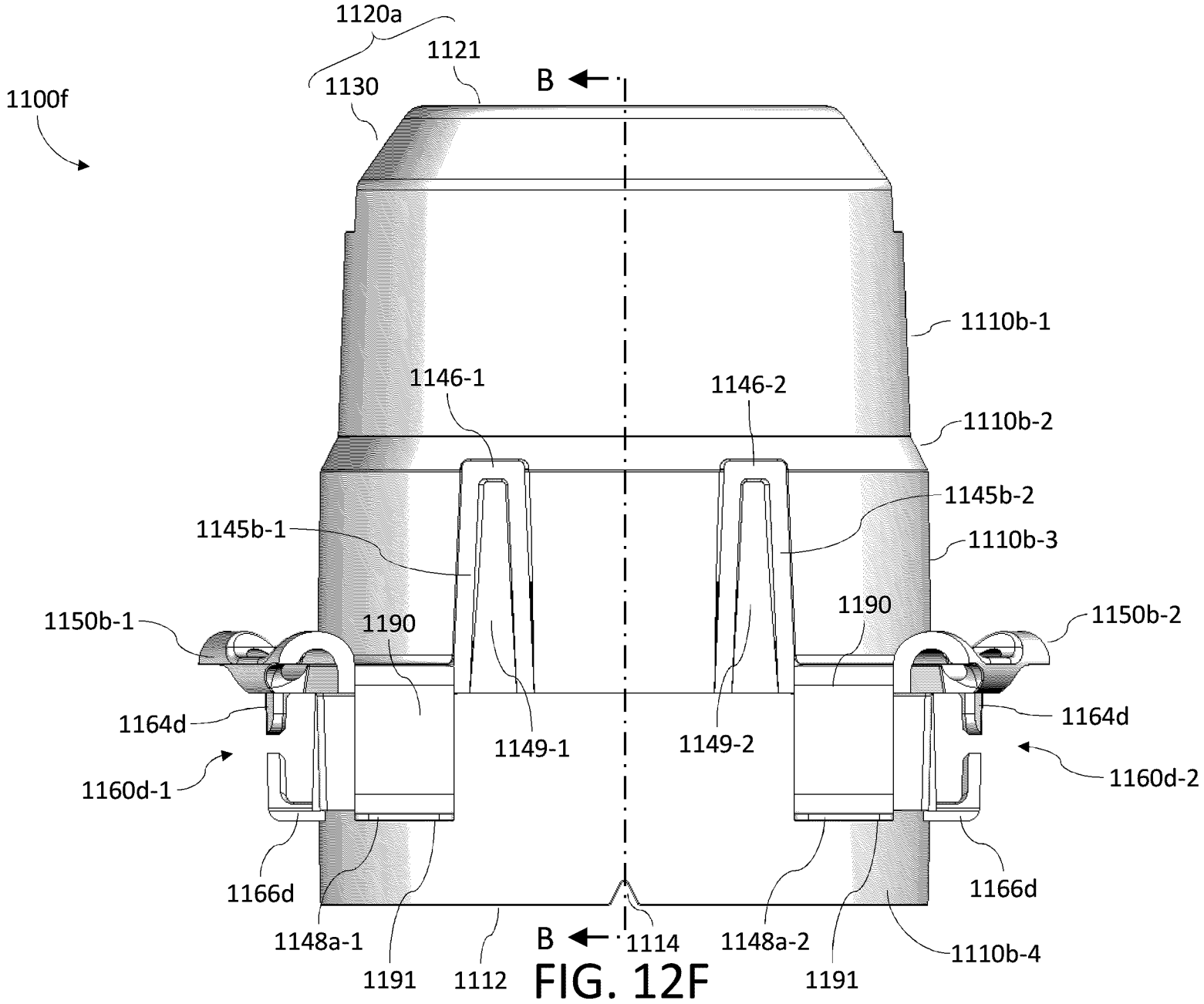



FIG. 12F

Date Reçue/Date Received 2021-07-16

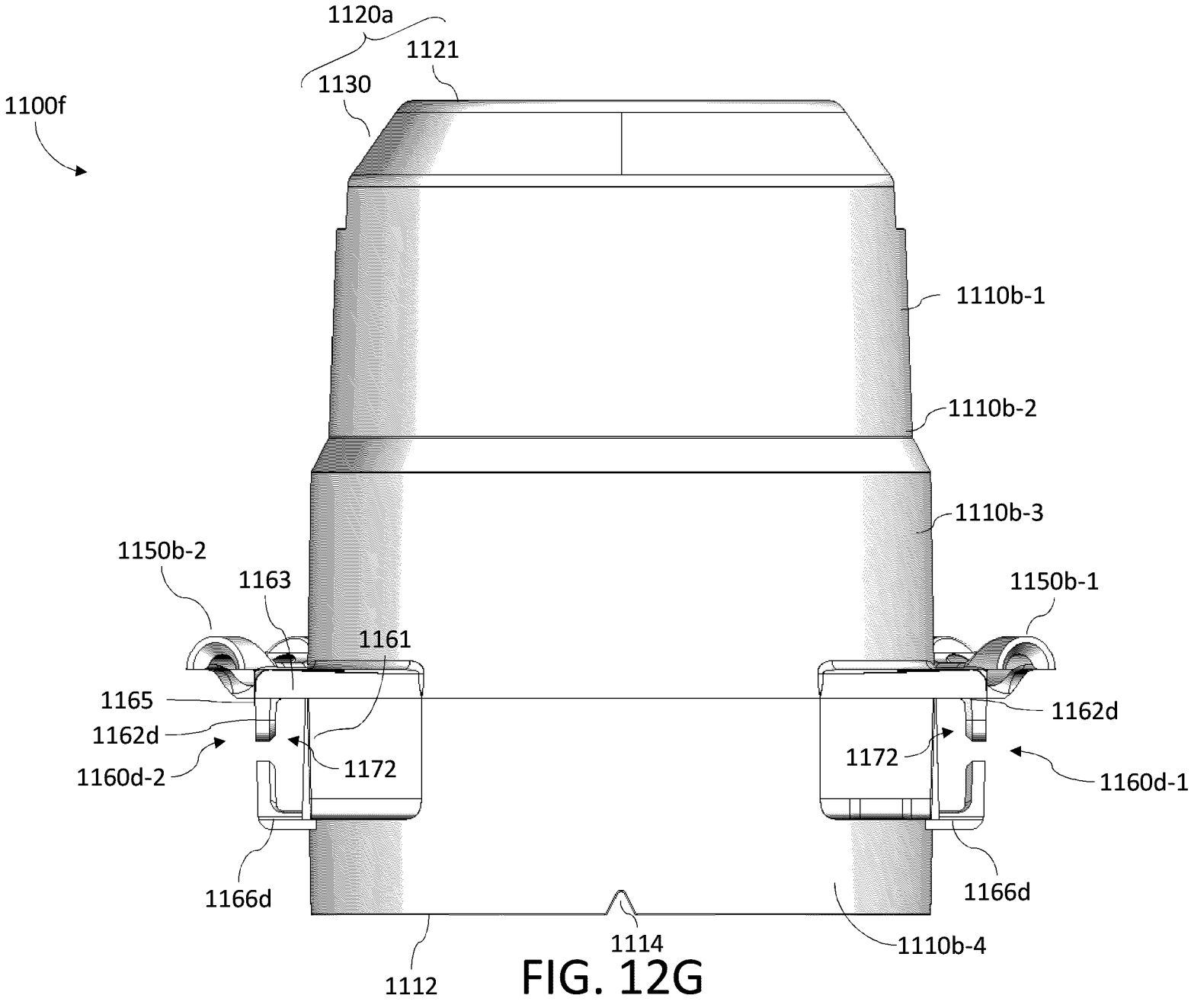



FIG. 12G

Date Reçue/Date Received 2021-07-16

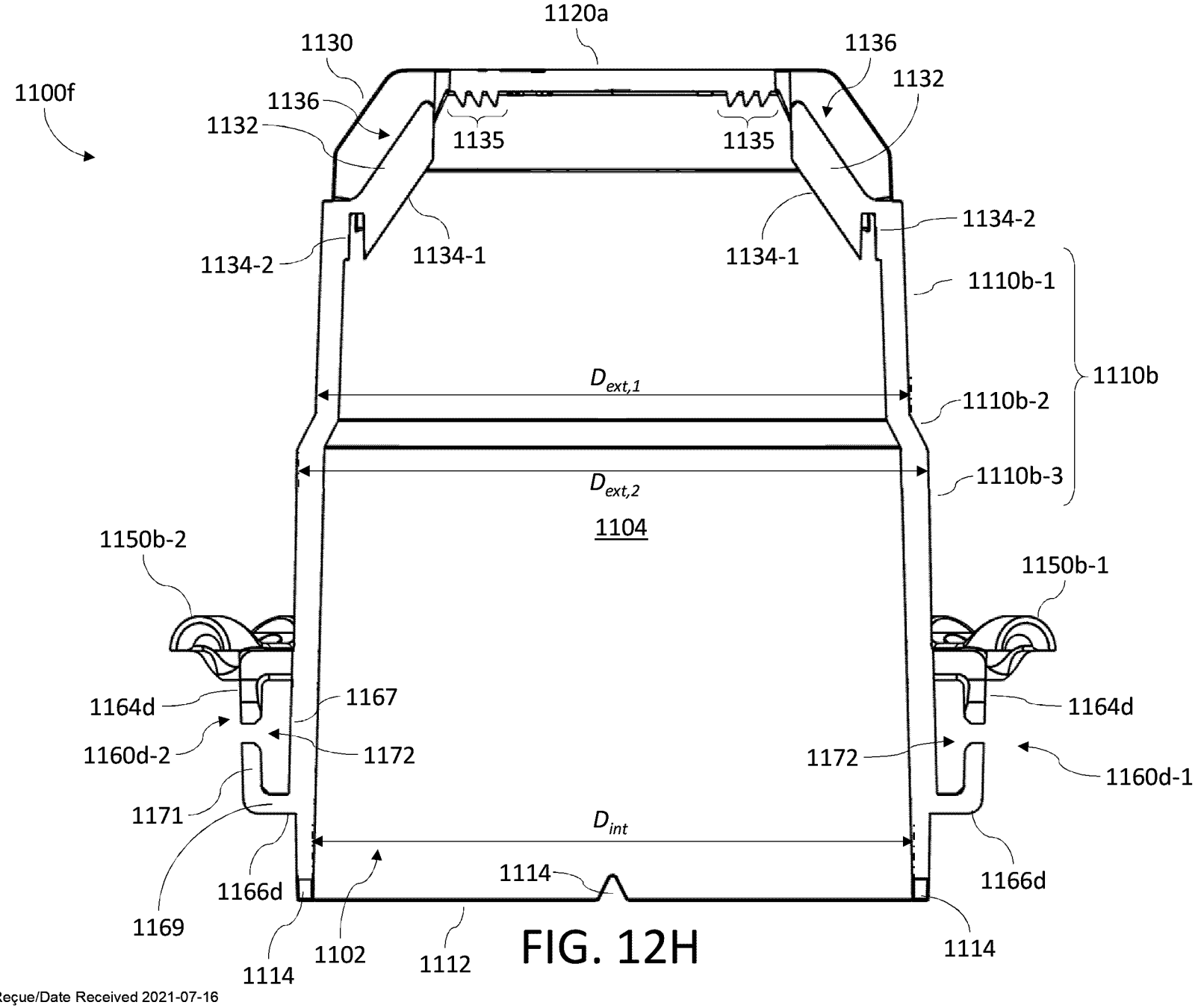



FIG. 12H

Date Reçue/Date Received 2021-07-16

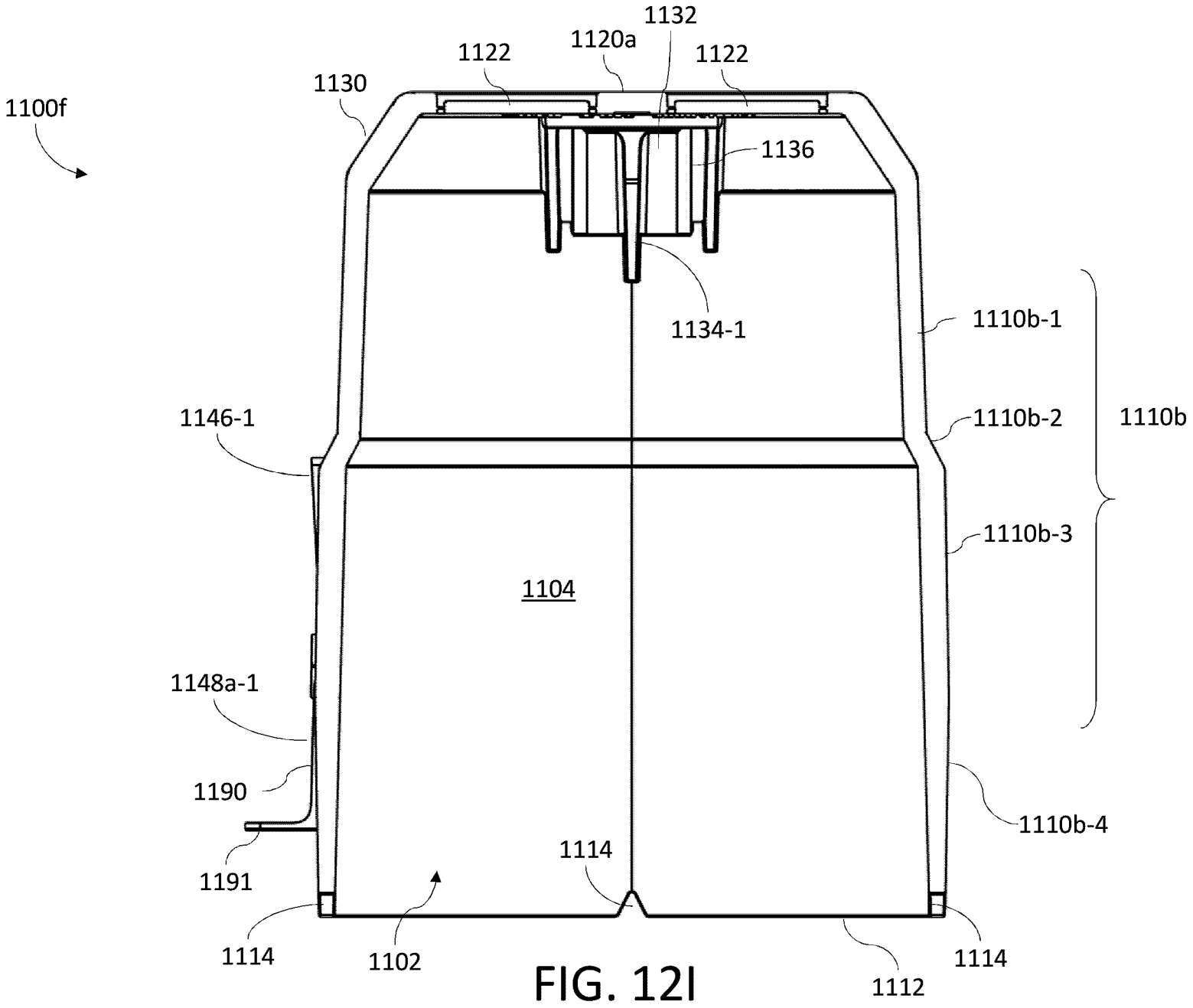



FIG. 12I

Date Reçue/Date Received 2021-07-16

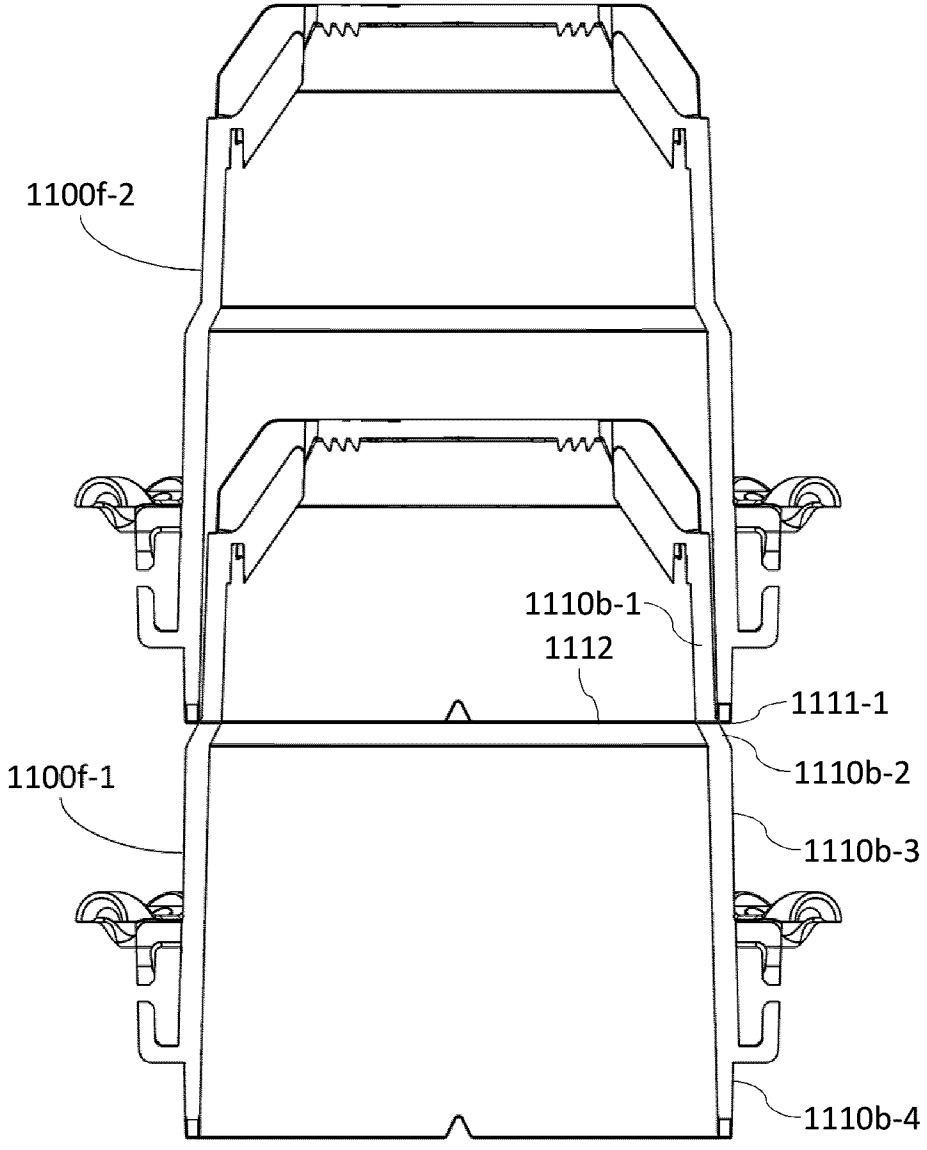



FIG. 13

Date Reçue/Date Received 2021-07-16

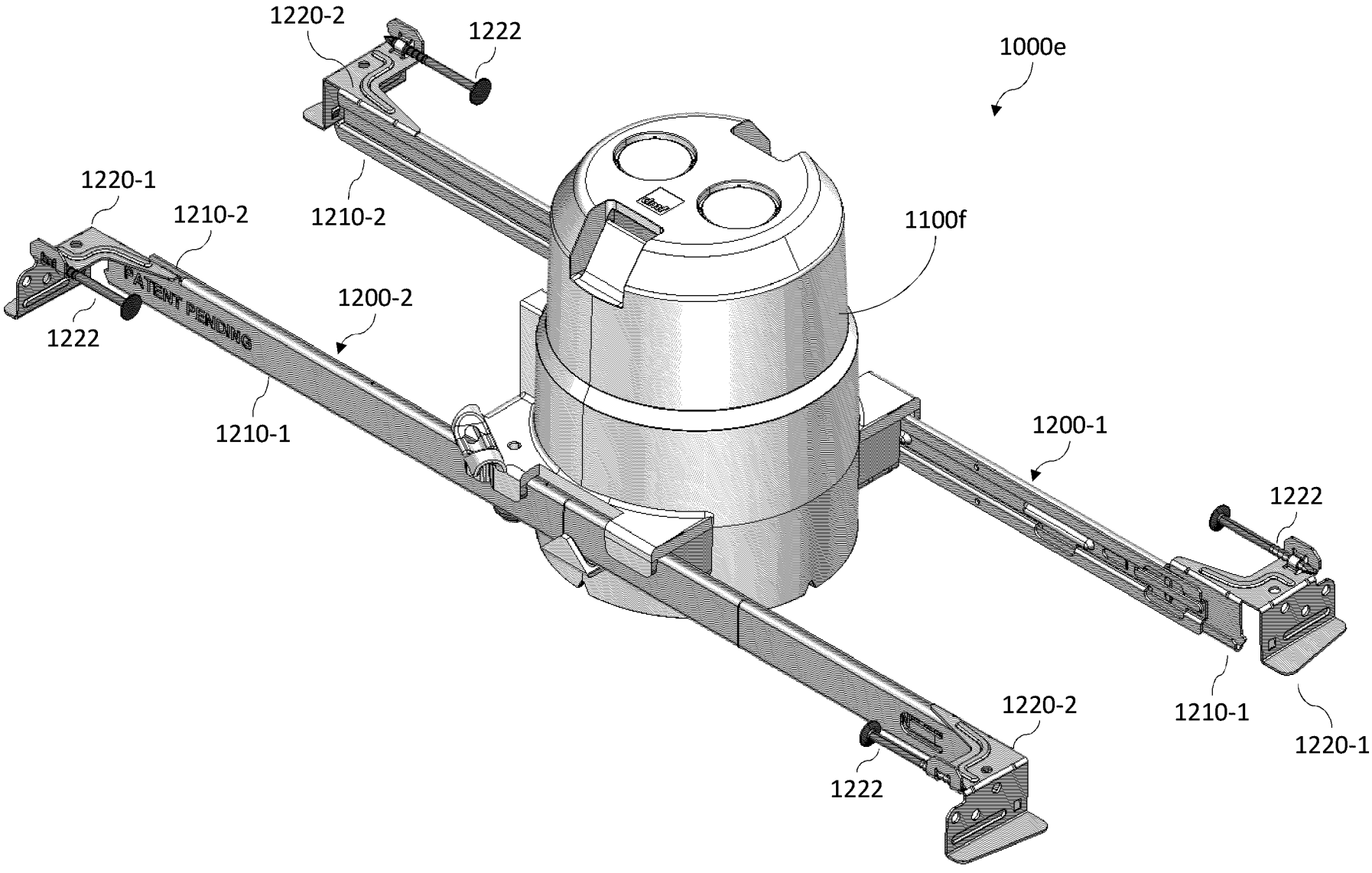



FIG. 14A

Date Reçue/Date Received 2021-07-16

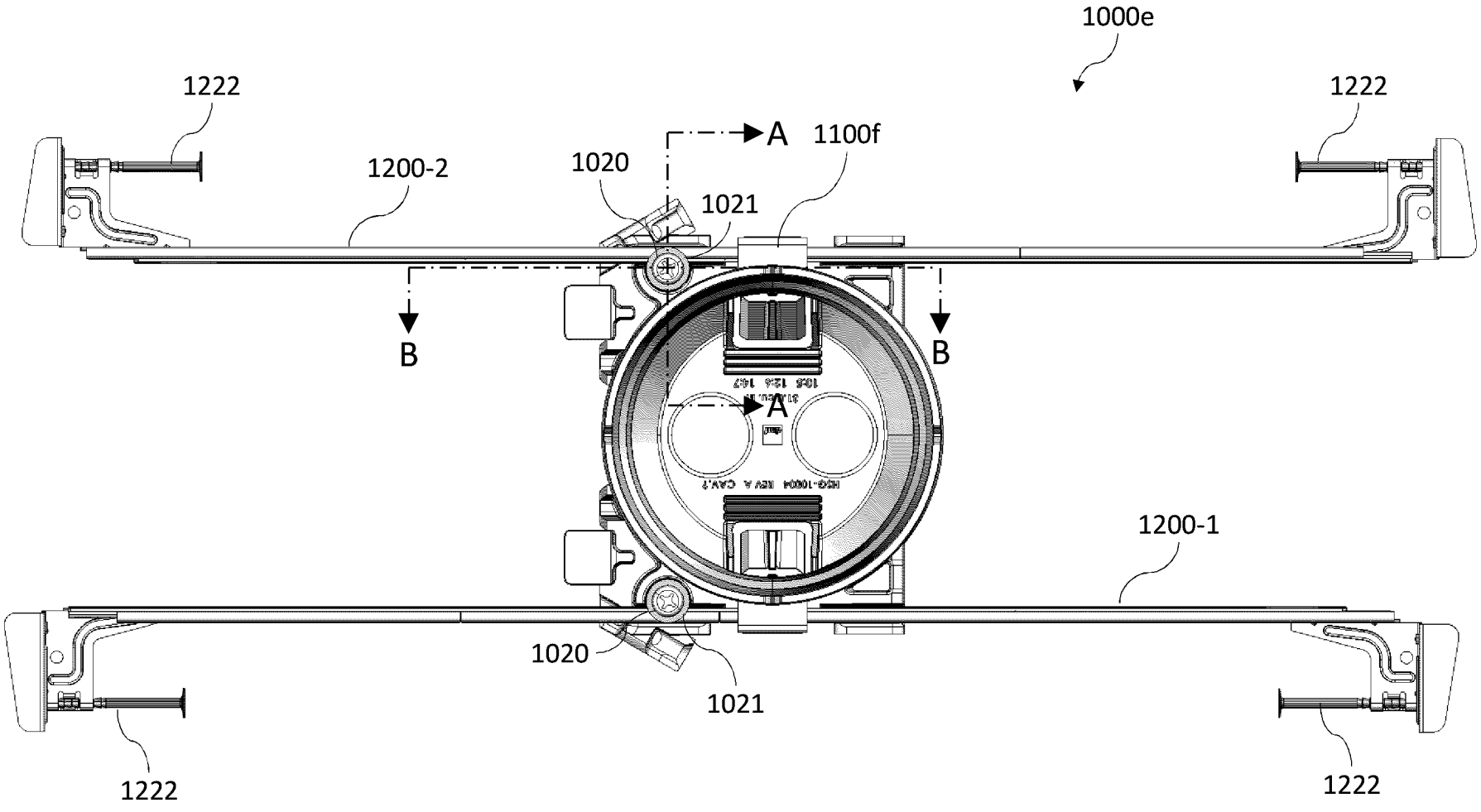



FIG. 14B

Date Reçue/Date Received 2021-07-16

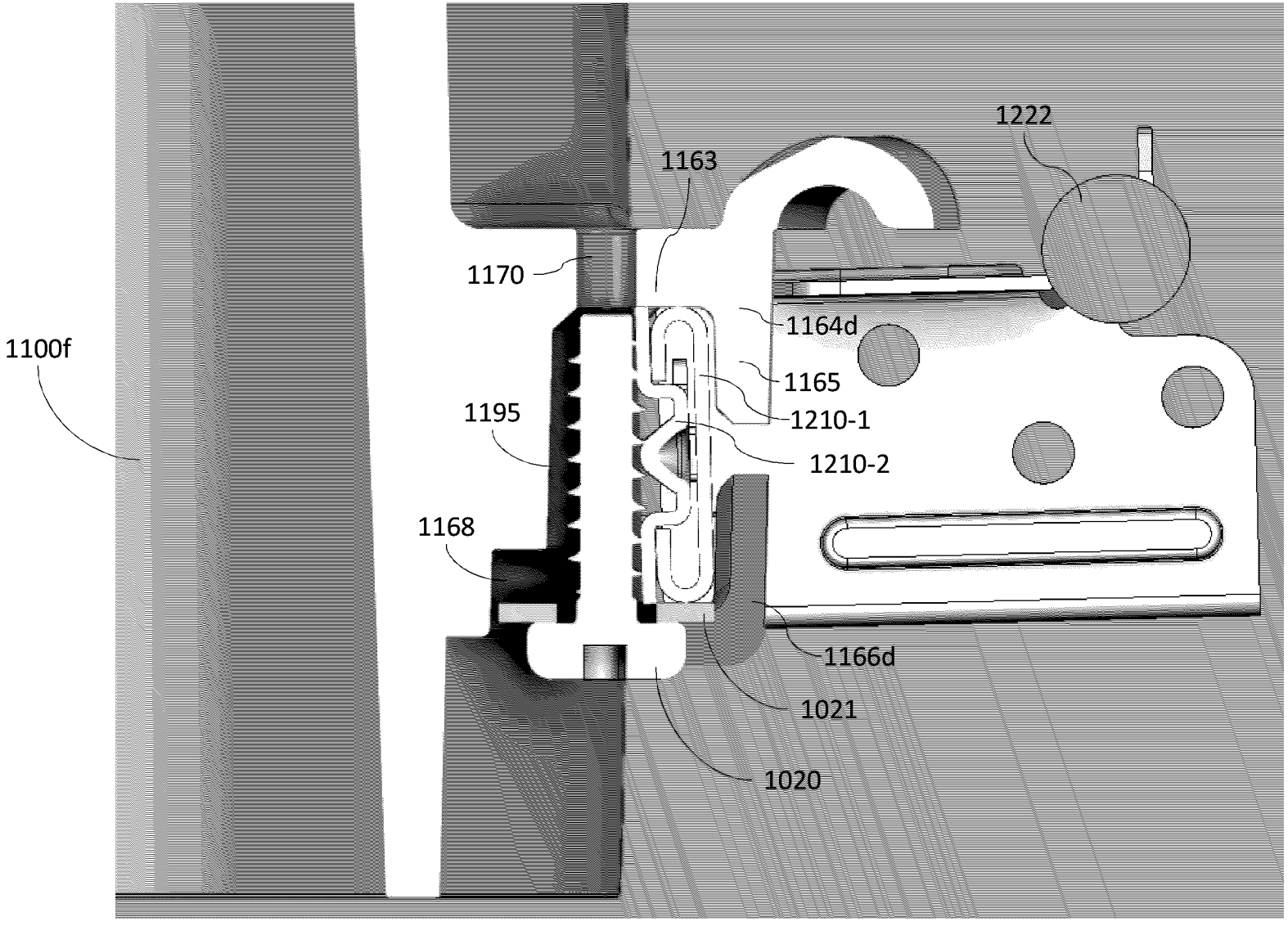



FIG. 14C

Date Reçue/Date Received 2021-07-16

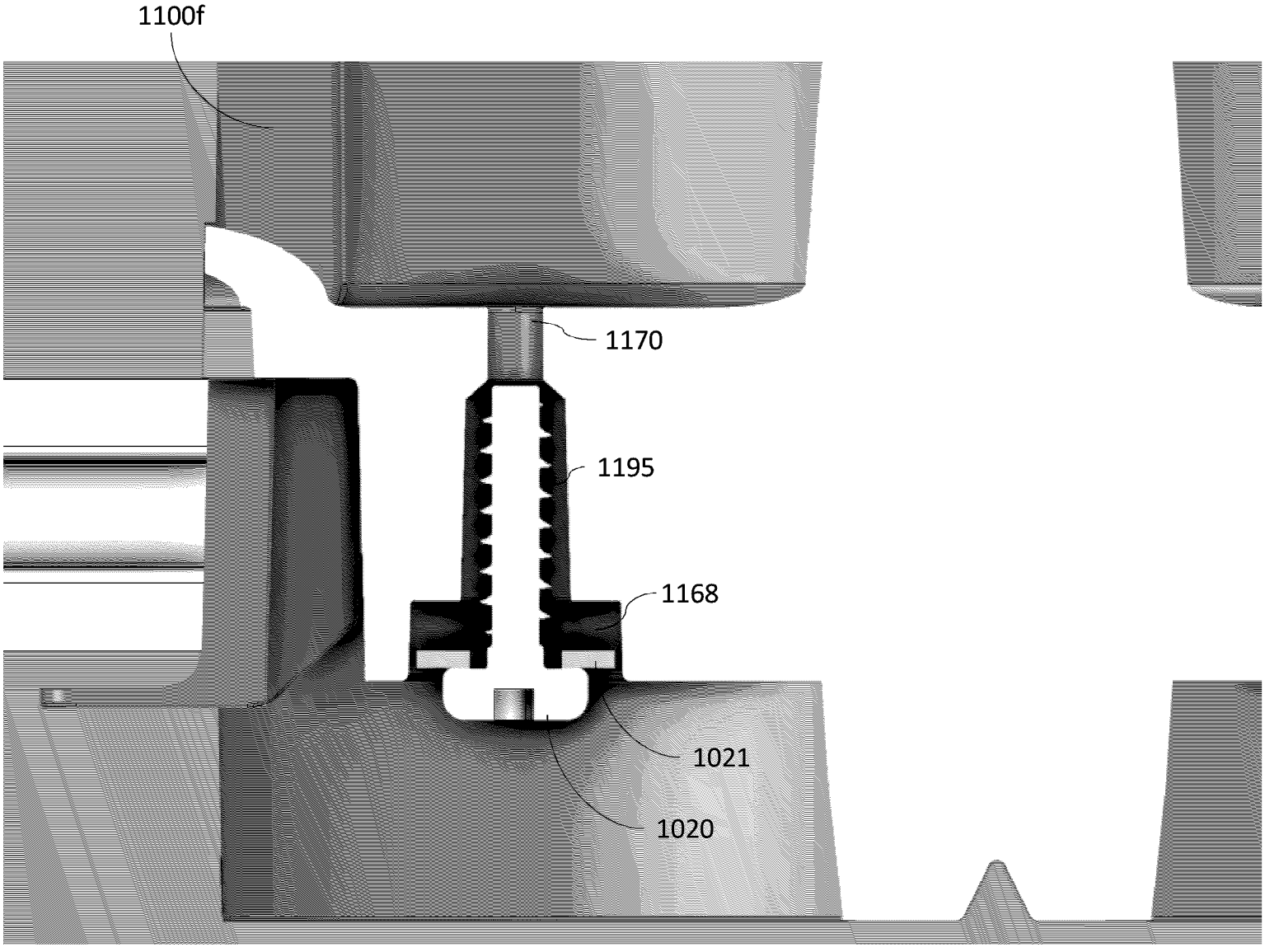



FIG. 14D

Date Reçue/Date Received 2021-07-16

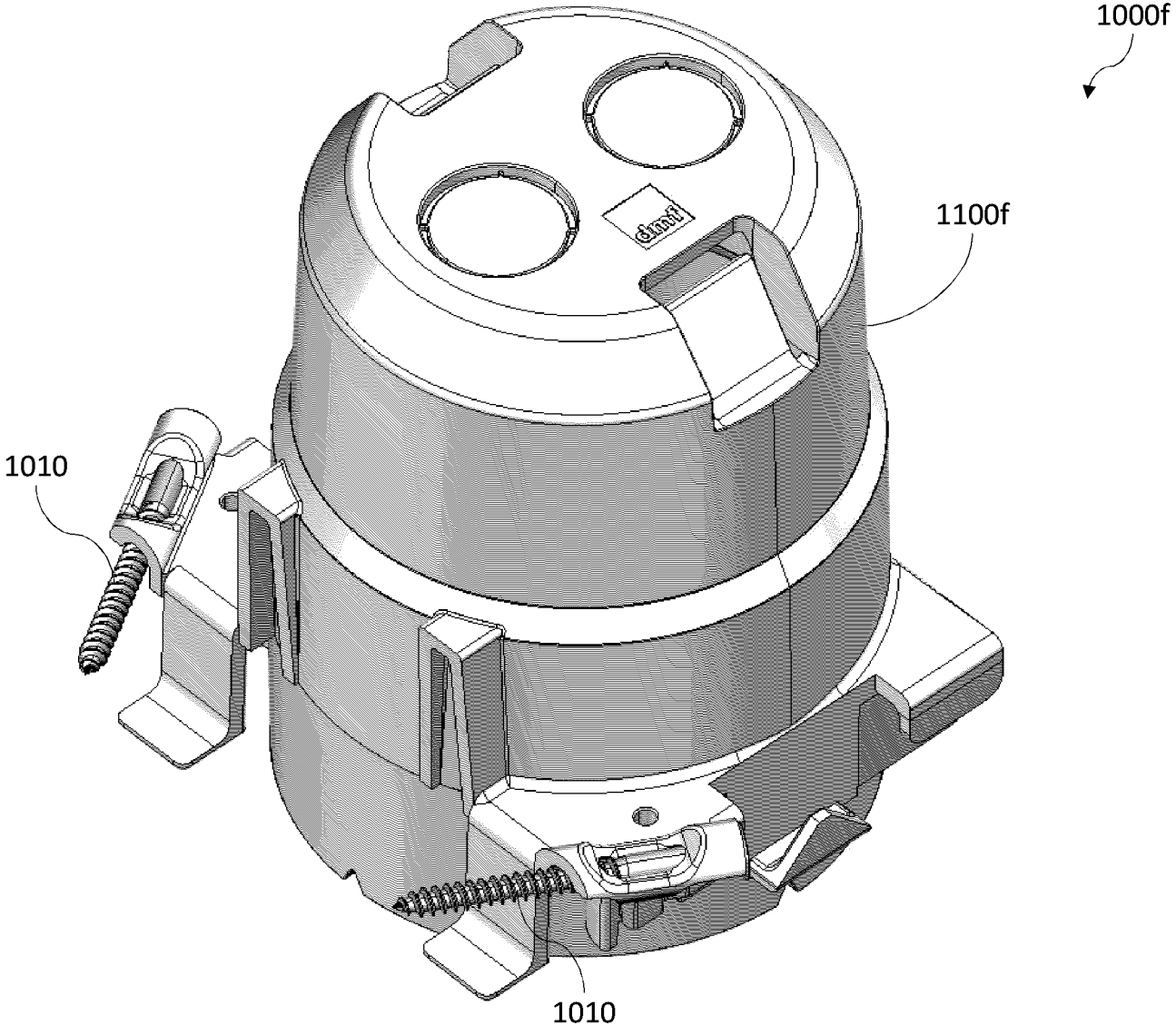



FIG. 15A

Date Reçue/Date Received 2021-07-16

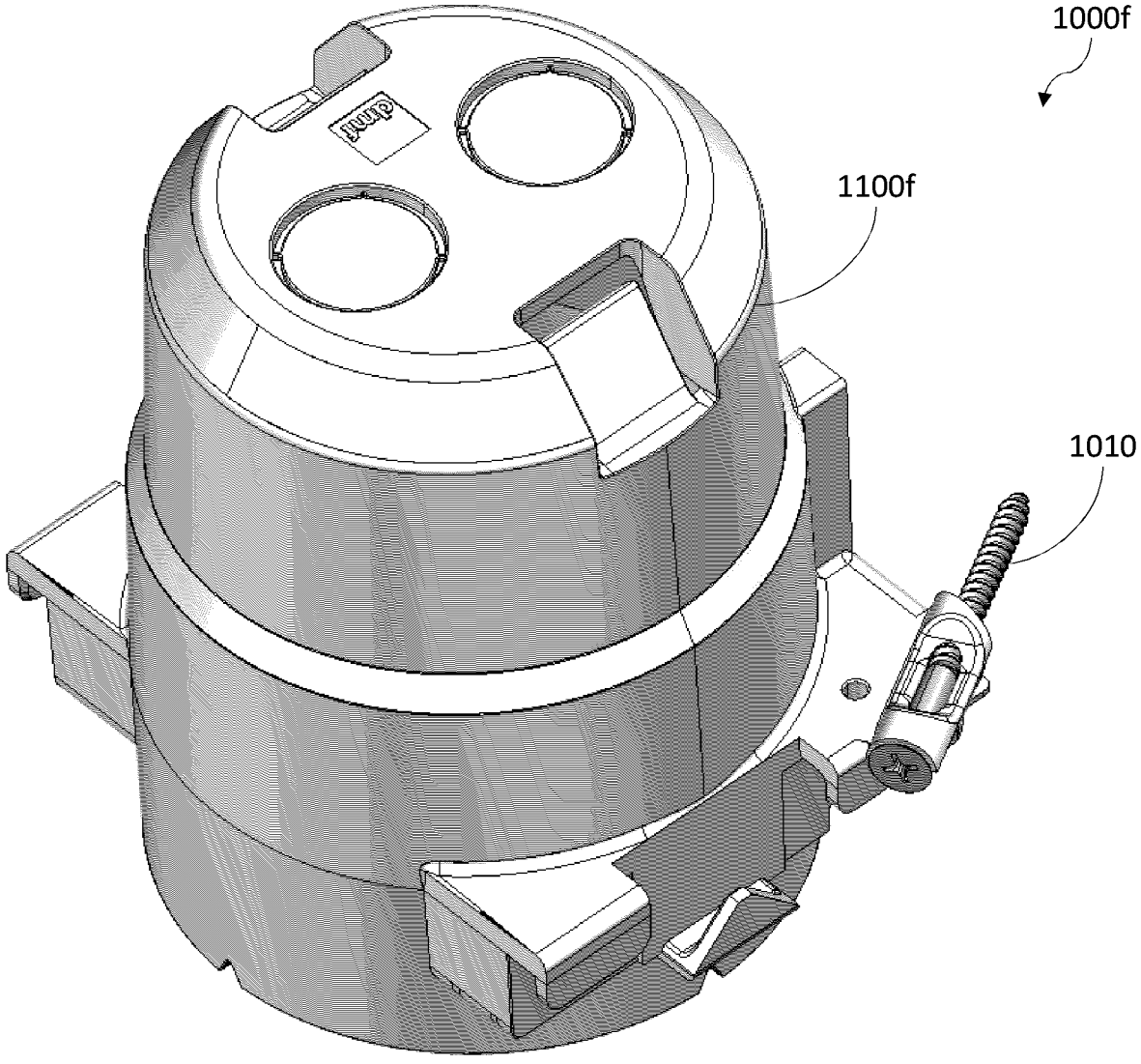



FIG. 15B

Date Reçue/Date Received 2021-07-16

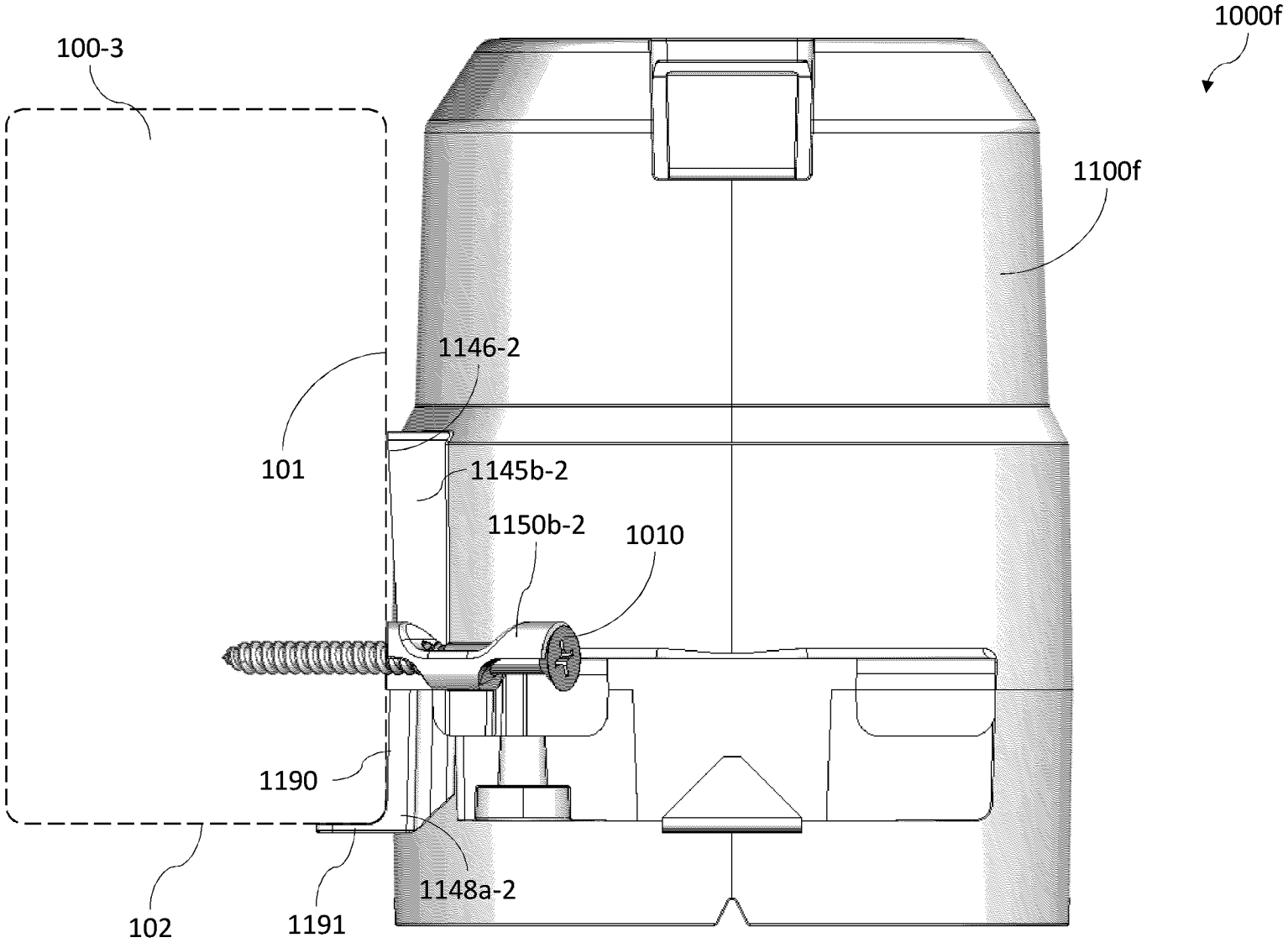



FIG. 15C

Date Reçue/Date Received 2021-07-16

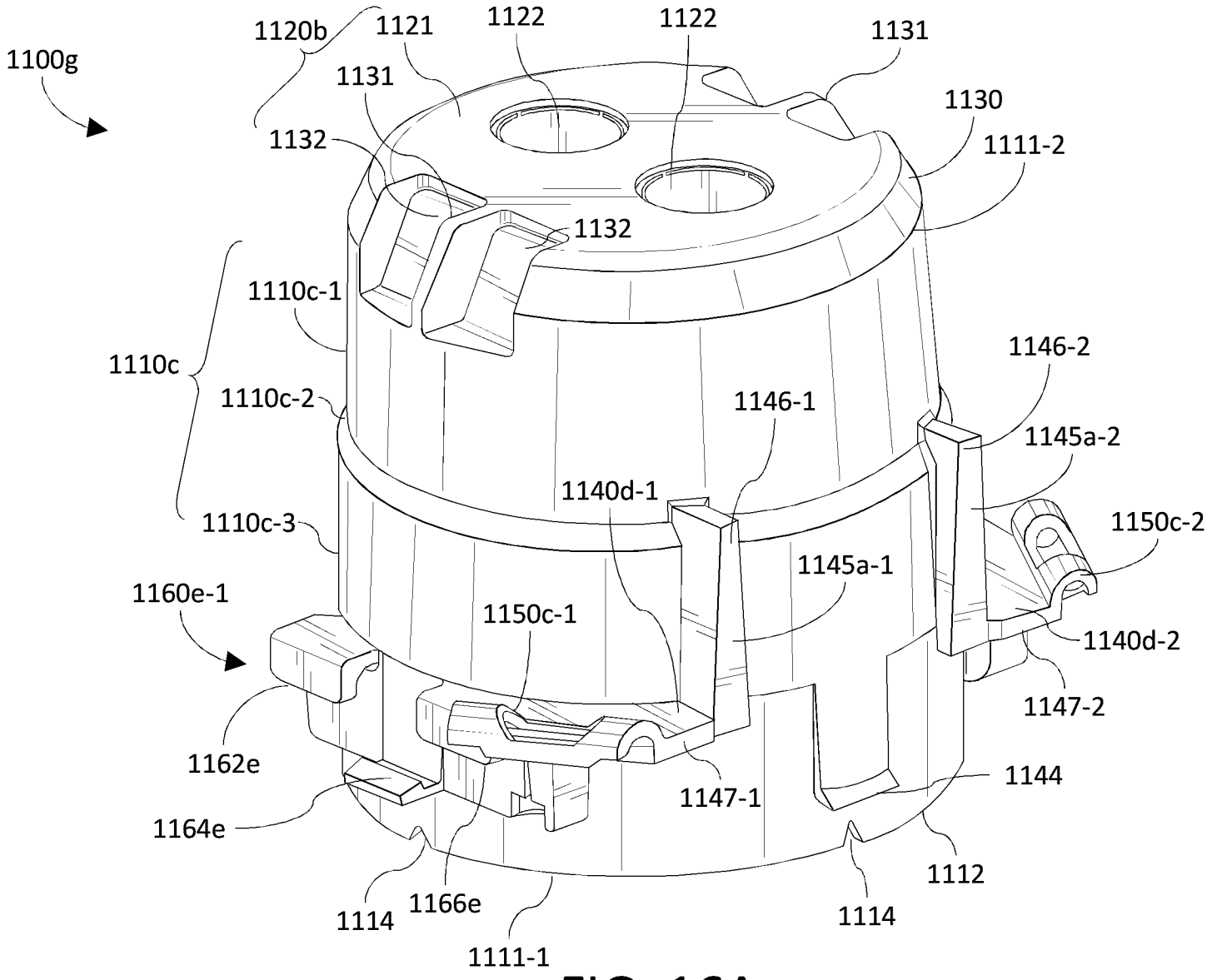



FIG. 16A

Date Reçue/Date Received 2021-07-16

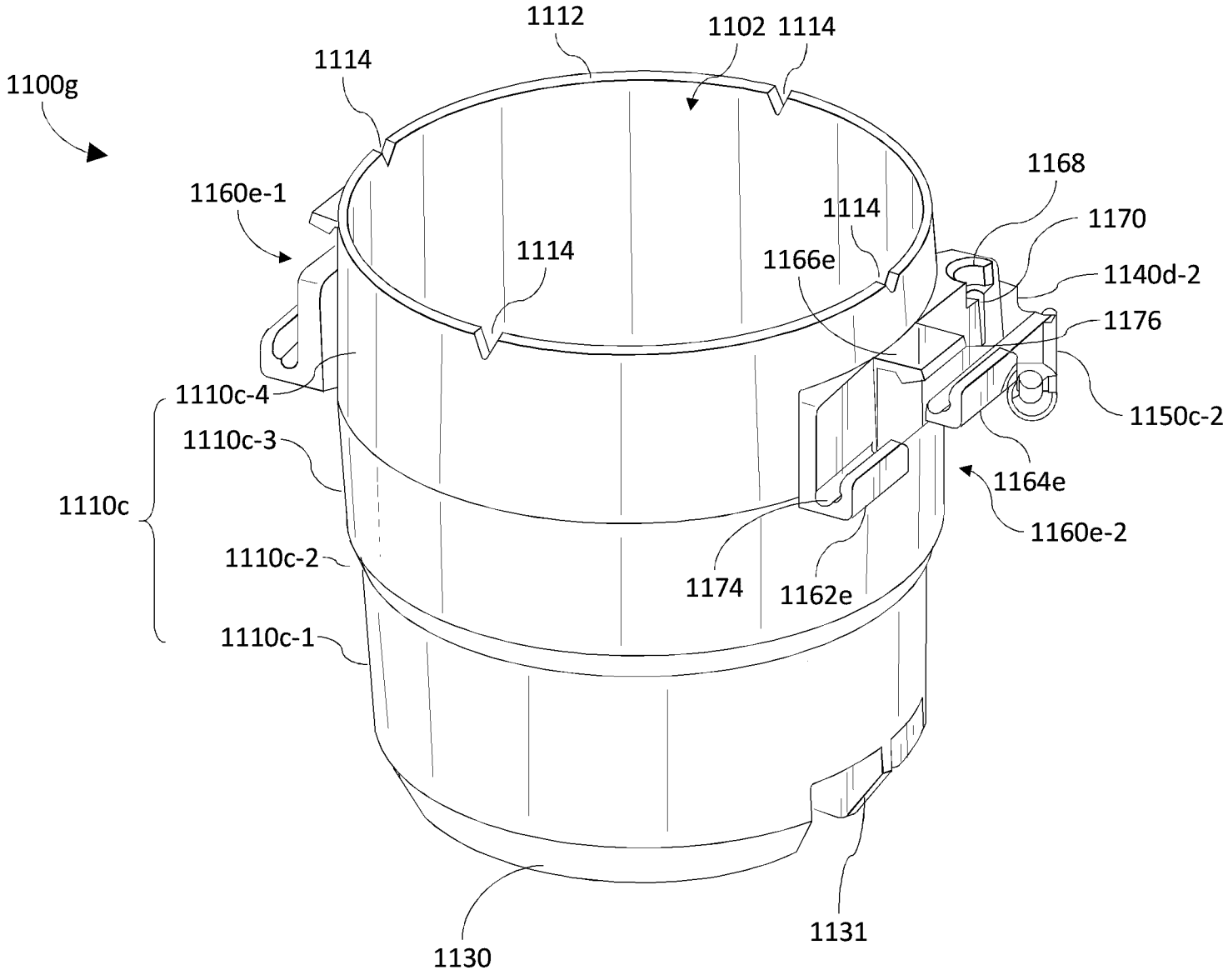



FIG. 16B

Date Reçue/Date Received 2021-07-16

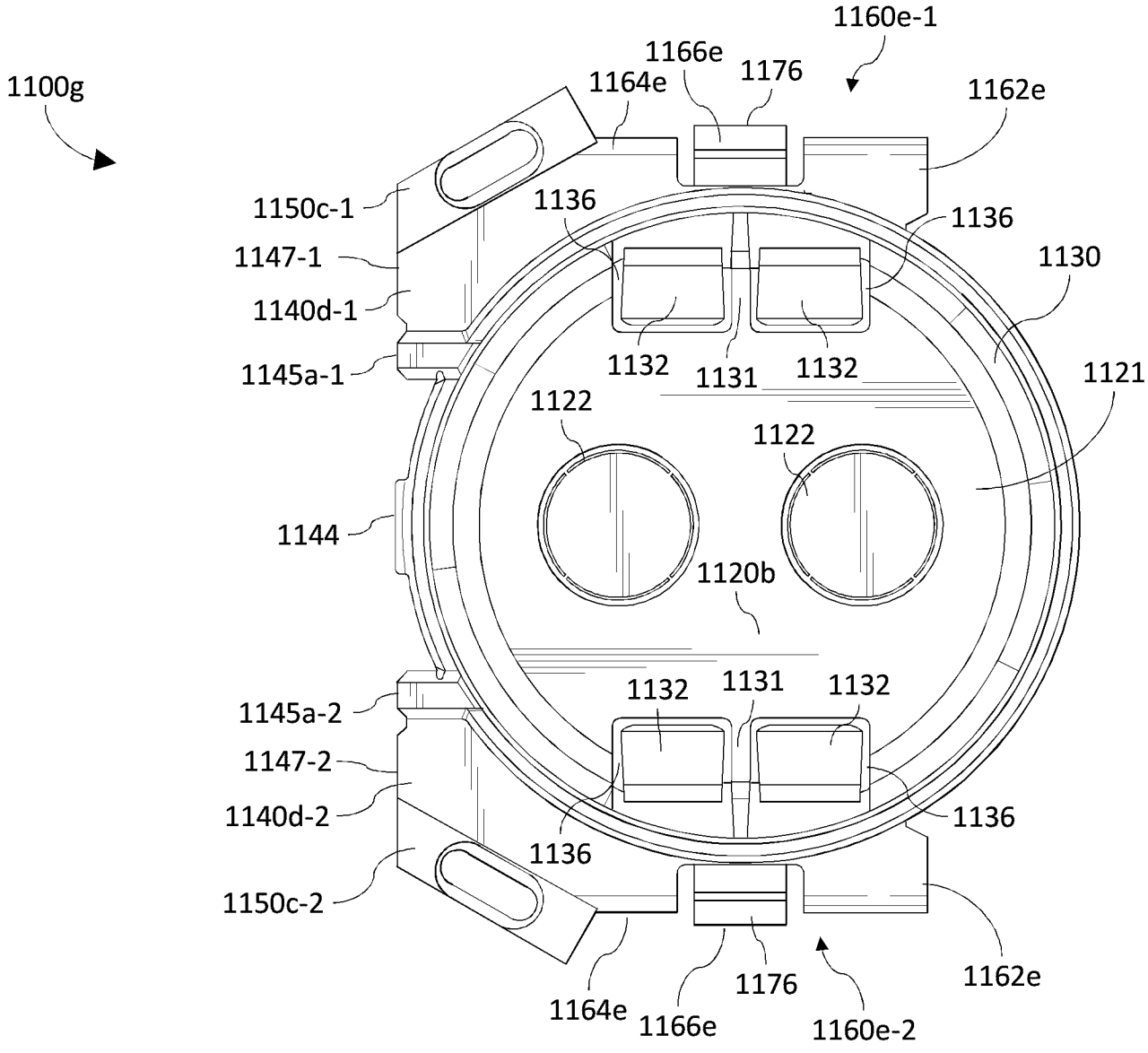



FIG. 16C

Date Reçue/Date Received 2021-07-16

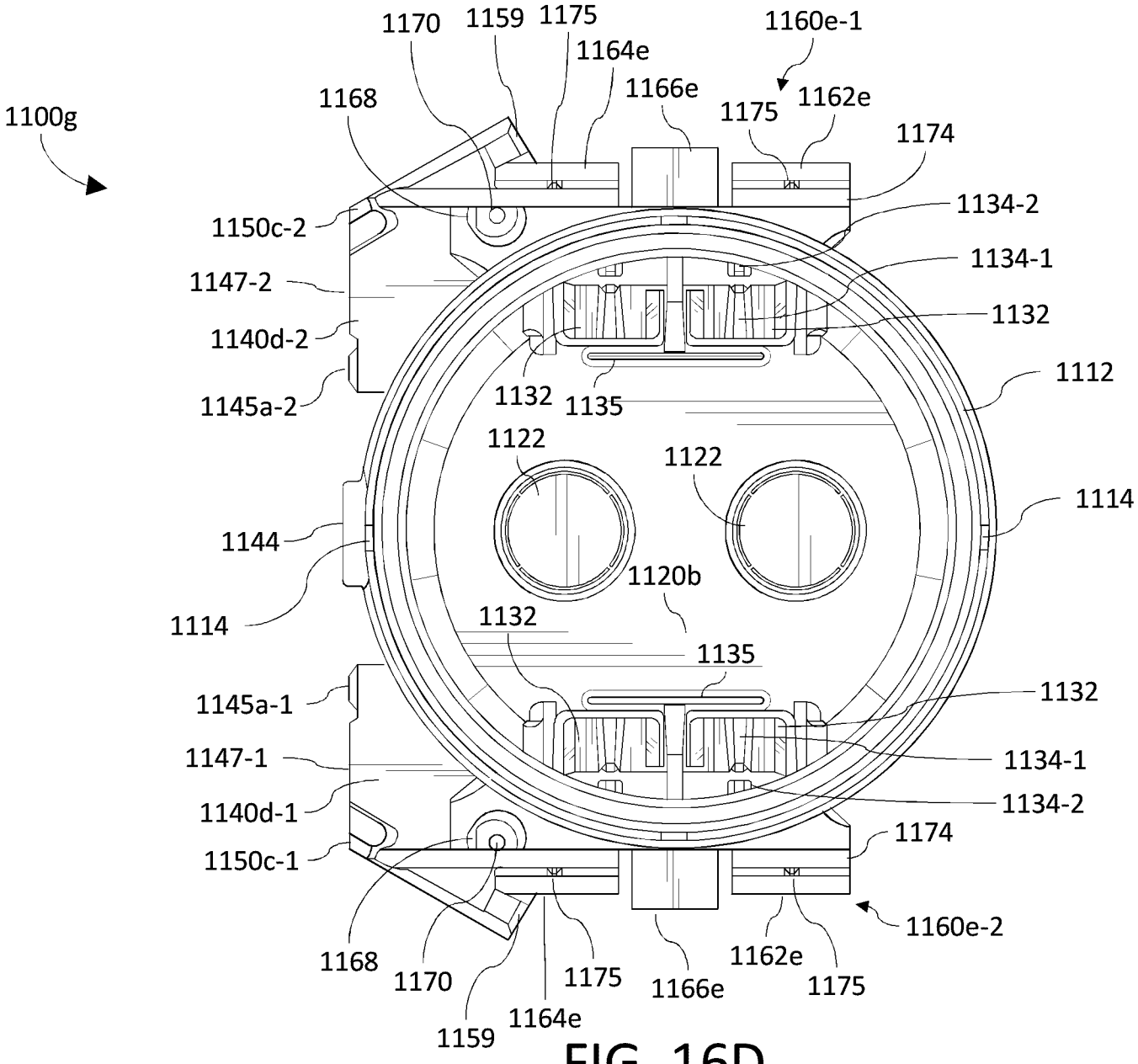



FIG. 16D

Date Reçue/Date Received 2021-07-16

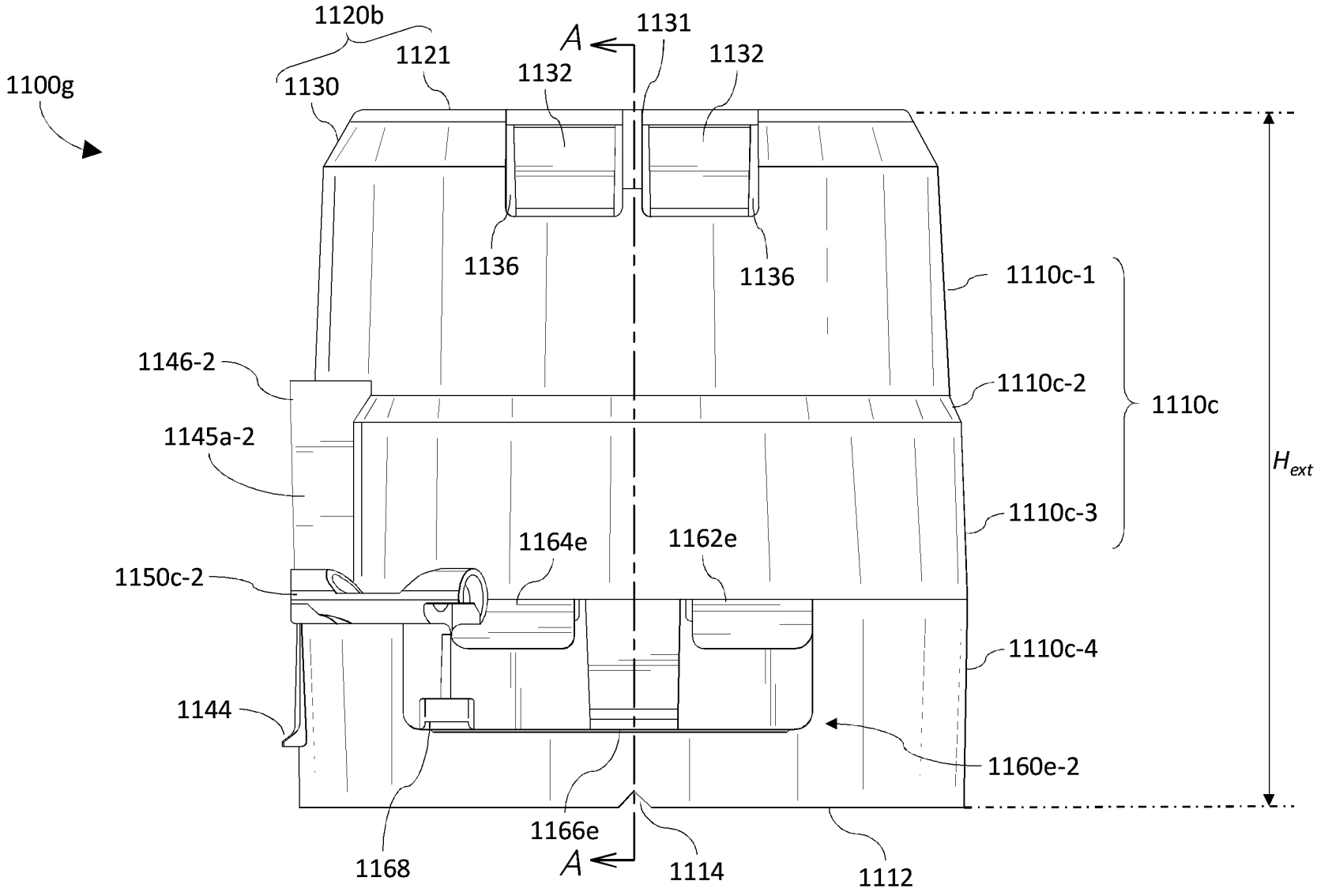



FIG. 16E

Date Reçue/Date Received 2021-07-16

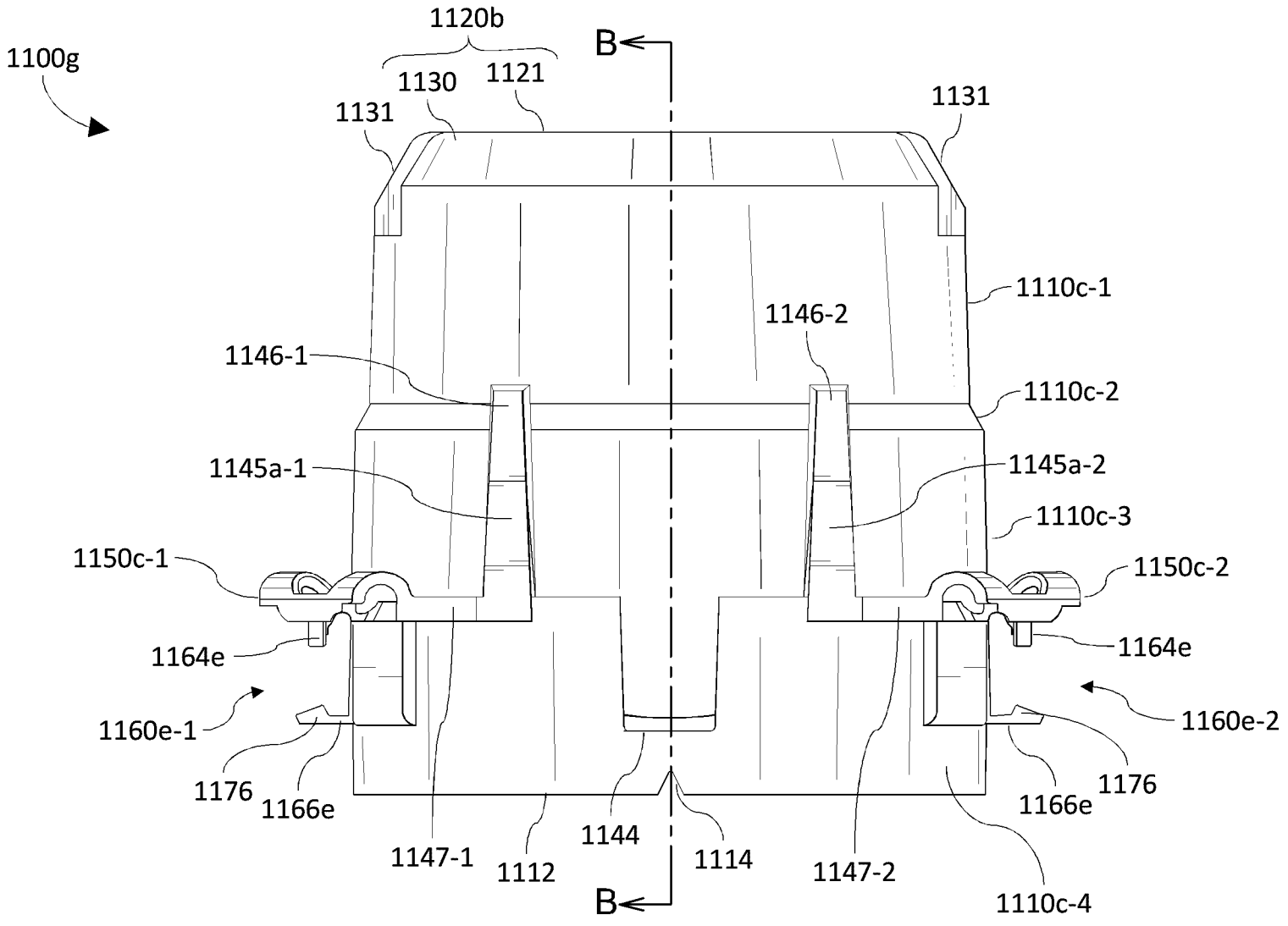



FIG. 16F

Date Reçue/Date Received 2021-07-16

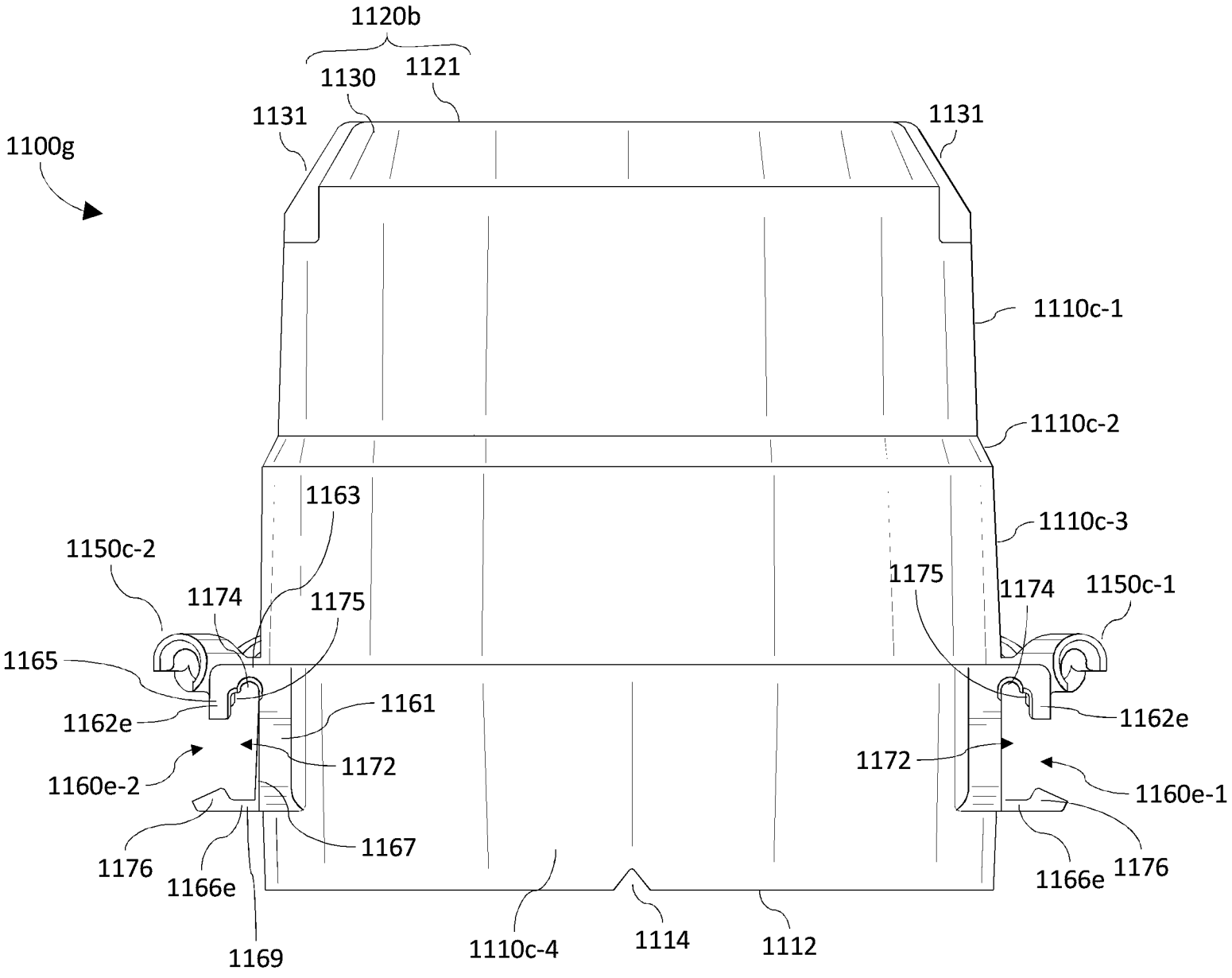



FIG. 16G

Date Reçue/Date Received 2021-07-16

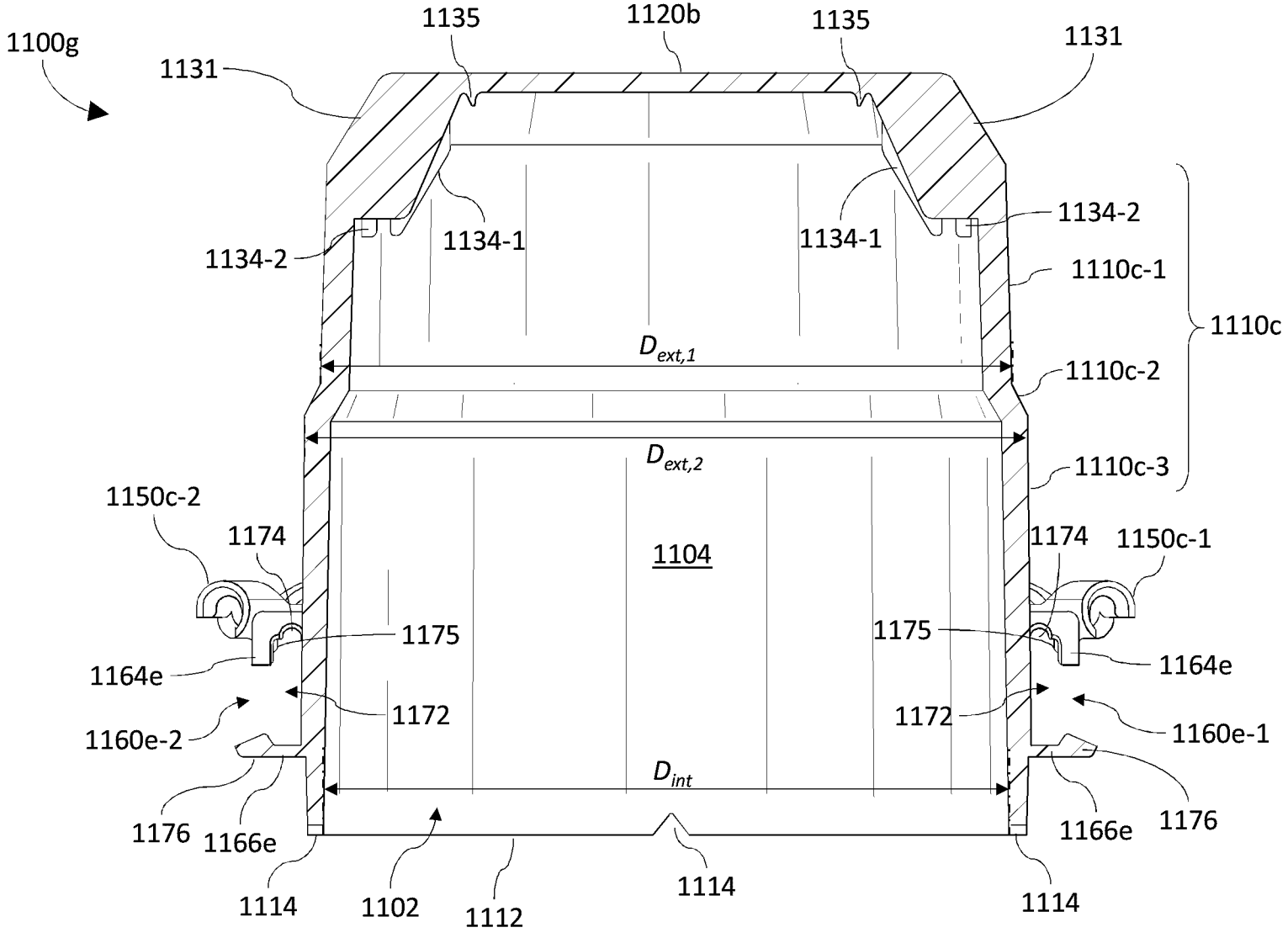



FIG. 16H

Date Reçue/Date Received 2021-07-16

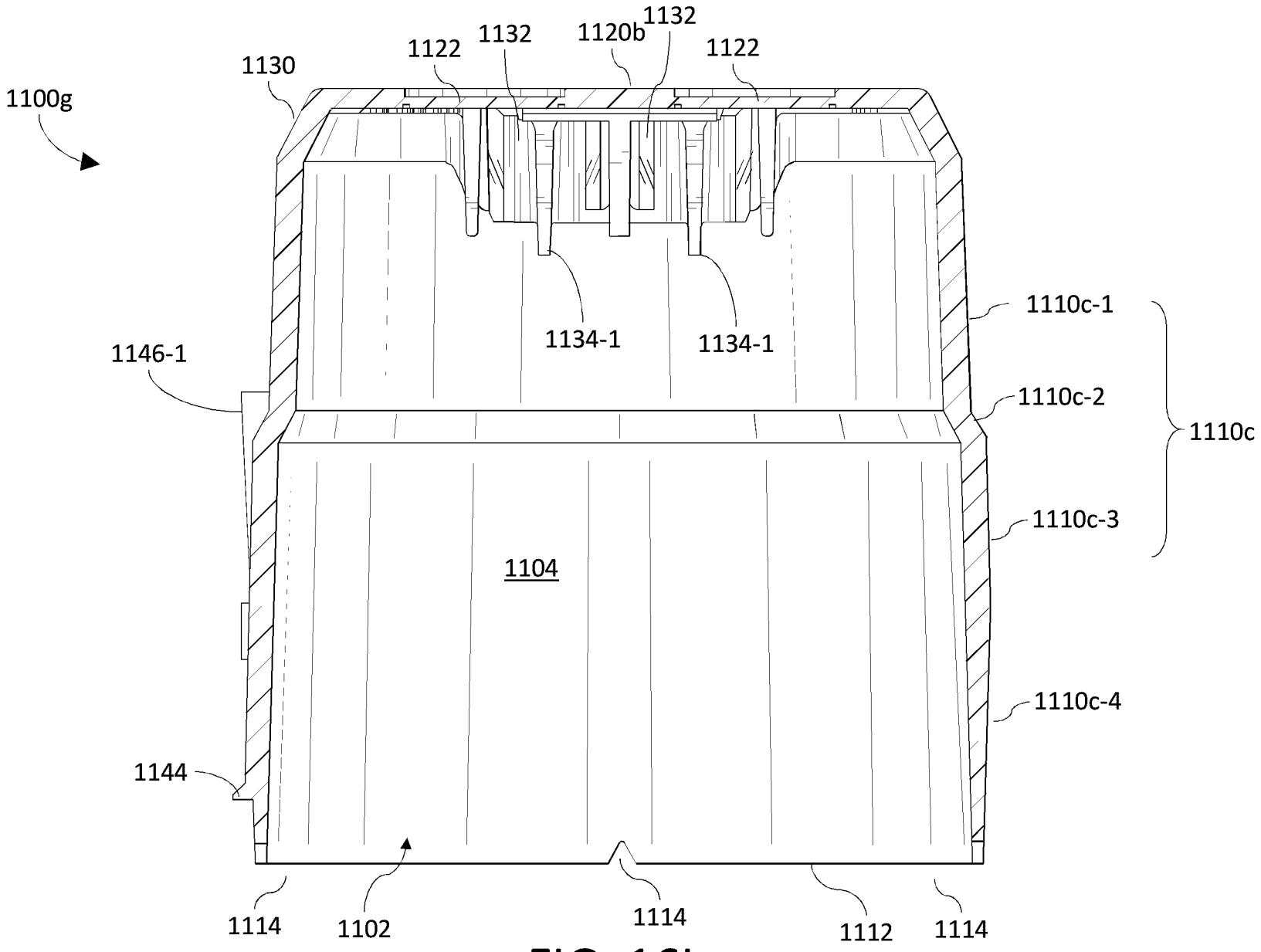



FIG. 16I

Date Reçue/Date Received 2021-07-16

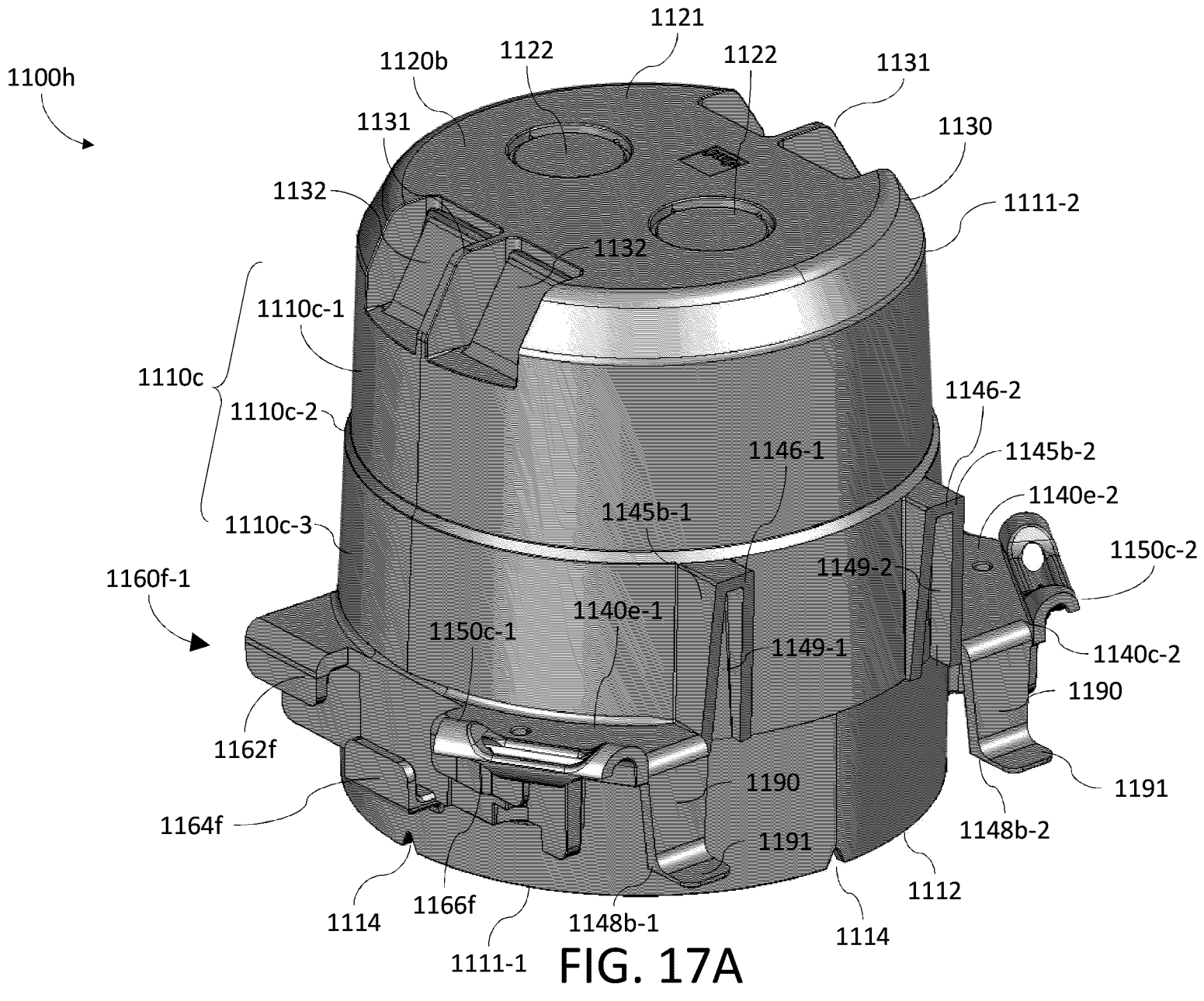



FIG. 17A

Date Reçue/Date Received 2021-07-16

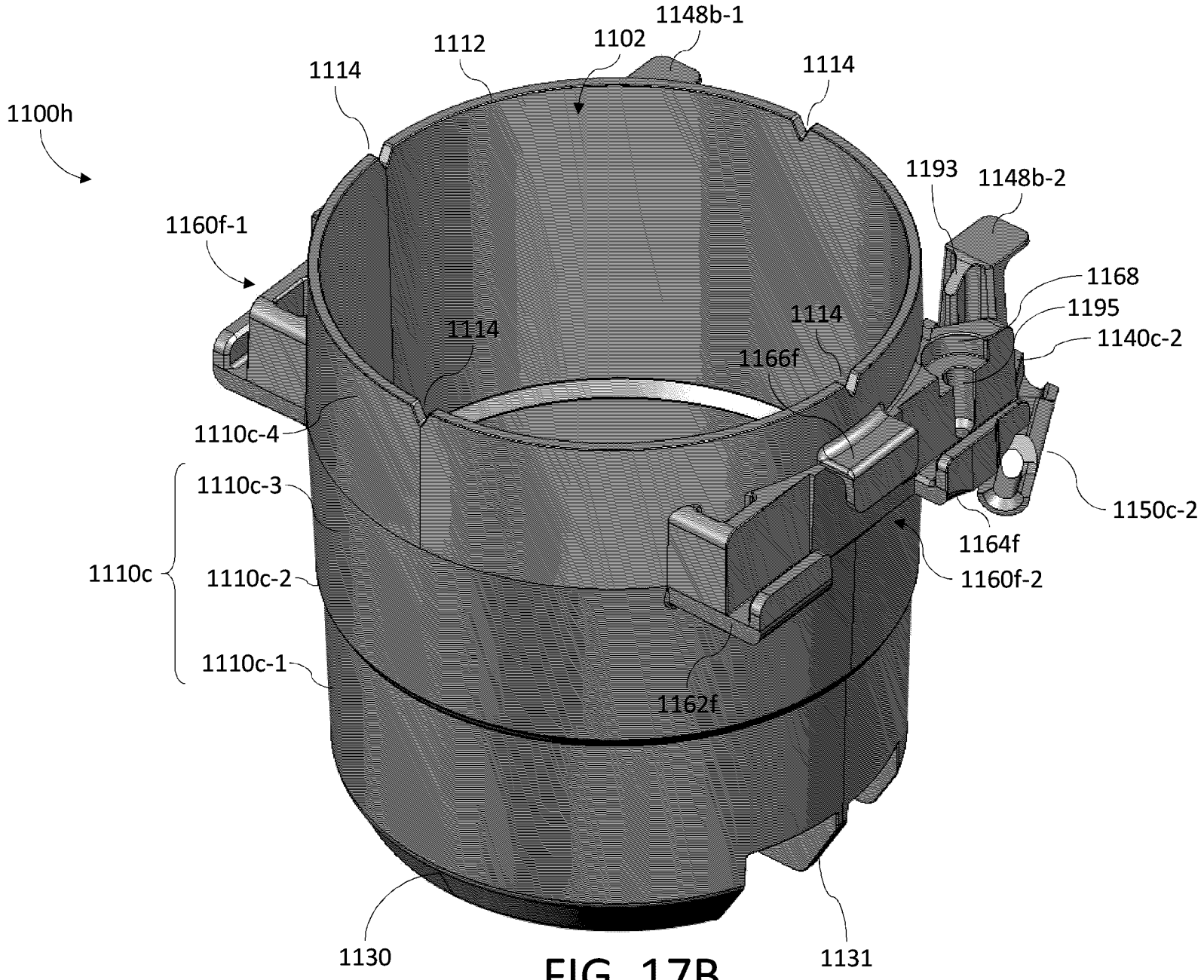



FIG. 17B

Date Reçue/Date Received 2021-07-16

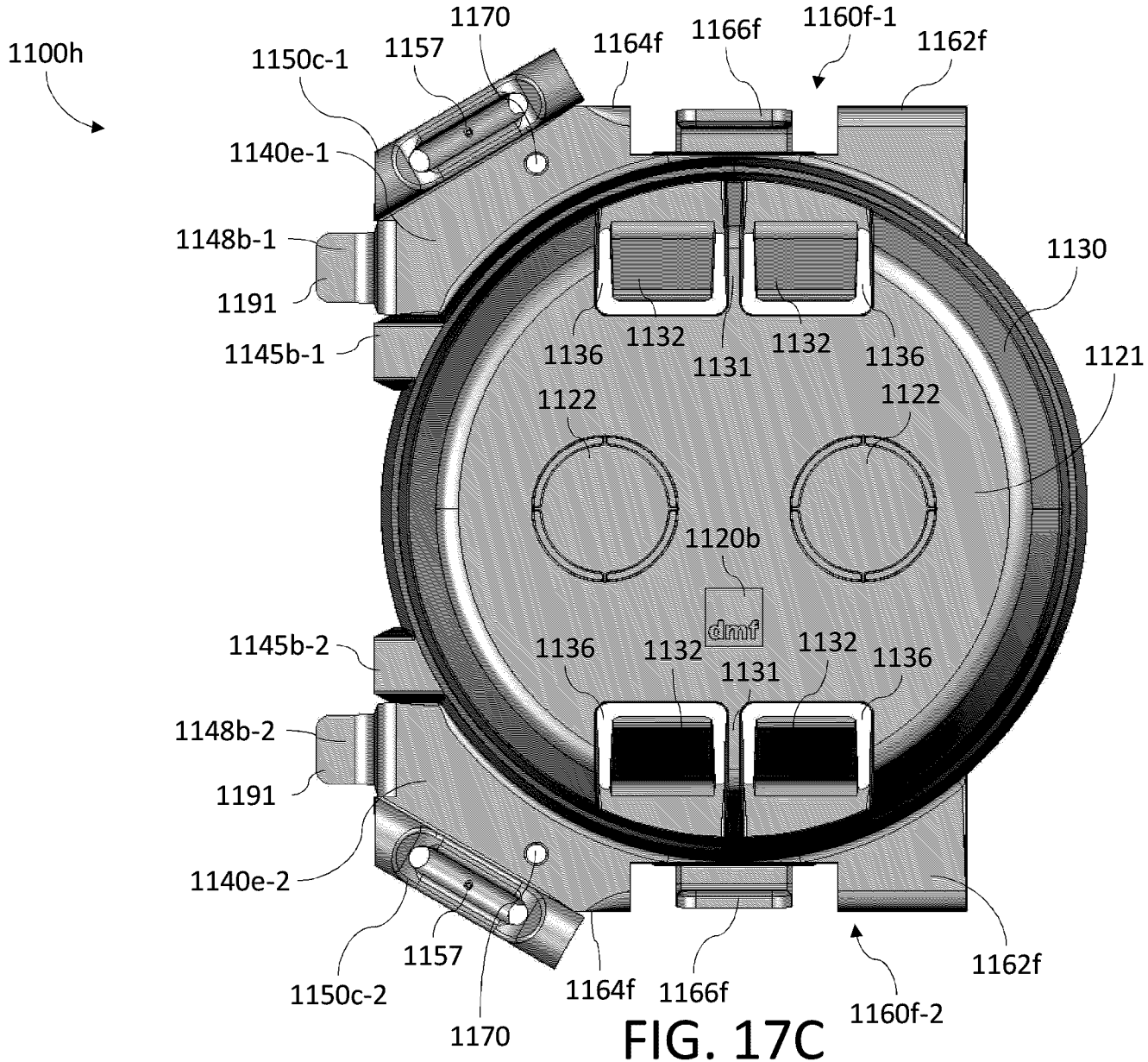



FIG. 17C

Date Reçue/Date Received 2021-07-16

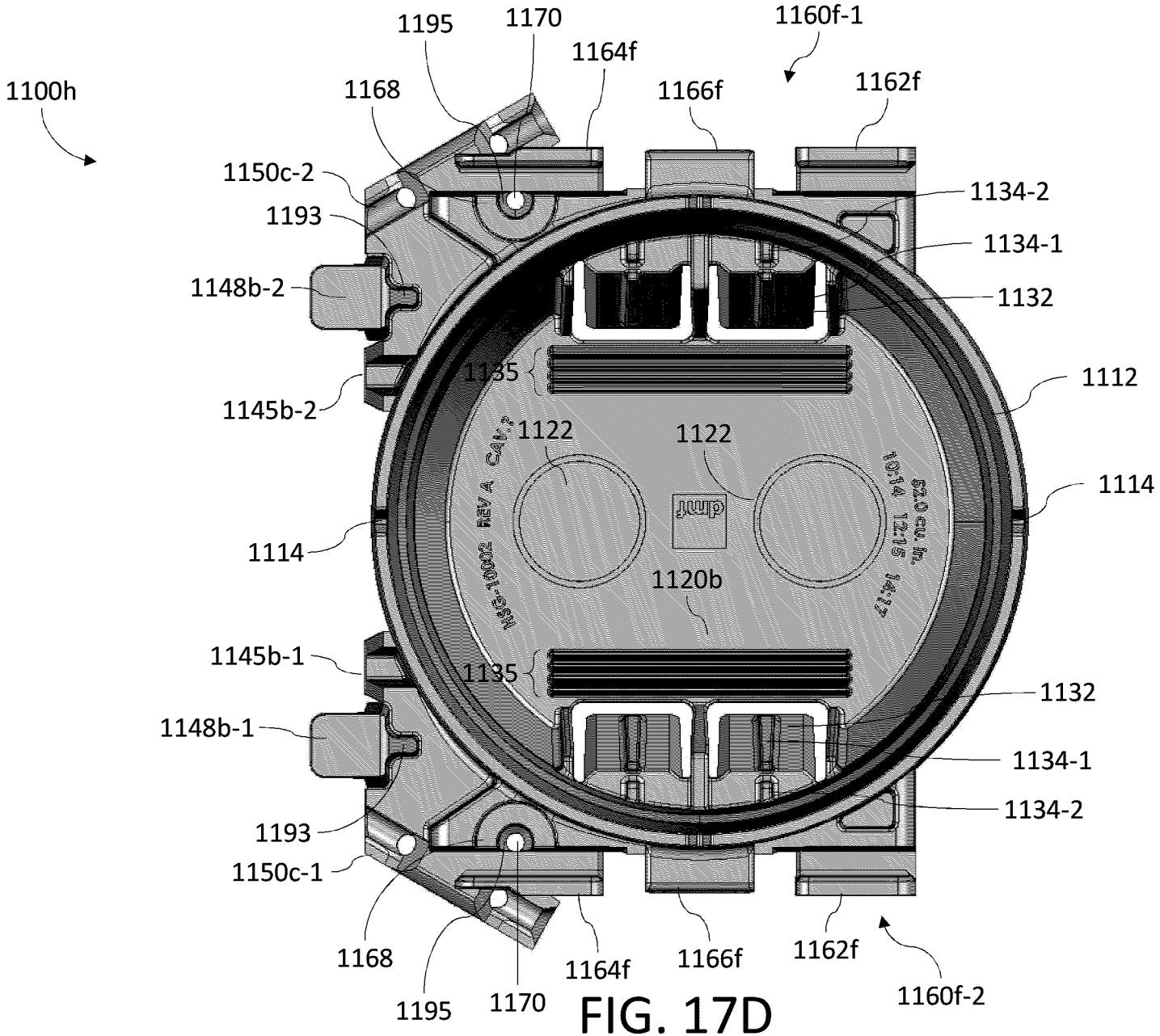



FIG. 17D

Date Reçue/Date Received 2021-07-16

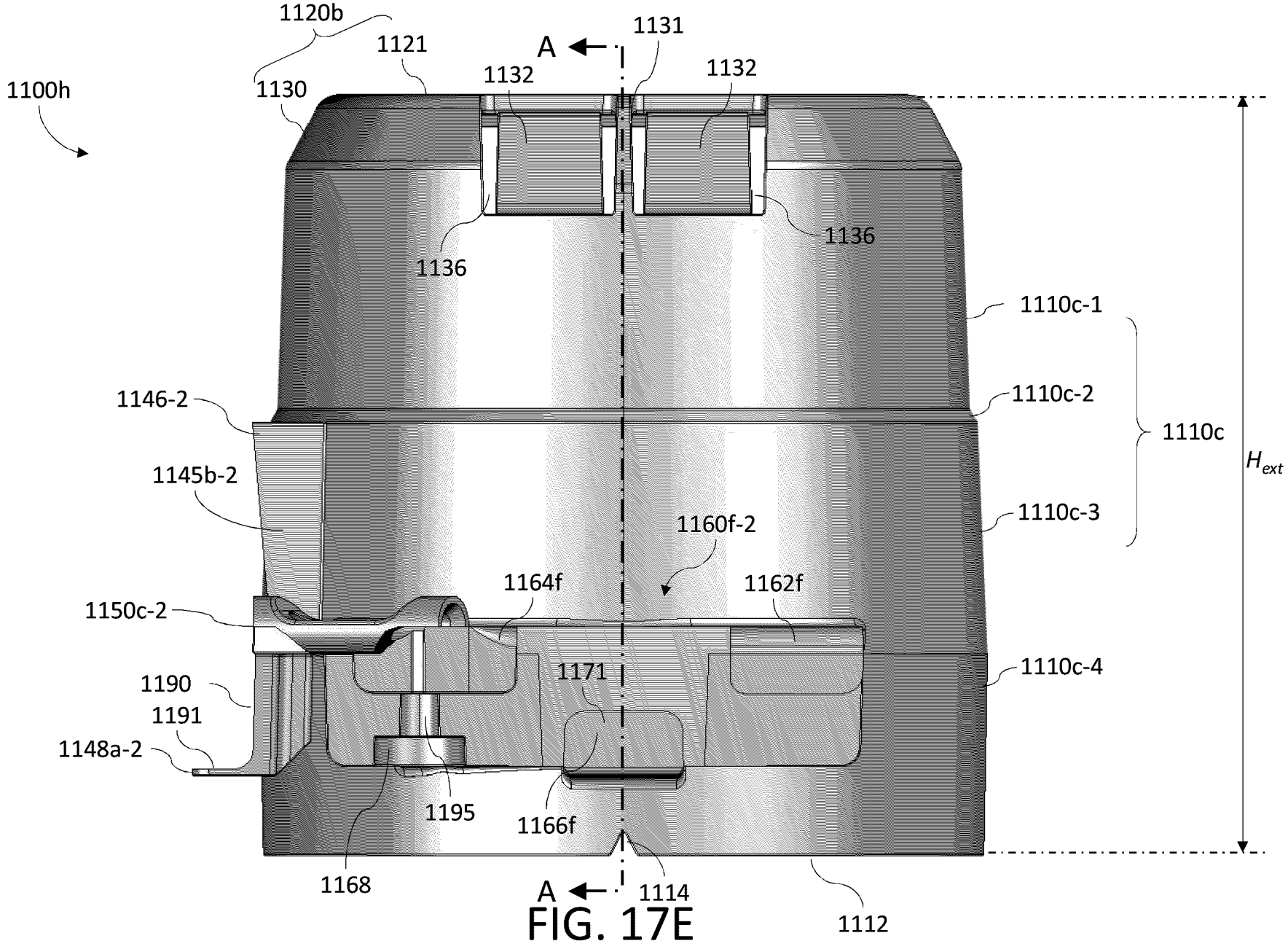



FIG. 17E

Date Reçue/Date Received 2021-07-16

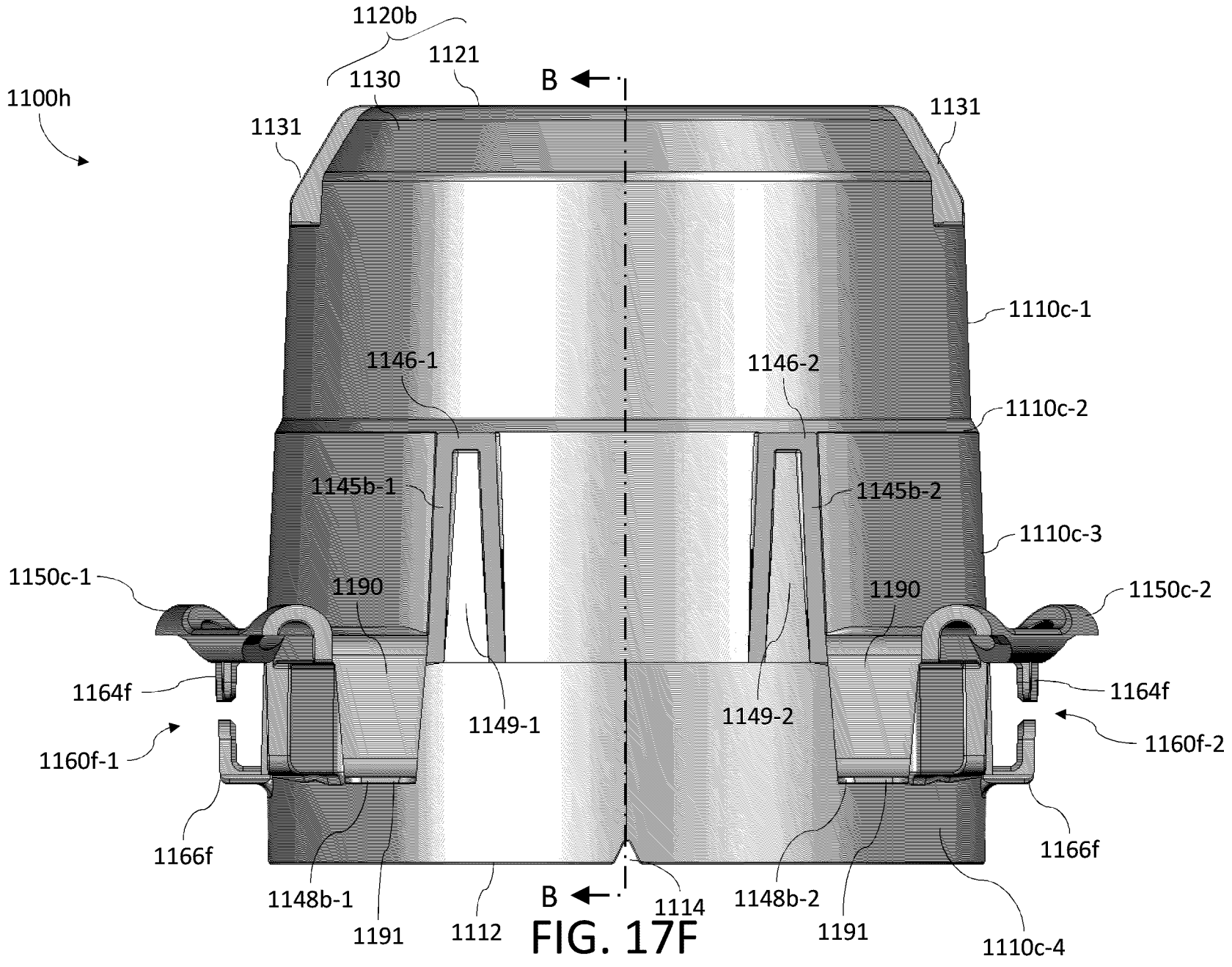



FIG. 17F

Date Reçue/Date Received 2021-07-16

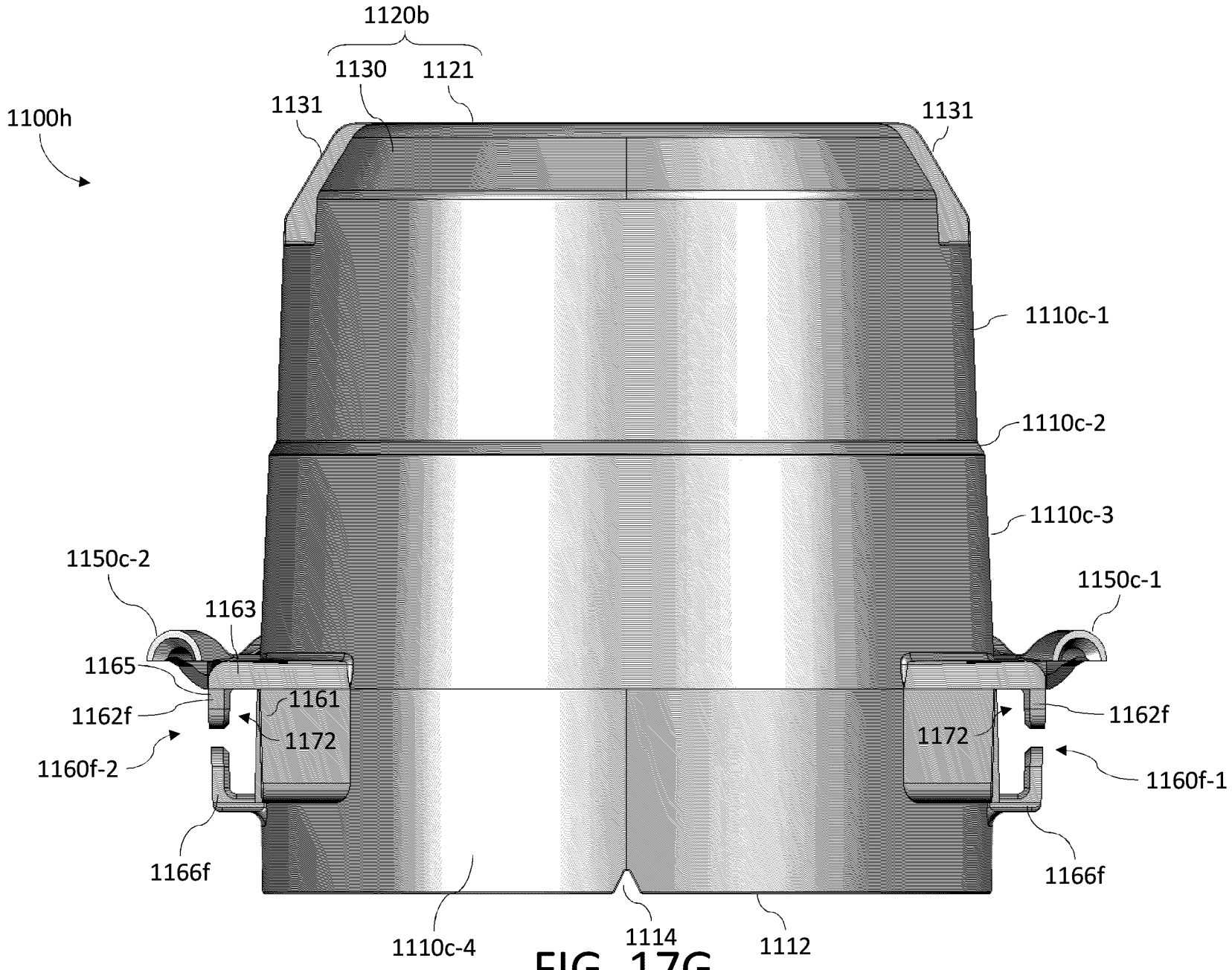



FIG. 17G

Date Reçue/Date Received 2021-07-16

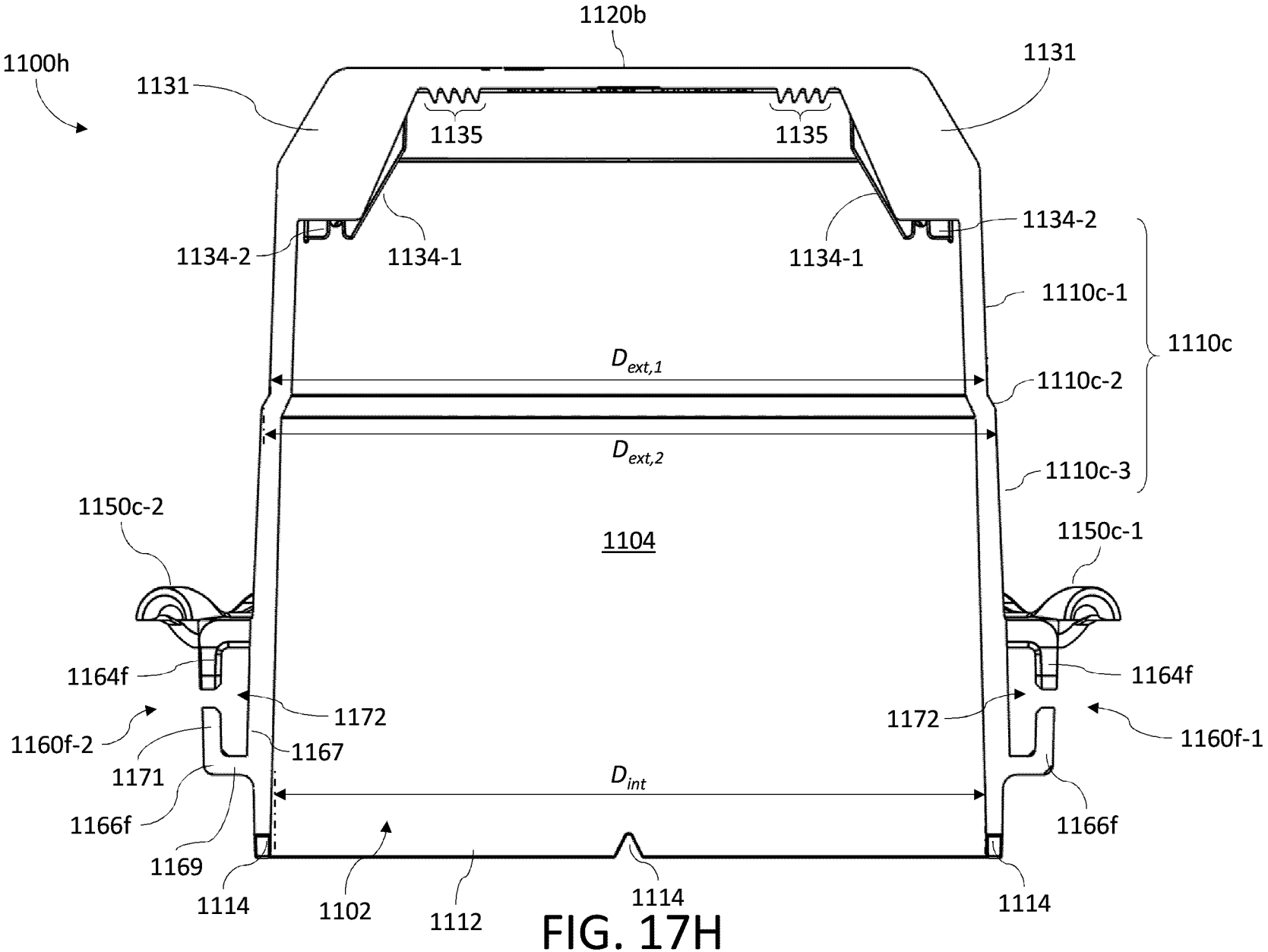



FIG. 17H

Date Reçue/Date Received 2021-07-16

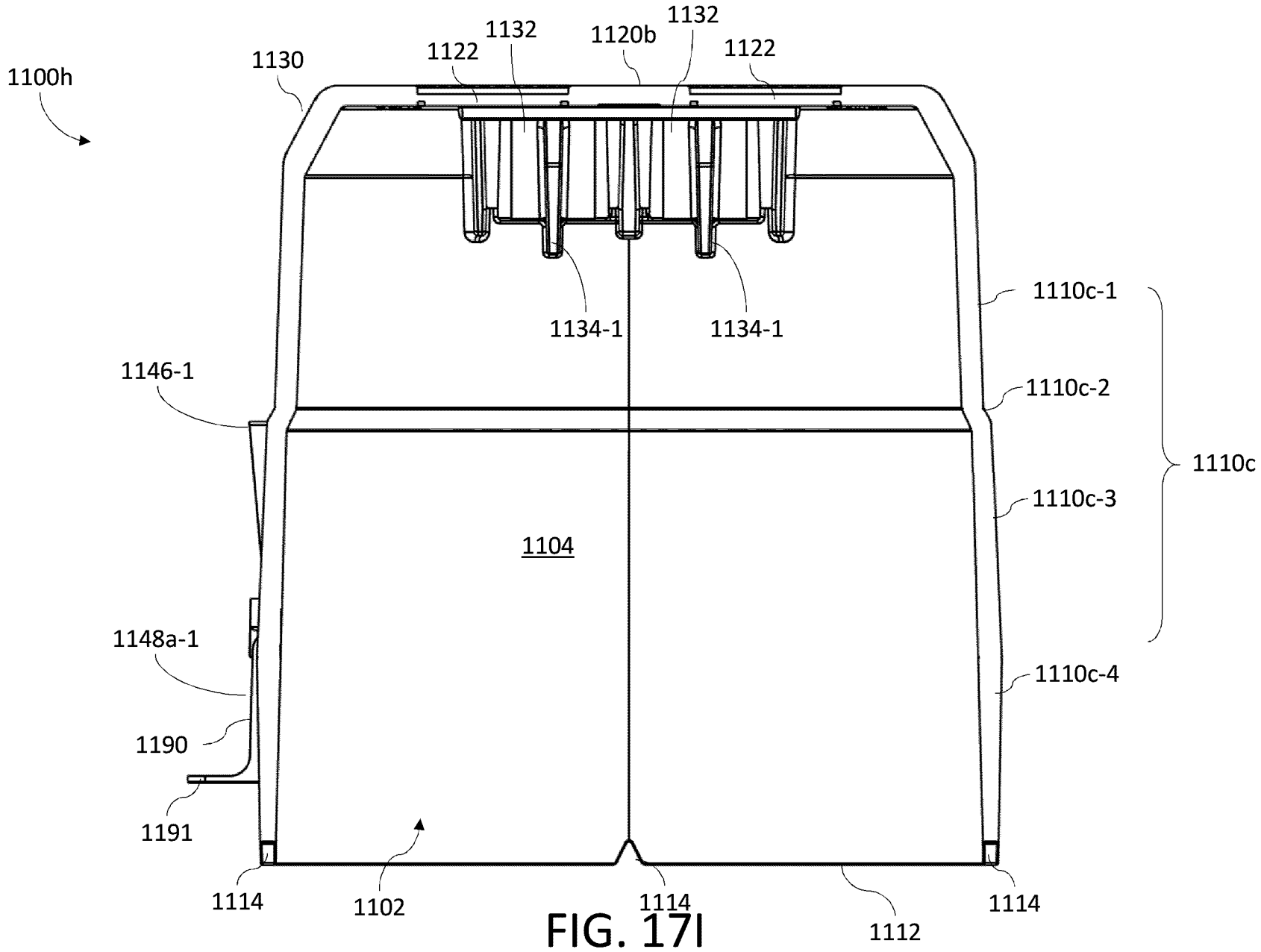



FIG. 17I

Date Reçue/Date Received 2021-07-16

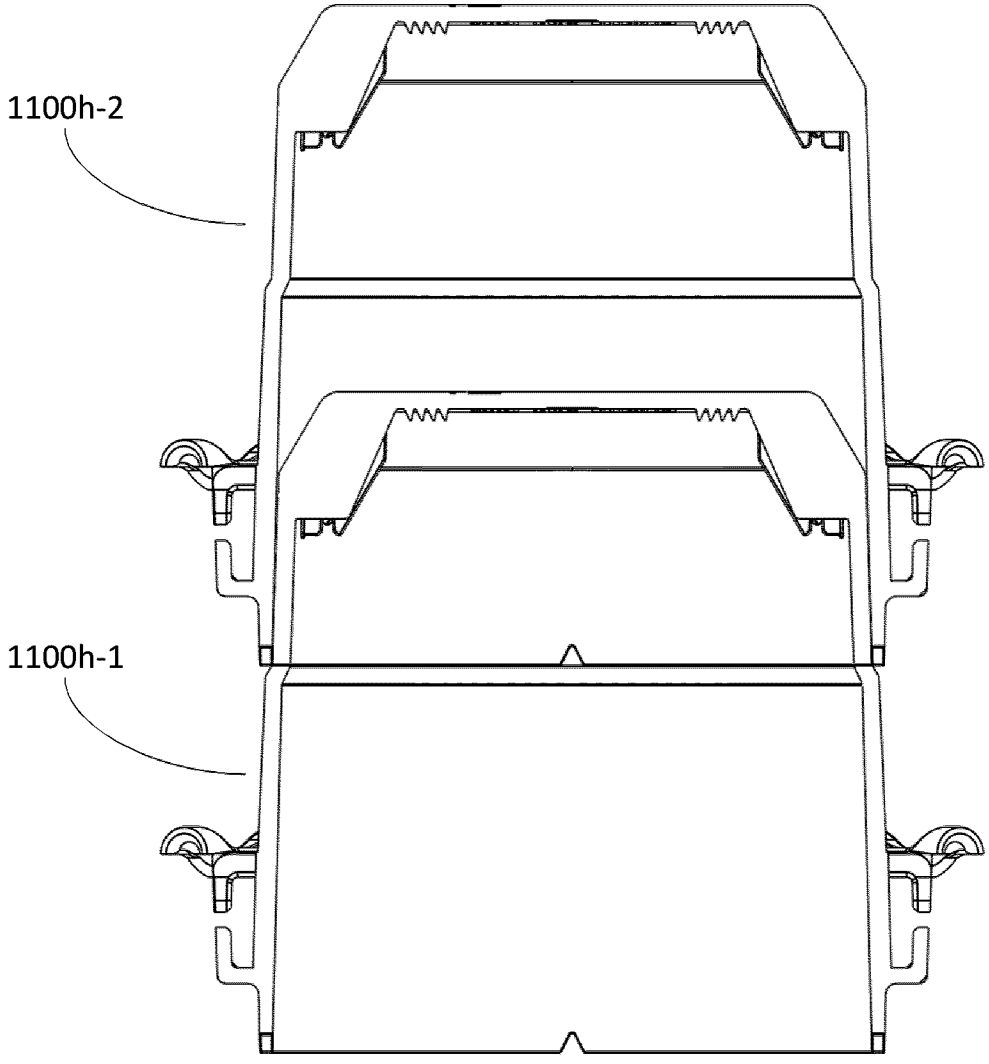



FIG. 18

Date Reçue/Date Received 2021-07-16

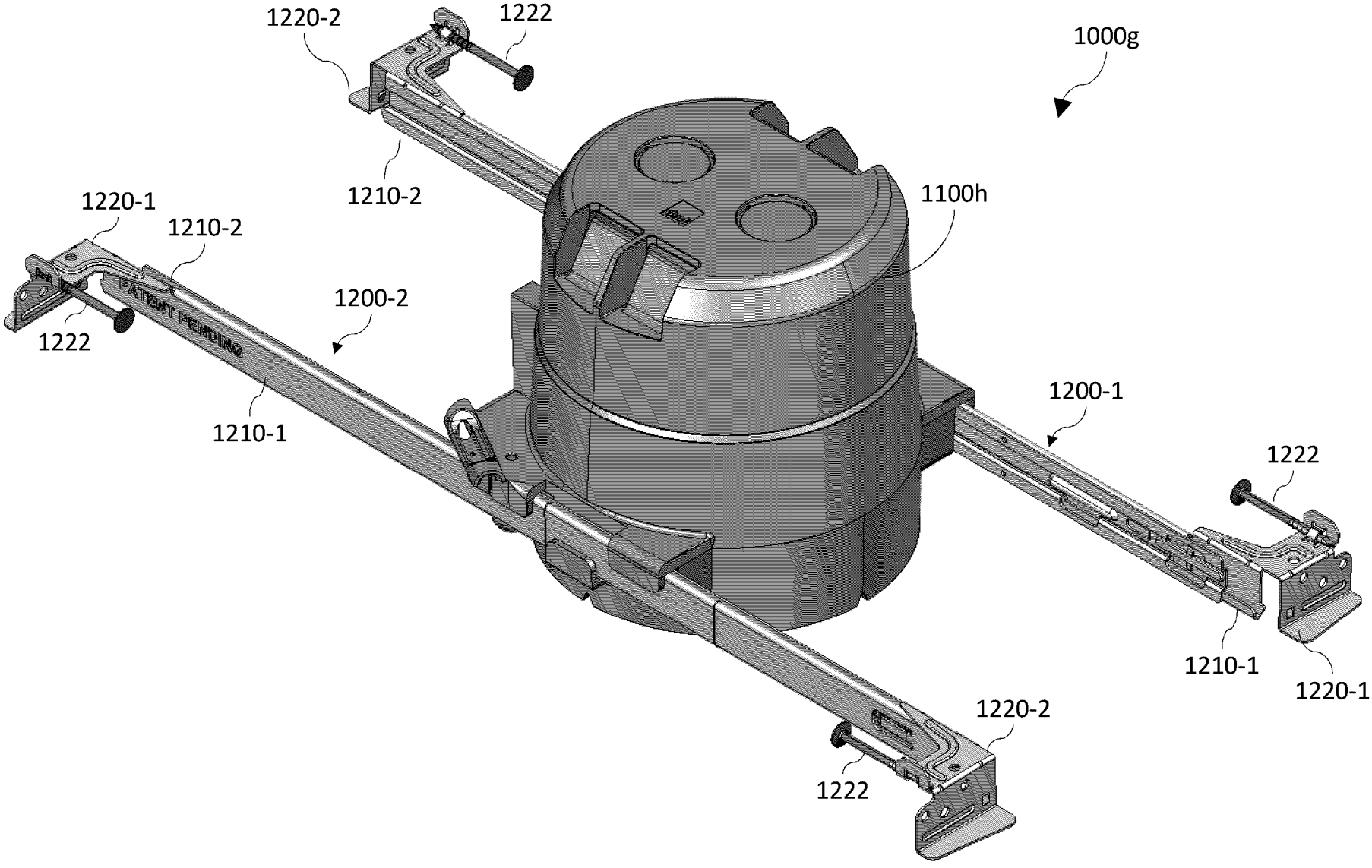



FIG. 19A

Date Reçue/Date Received 2021-07-16

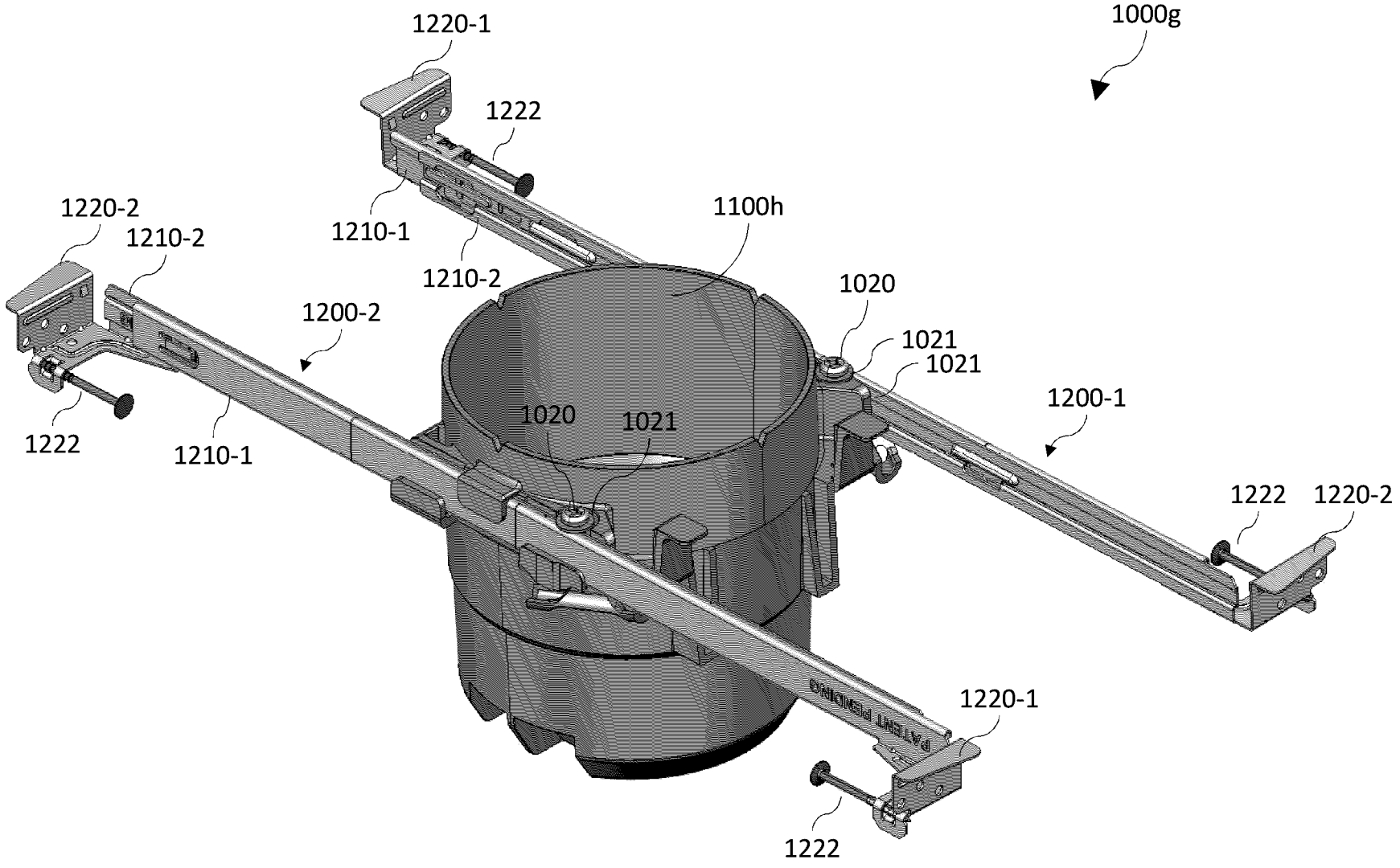



FIG. 19B

Date Reçue/Date Received 2021-07-16

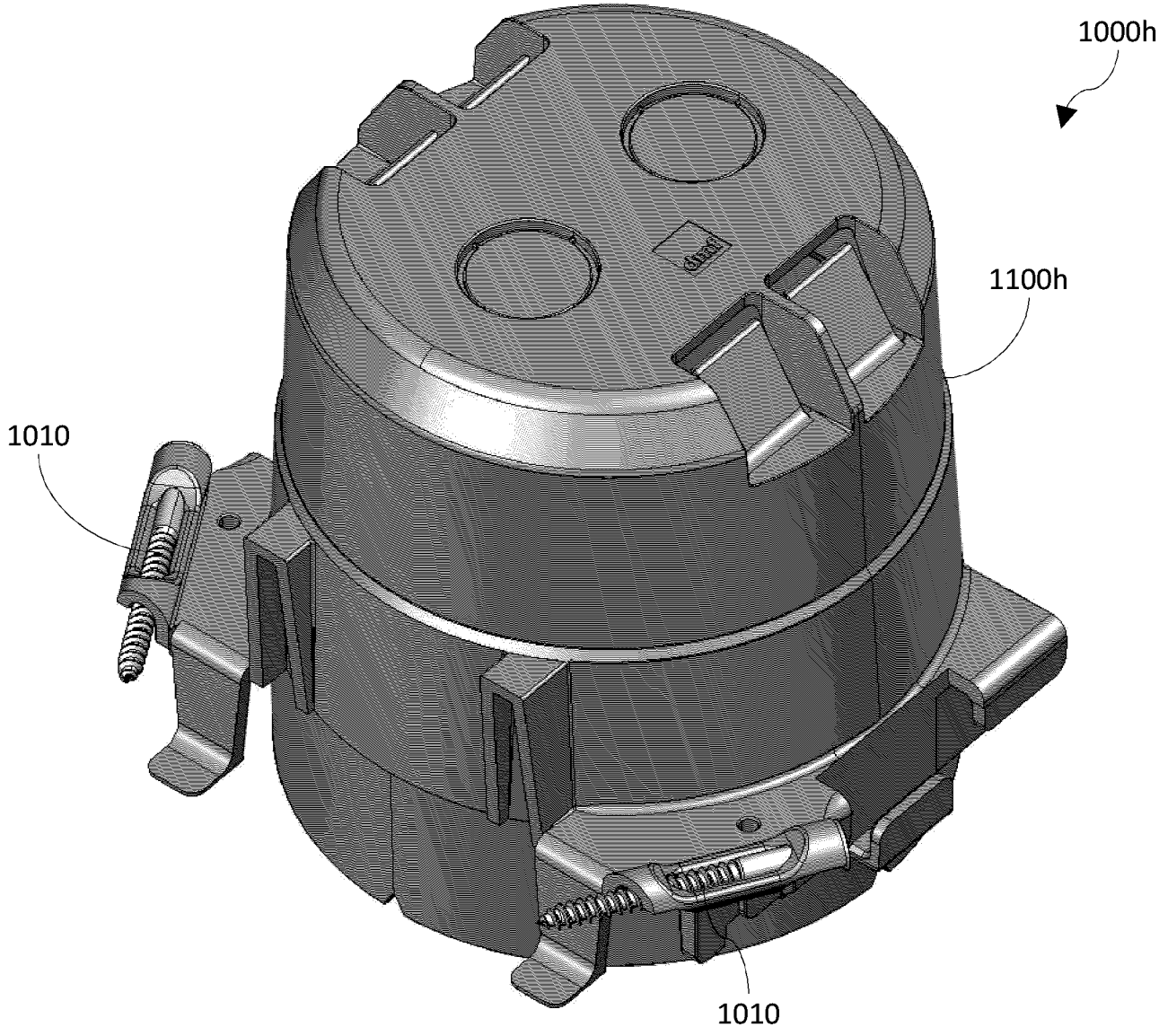



FIG. 20A

Date Reçue/Date Received 2021-07-16

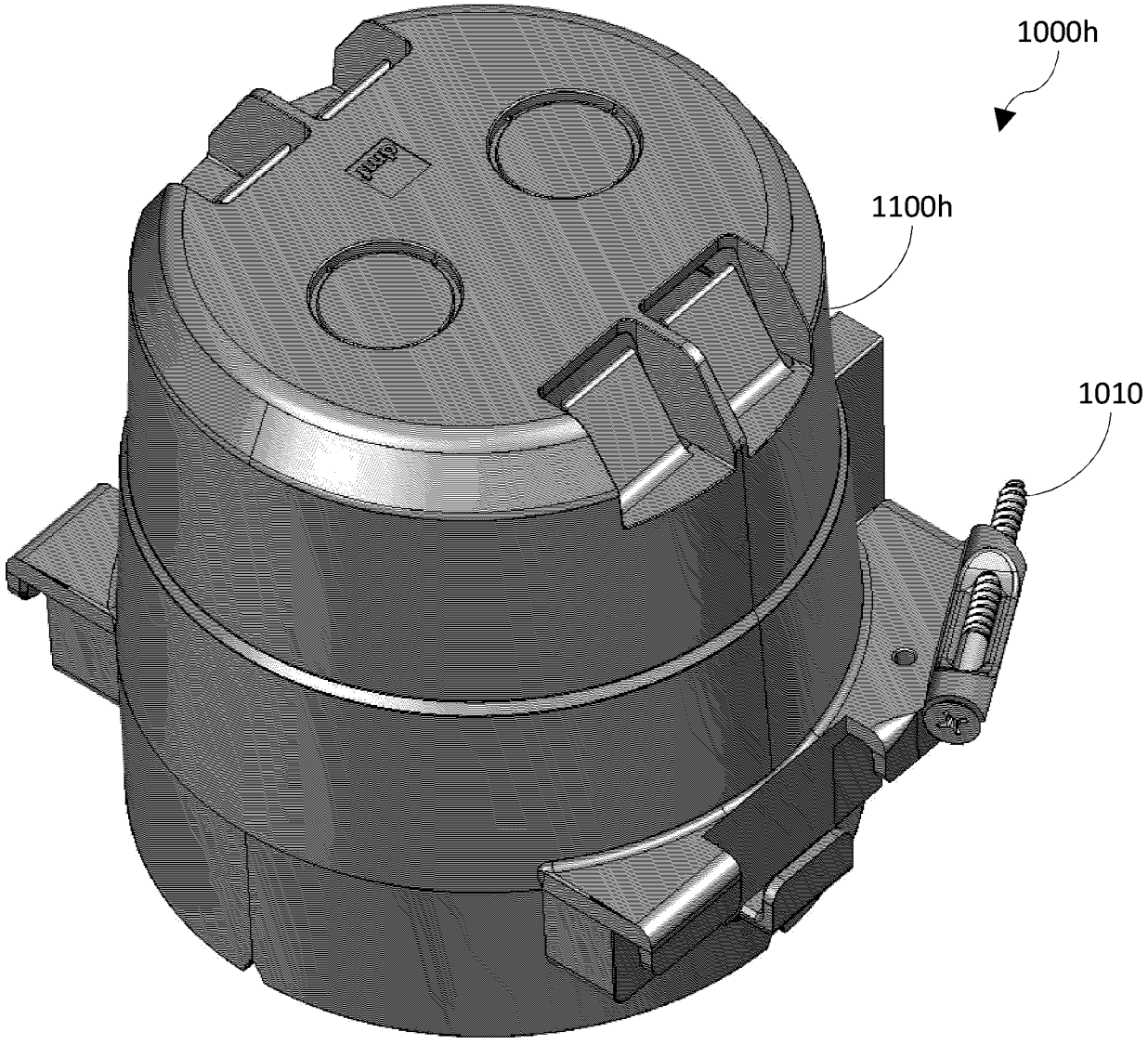



FIG. 20B

Date Reçue/Date Received 2021-07-16

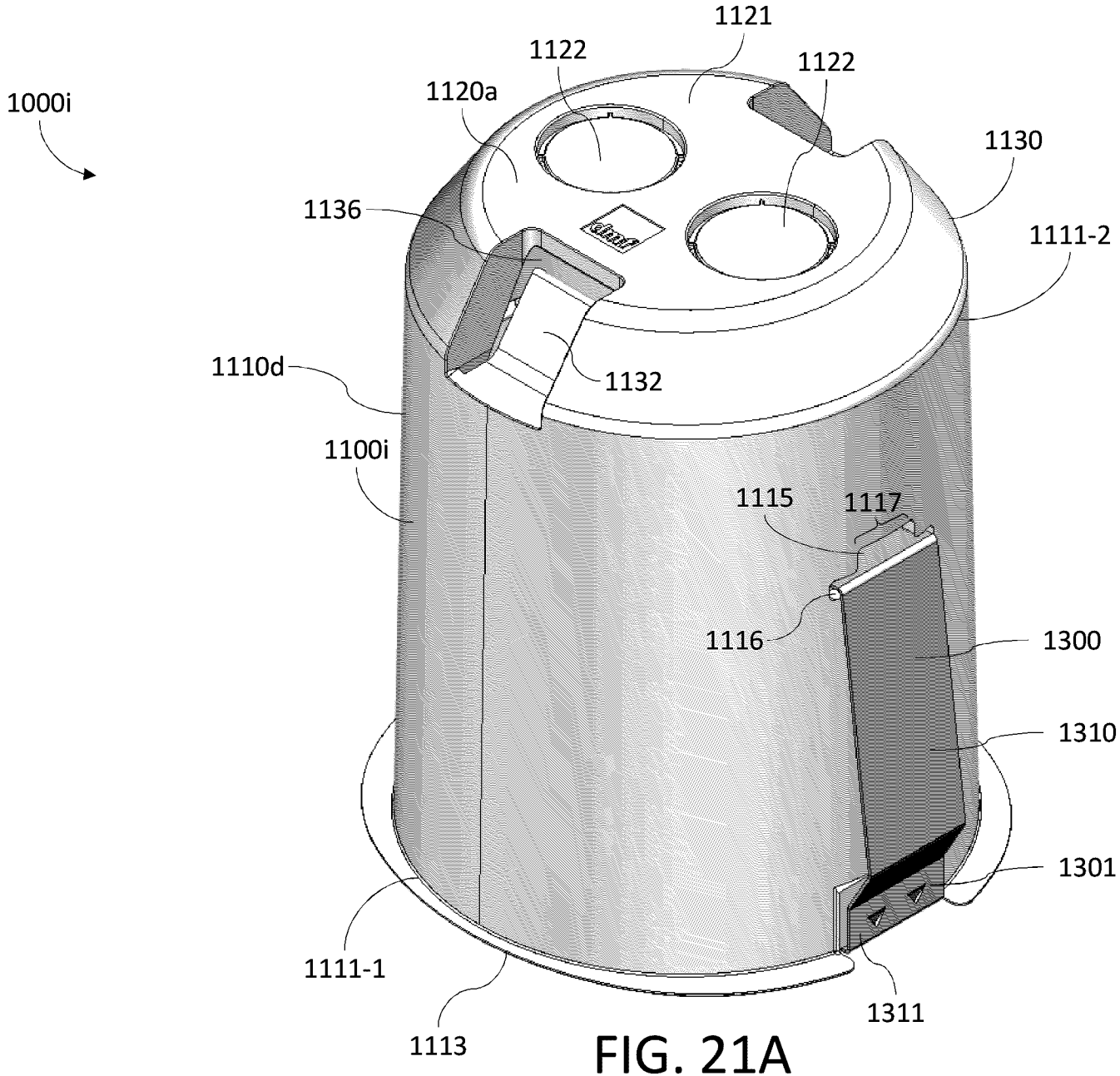



FIG. 21A

Date Reçue/Date Received 2021-07-16

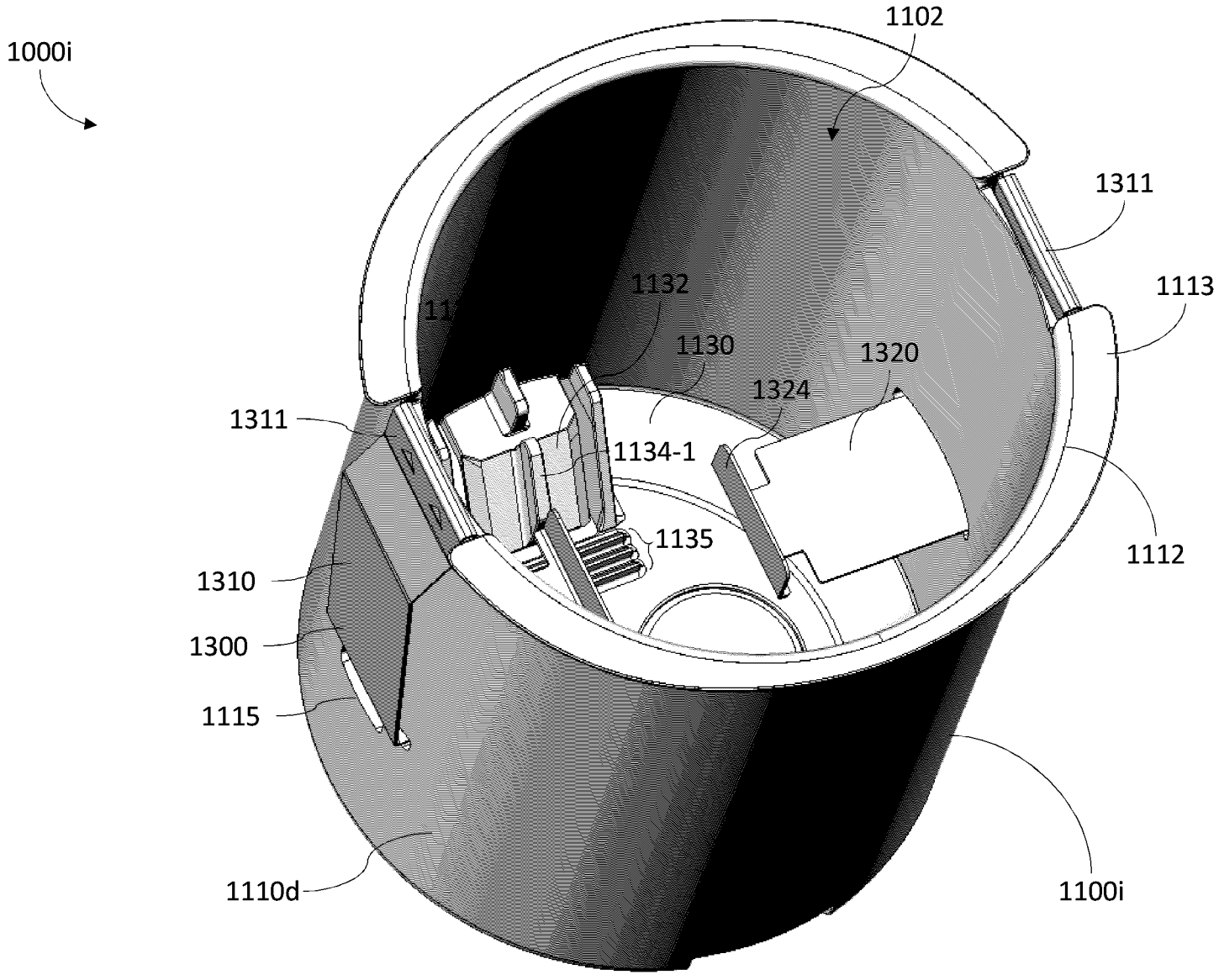



FIG. 21B

Date Reçue/Date Received 2021-07-16

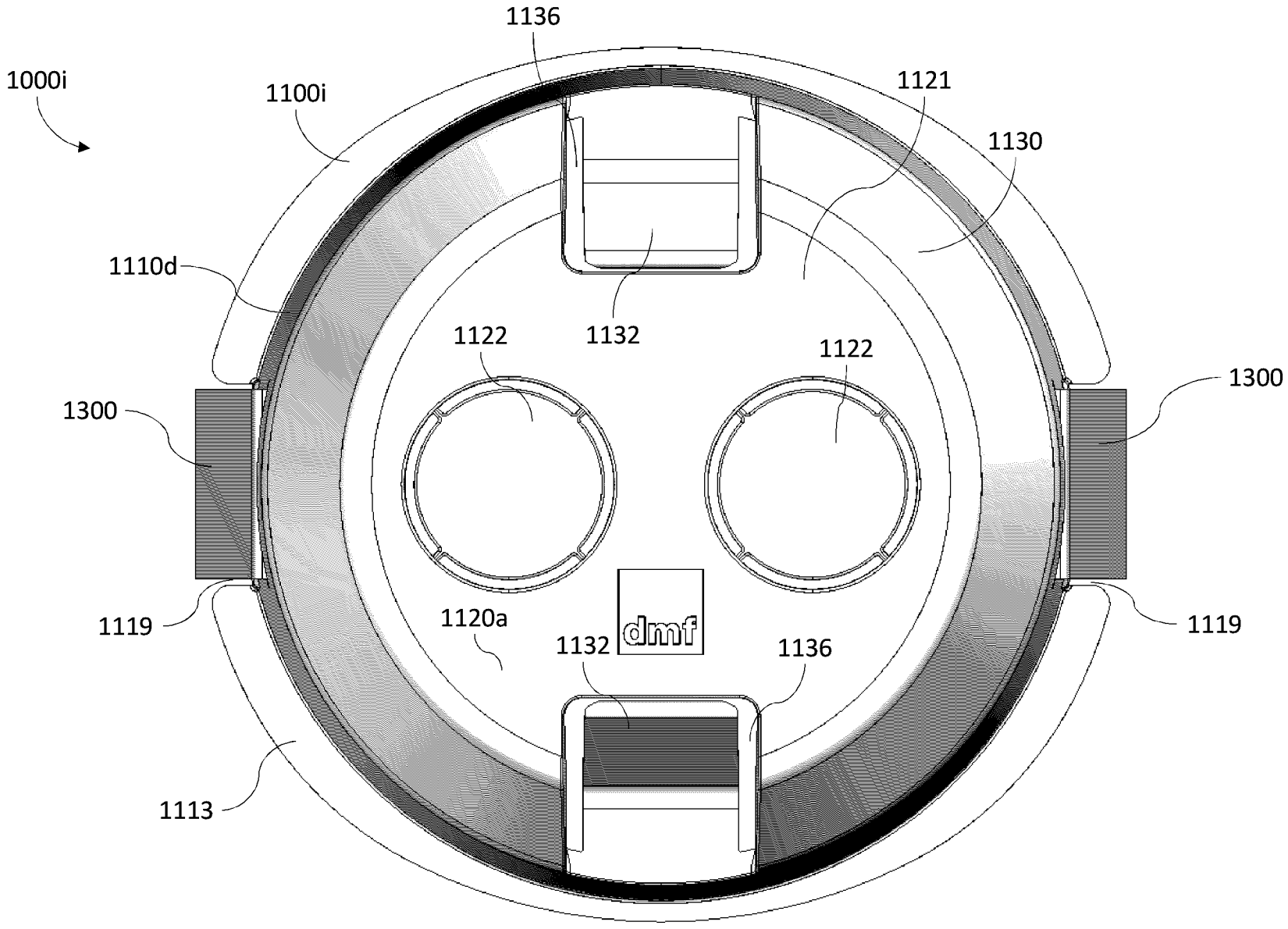



FIG. 21C

Date Reçue/Date Received 2021-07-16

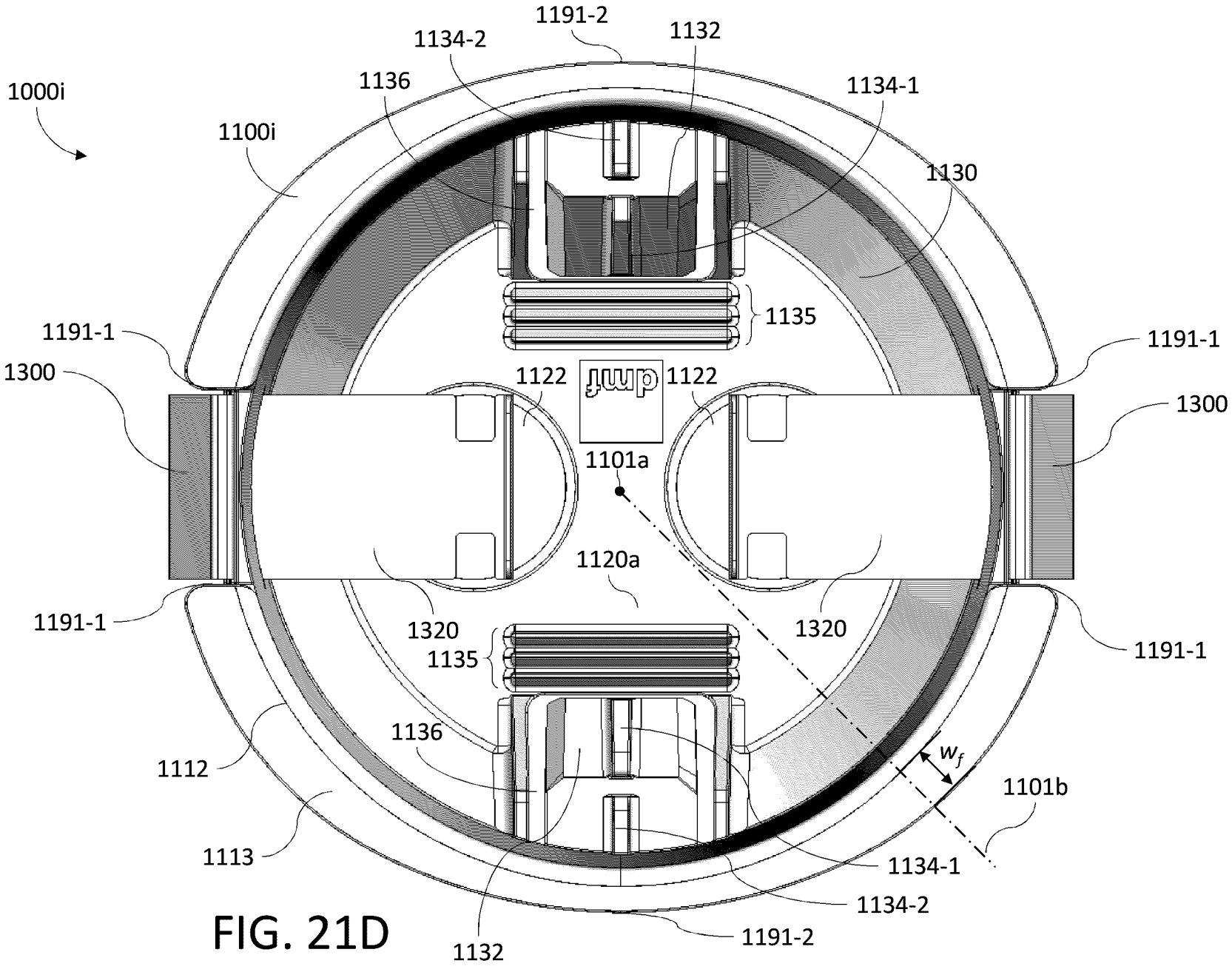



FIG. 21D

Date Reçue/Date Received 2021-07-16

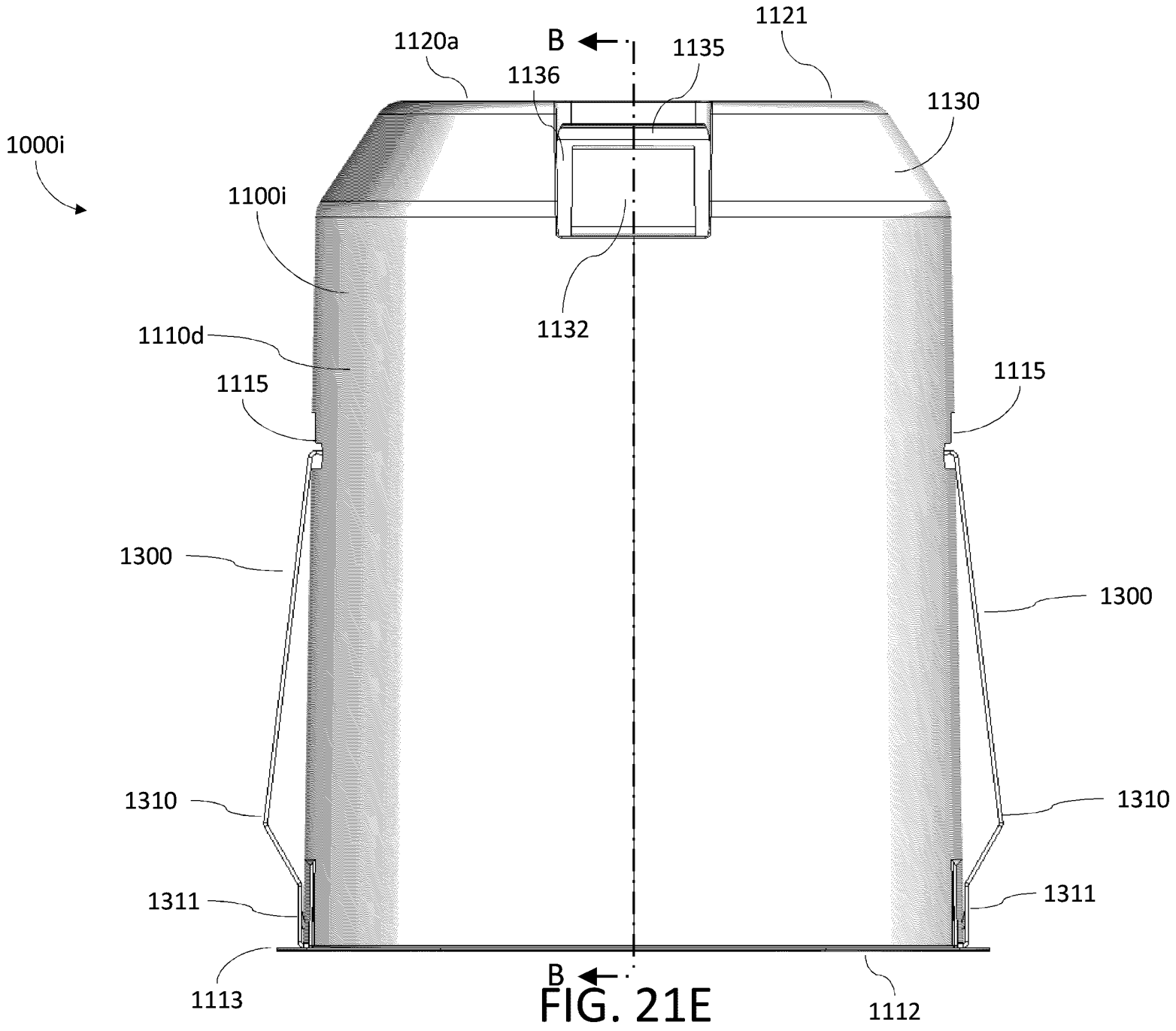



FIG. 21E

Date Reçue/Date Received 2021-07-16

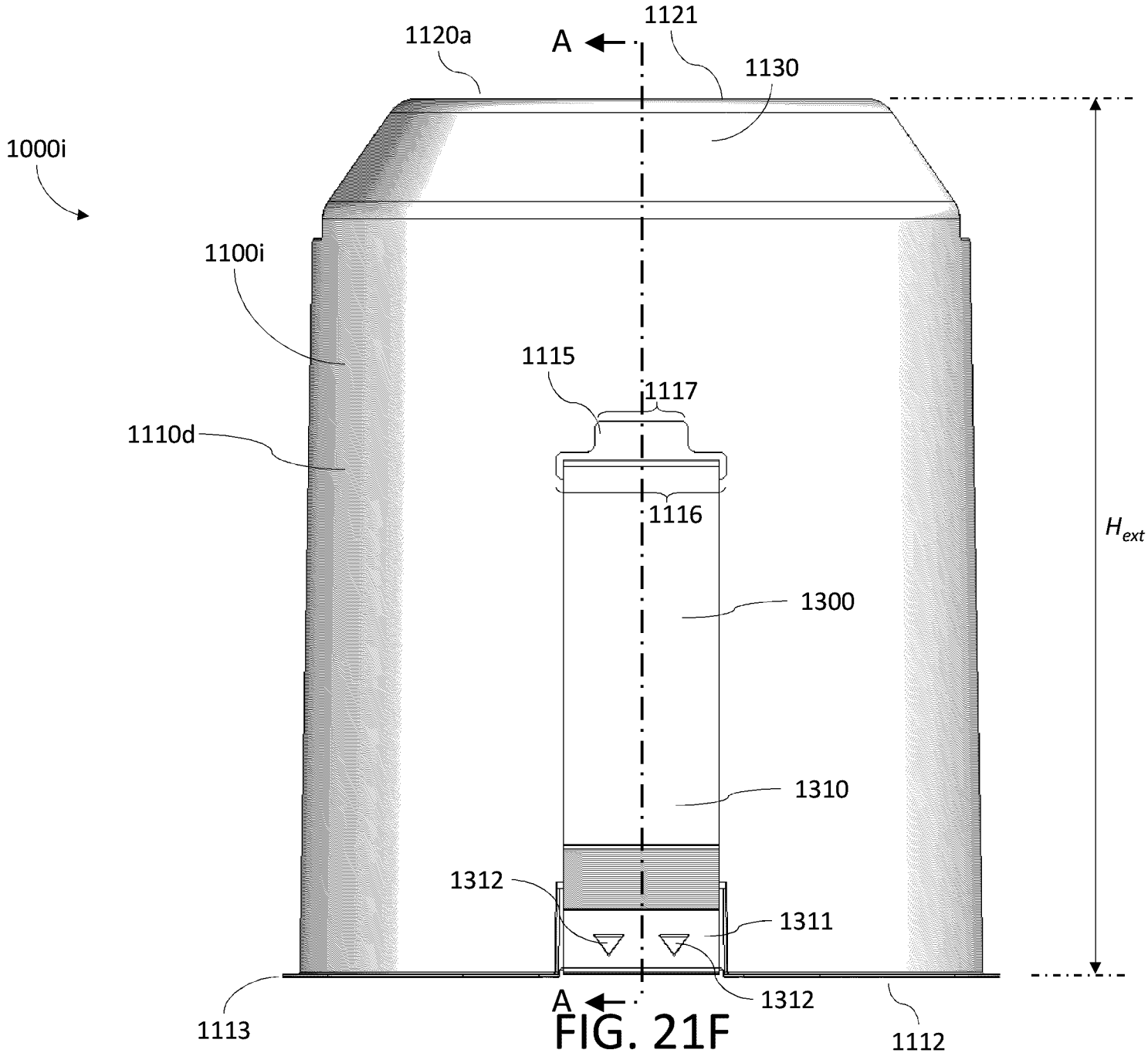



FIG. 21F

Date Reçue/Date Received 2021-07-16

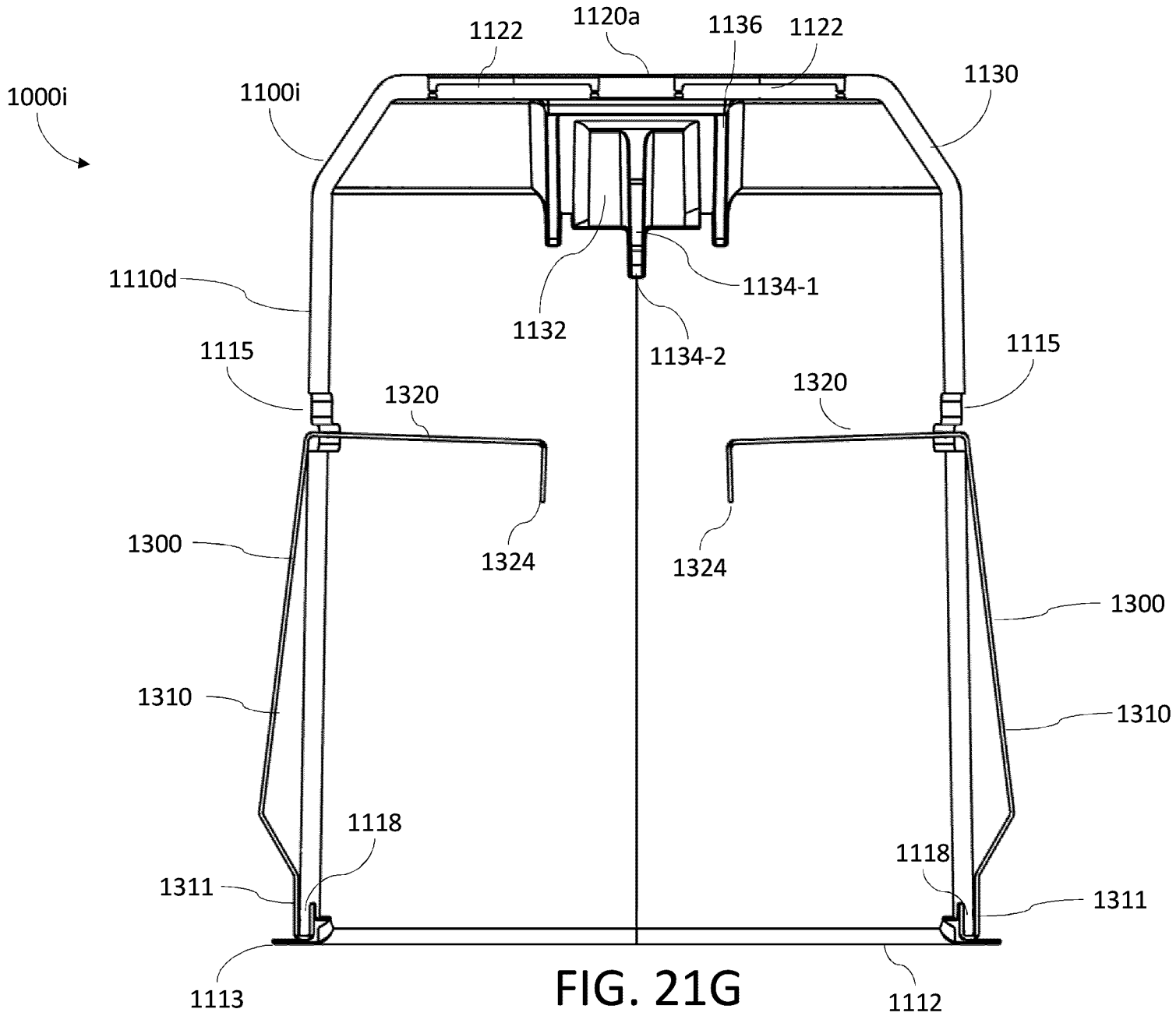



FIG. 21G

Date Reçue/Date Received 2021-07-16

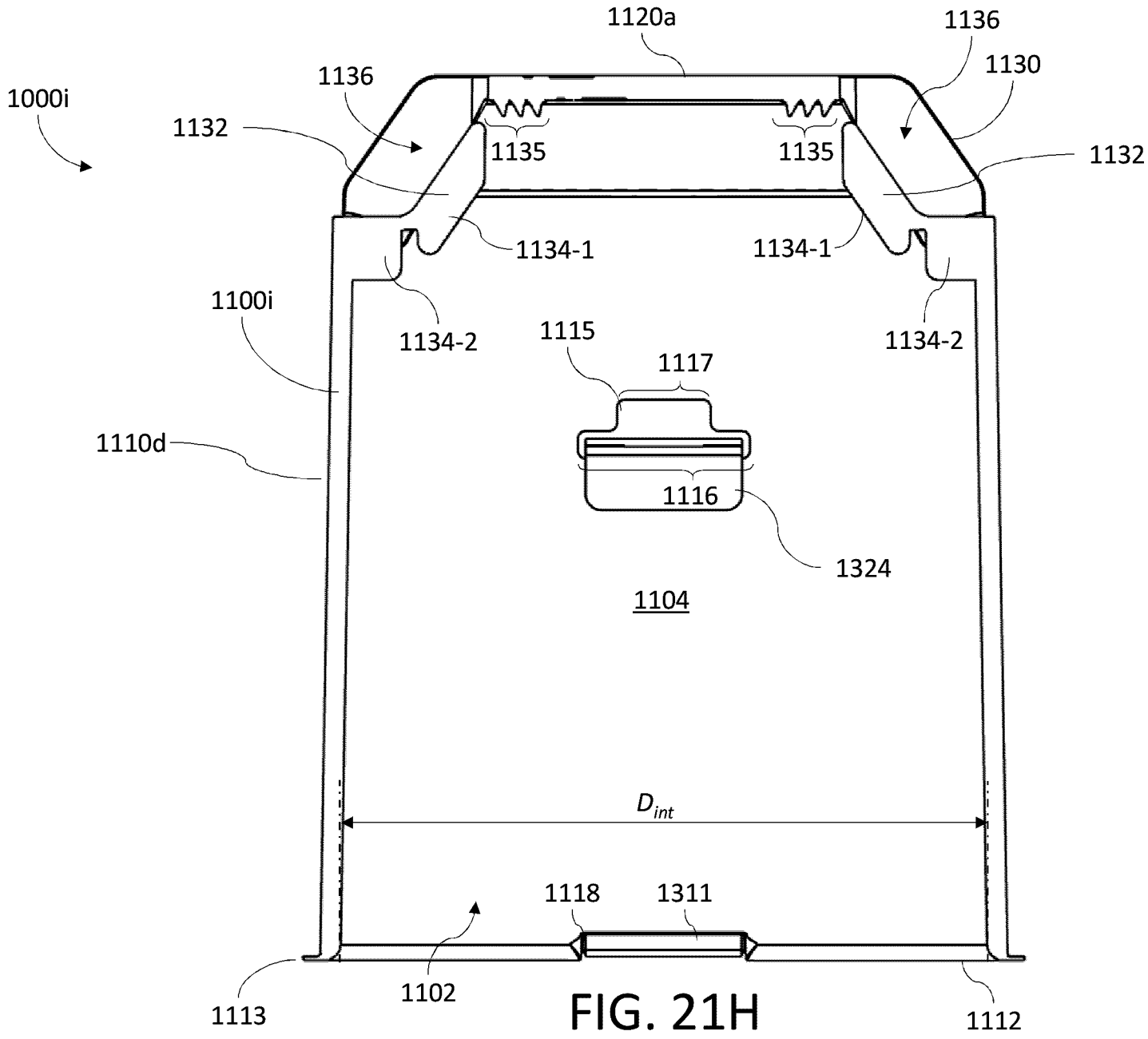



FIG. 21H

Date Reçue/Date Received 2021-07-16

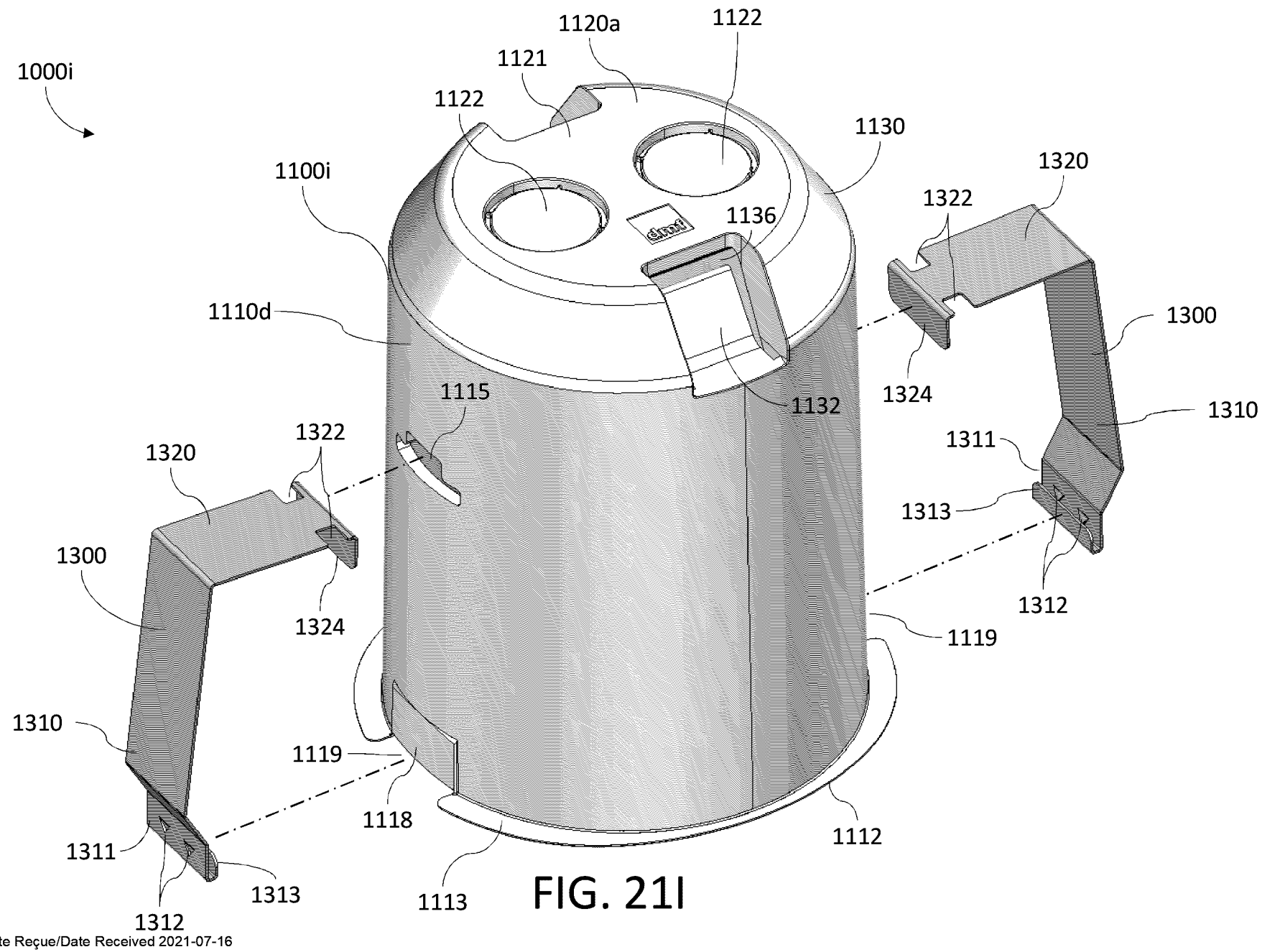



FIG. 21I

Date Reçue/Date Received 2021-07-16

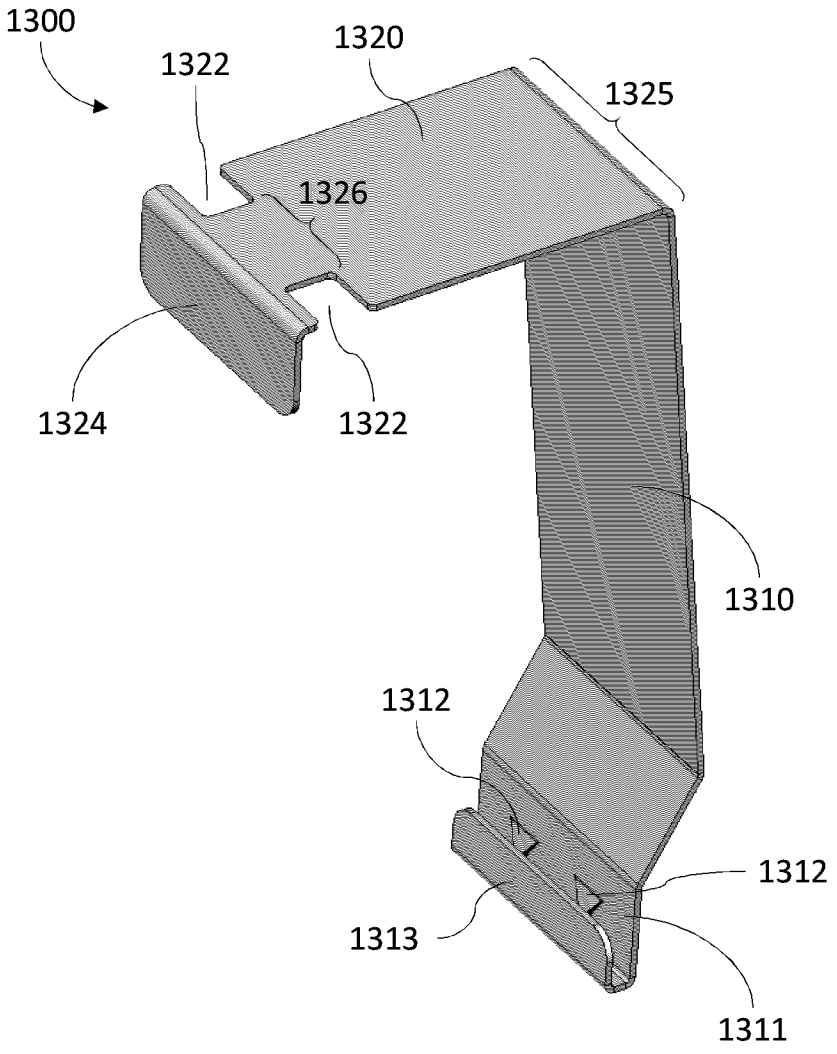



FIG. 22A

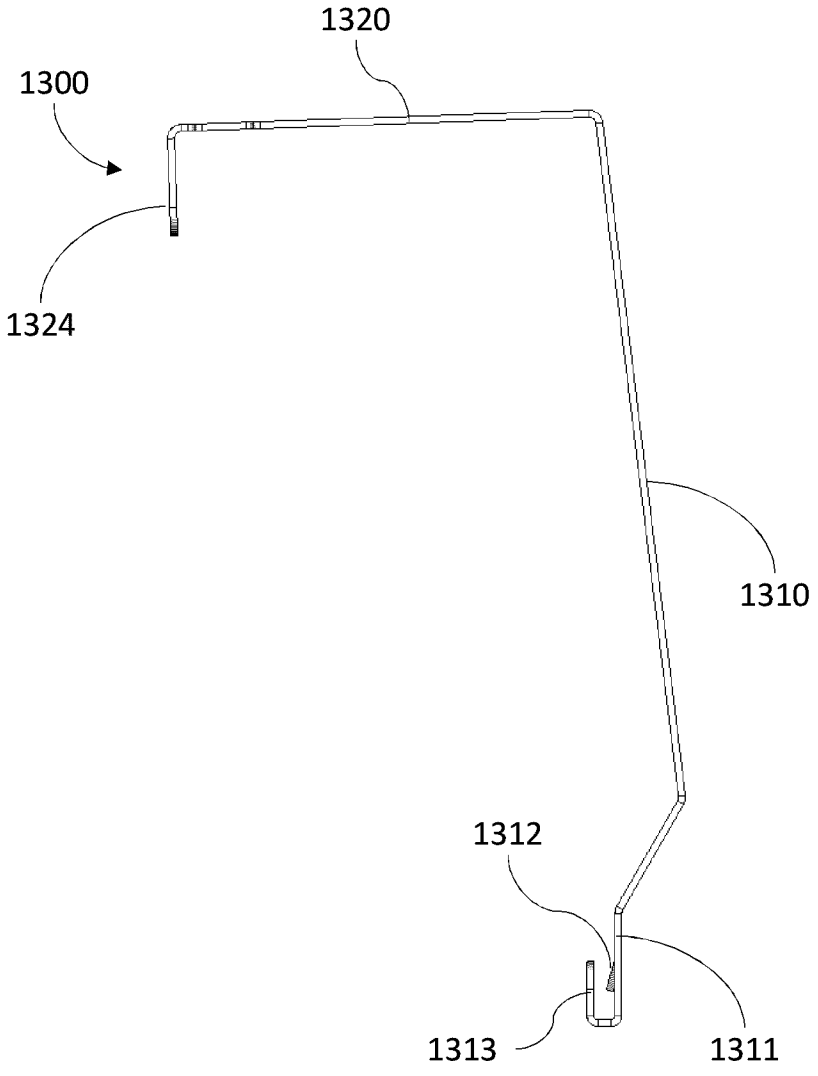



FIG. 22B

Date Reçue/Date Received 2021-07-16

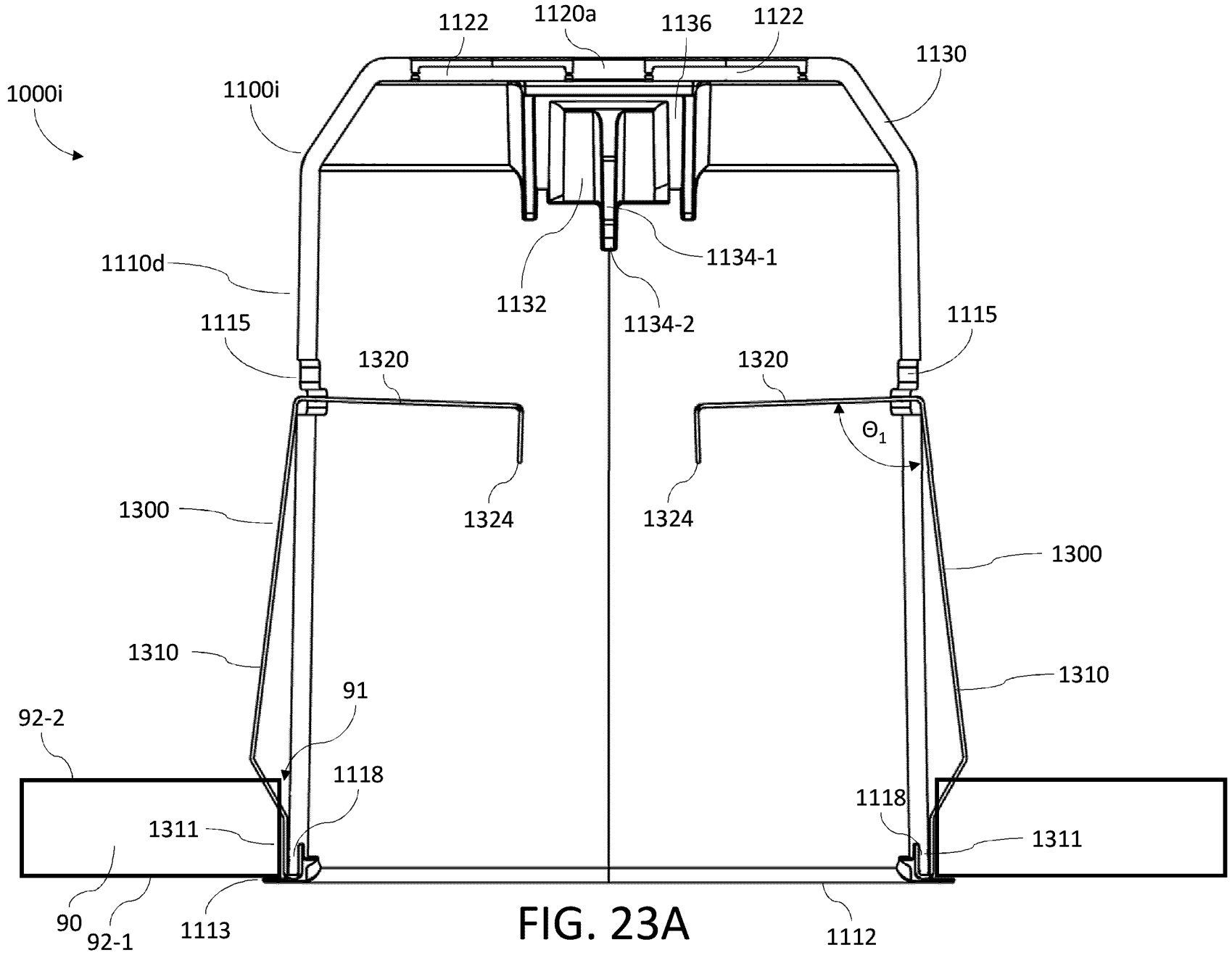



FIG. 23A

Date Reçue/Date Received 2021-07-16

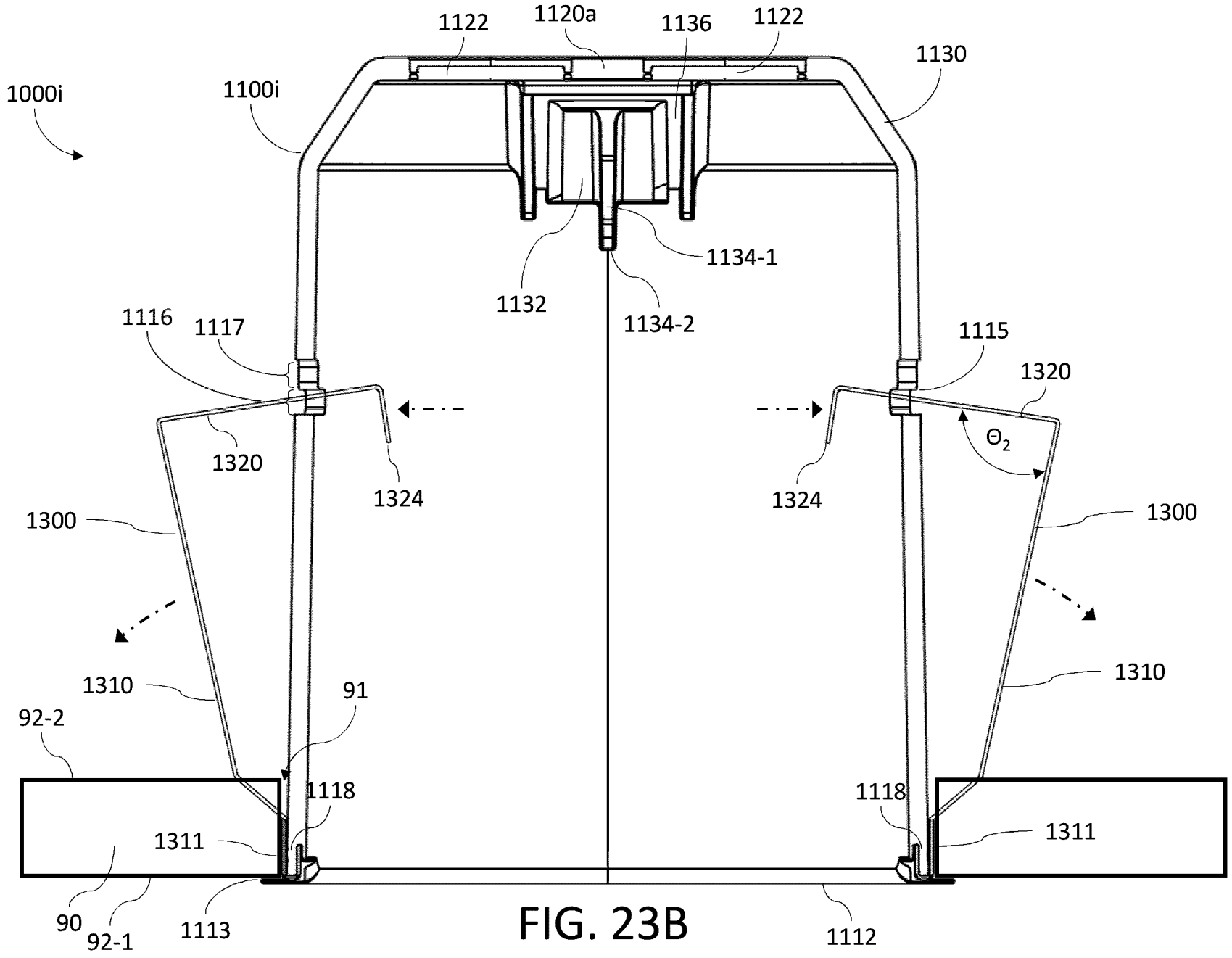



FIG. 23B

Date Reçue/Date Received 2021-07-16

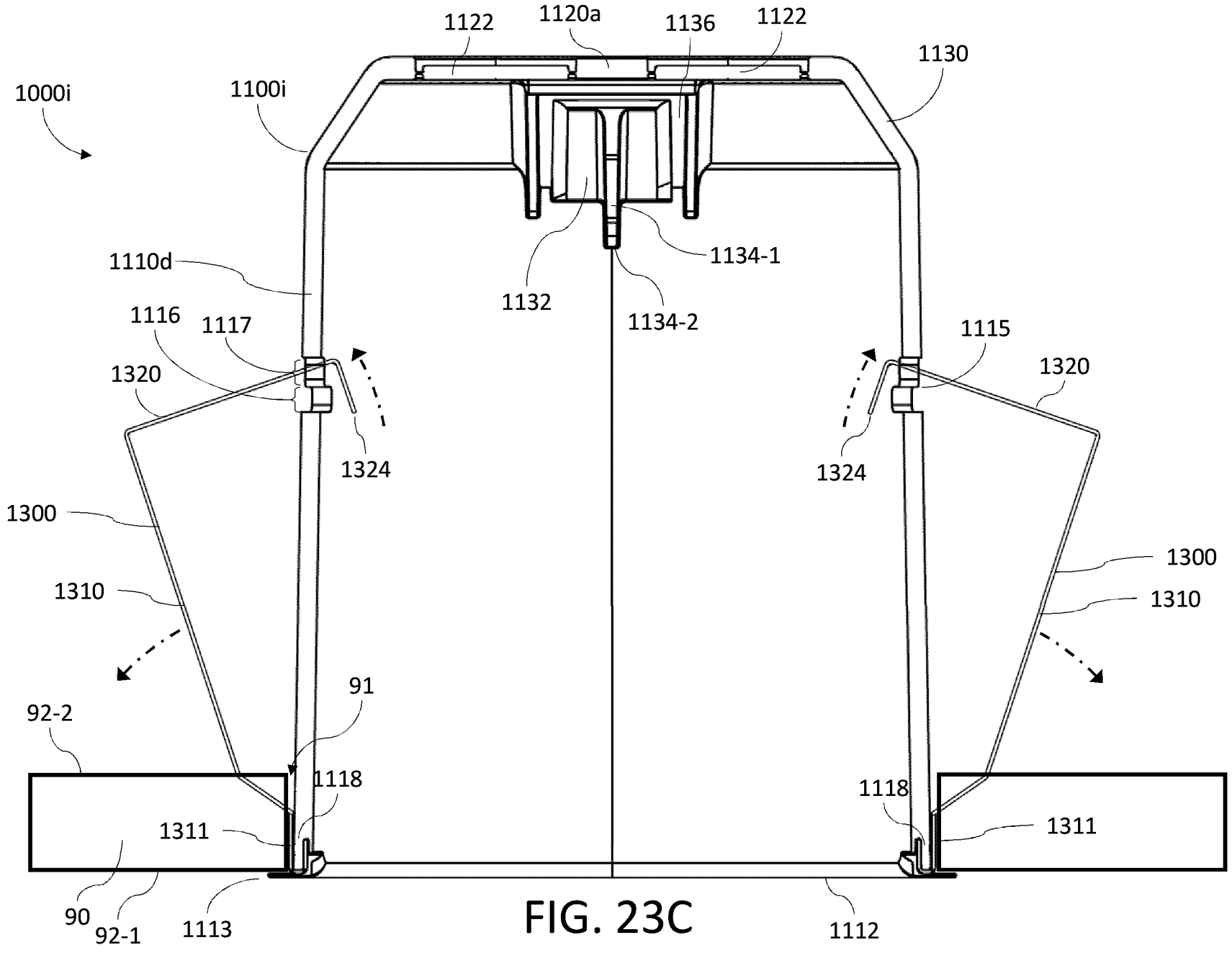



FIG. 23C

Date Reçue/Date Received 2021-07-16

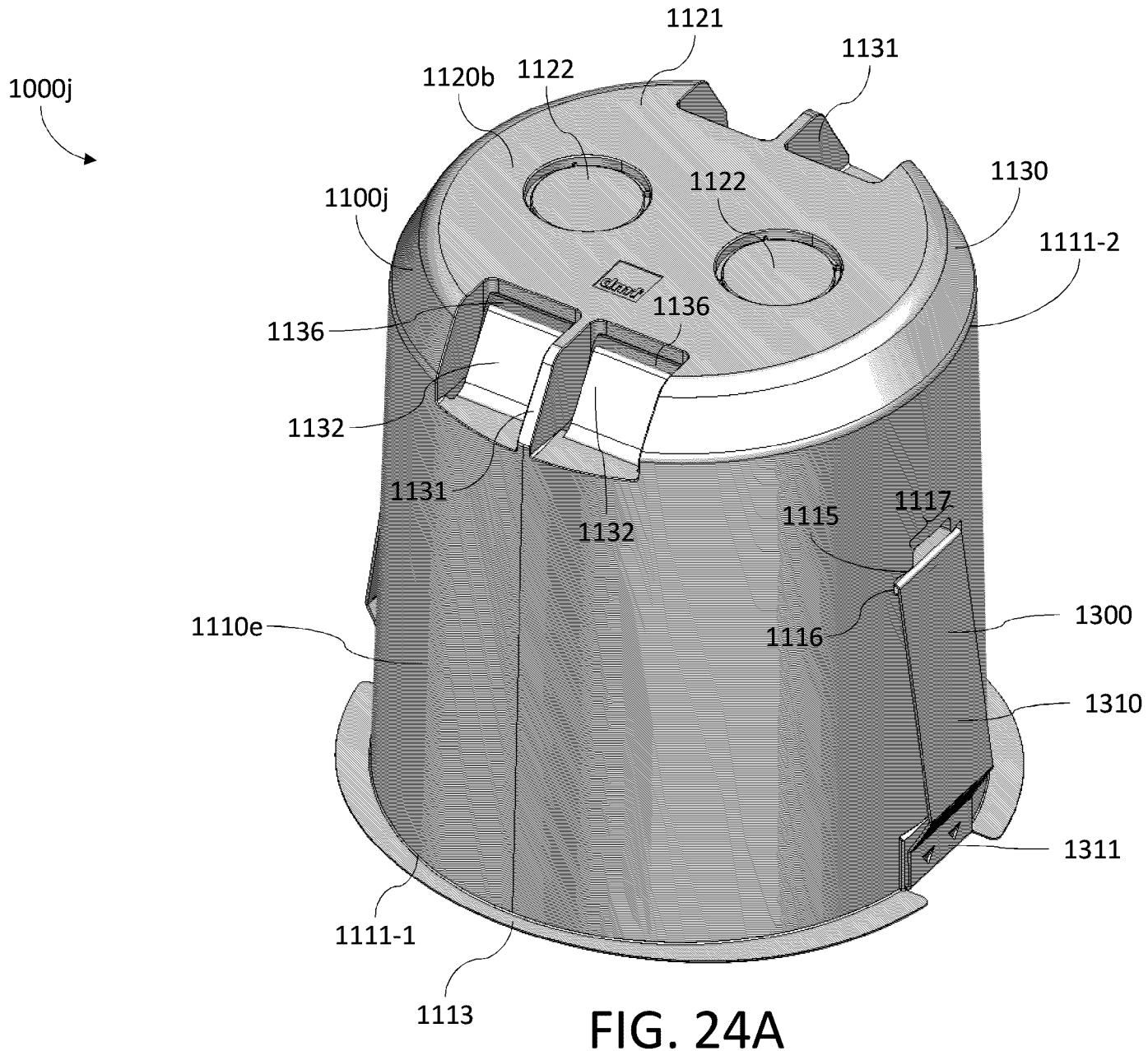



FIG. 24A

Date Reçue/Date Received 2021-07-16

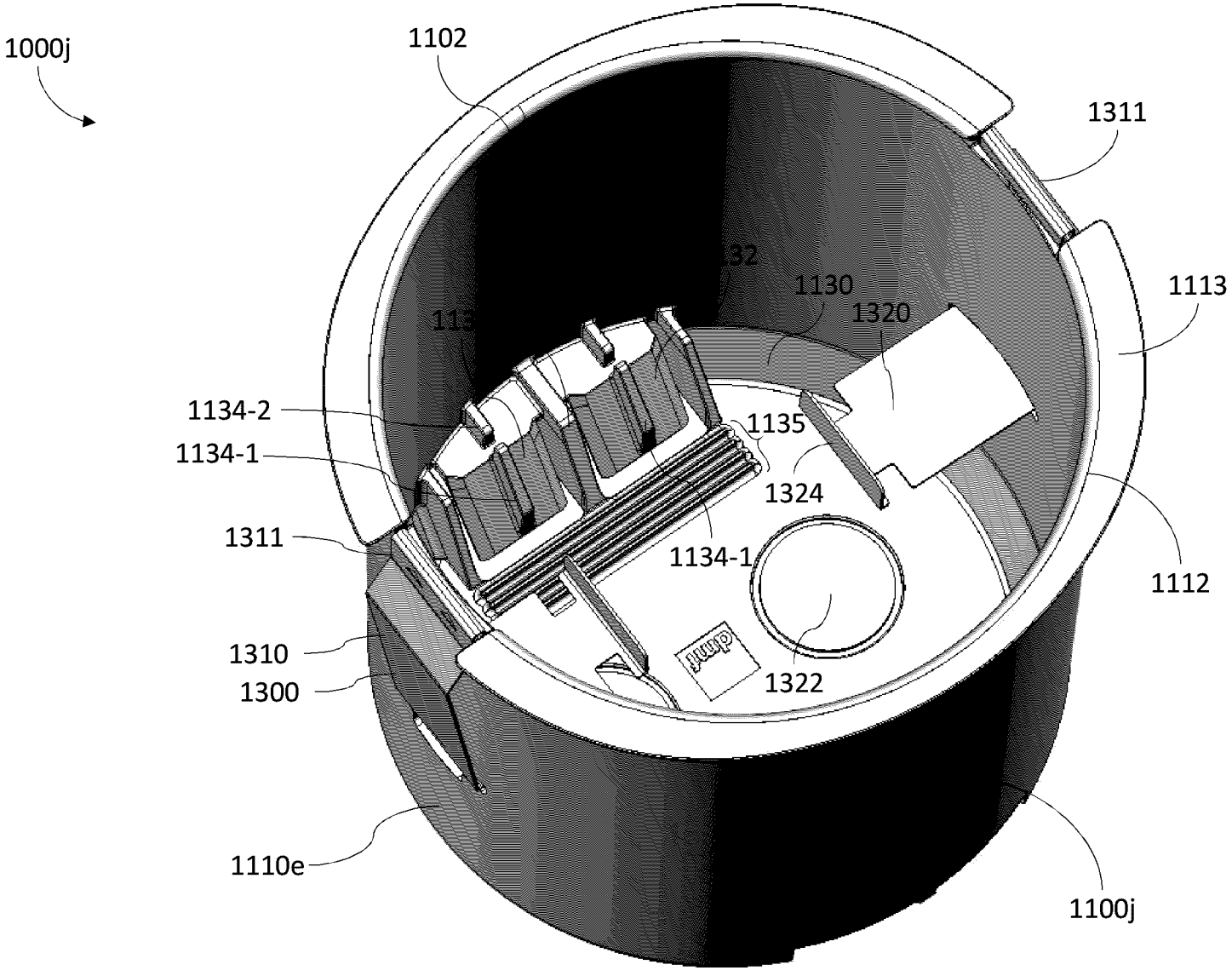



FIG. 24B

Date Reçue/Date Received 2021-07-16

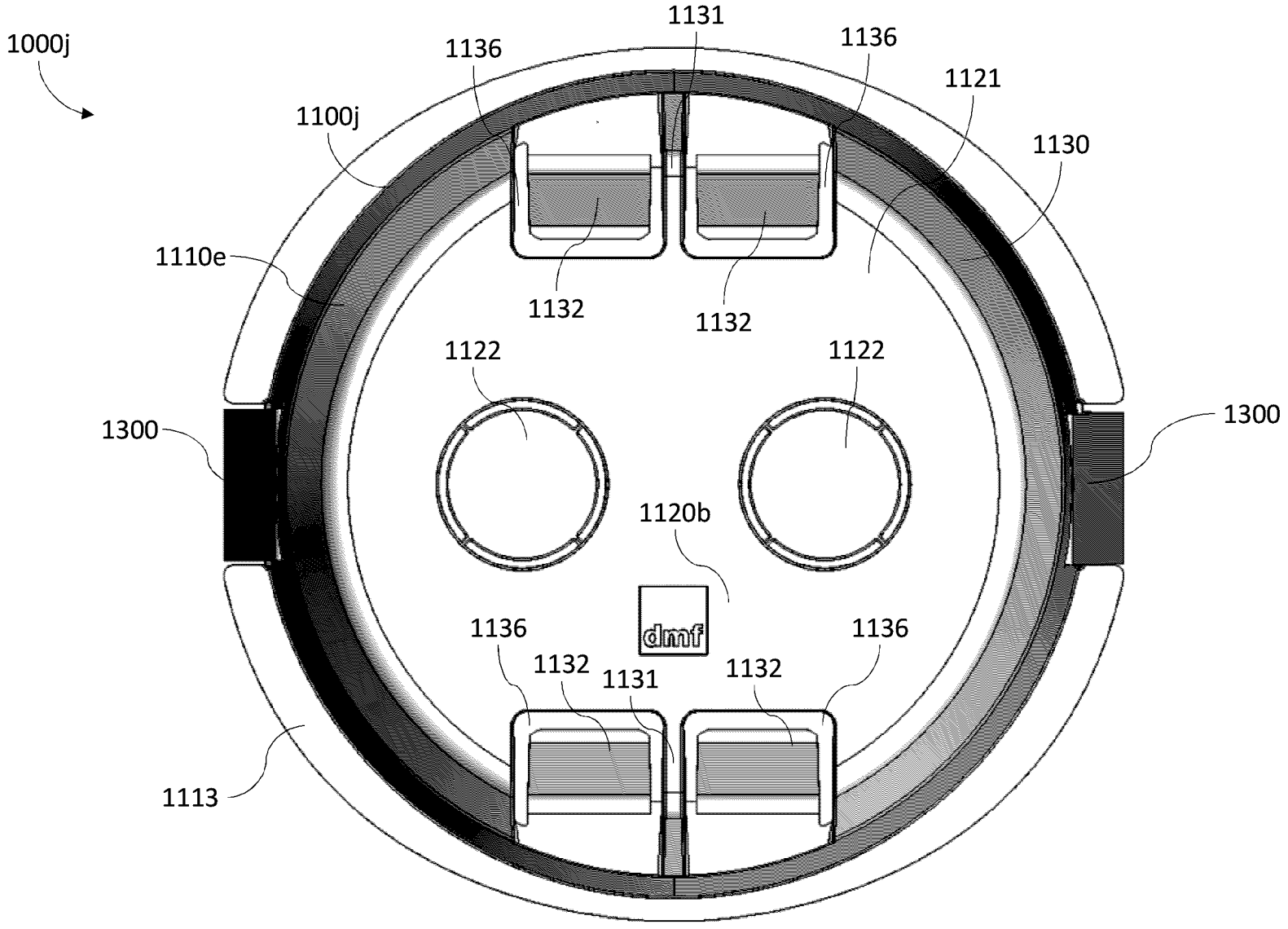



FIG. 24C

Date Reçue/Date Received 2021-07-16

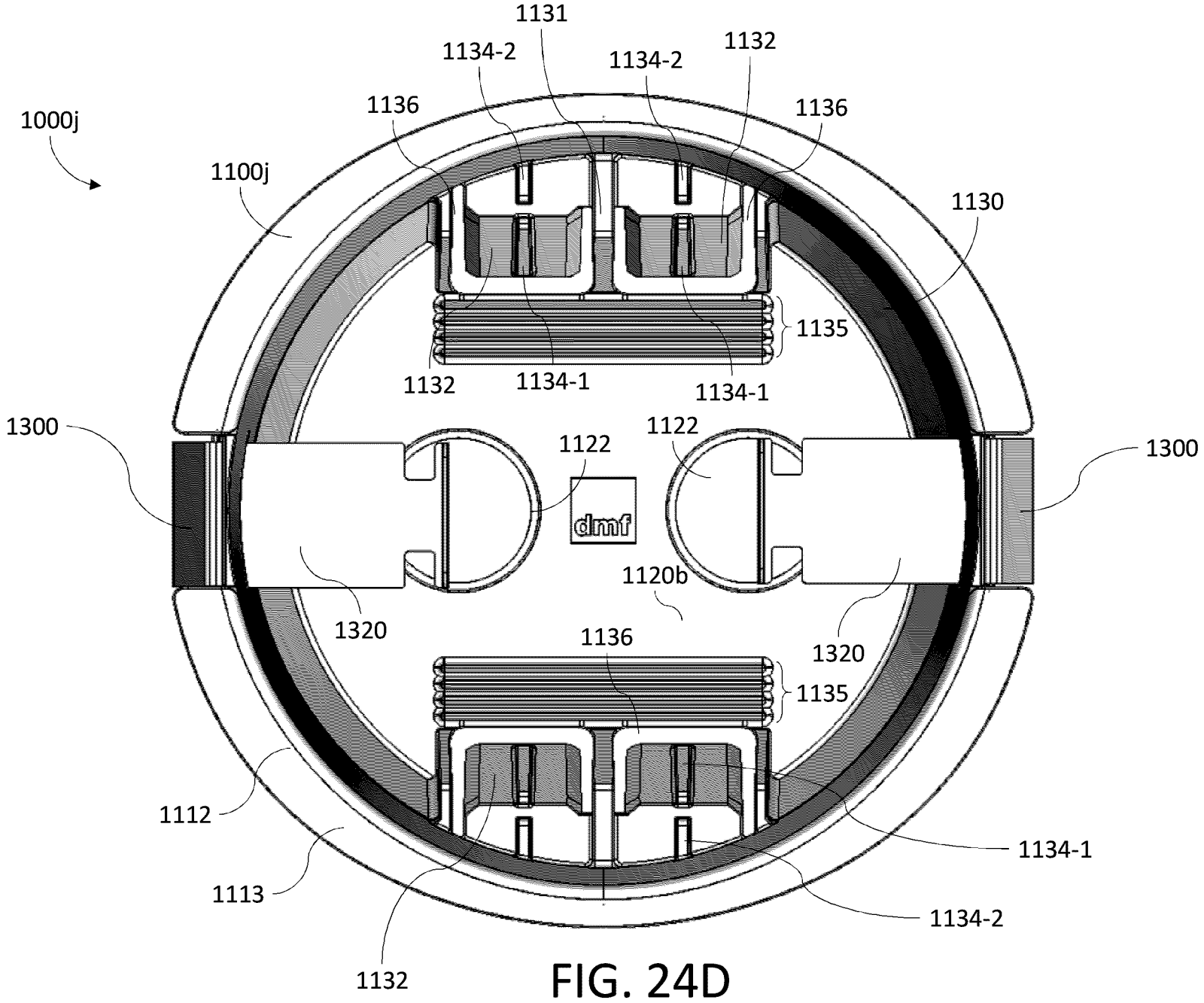



FIG. 24D

Date Reçue/Date Received 2021-07-16

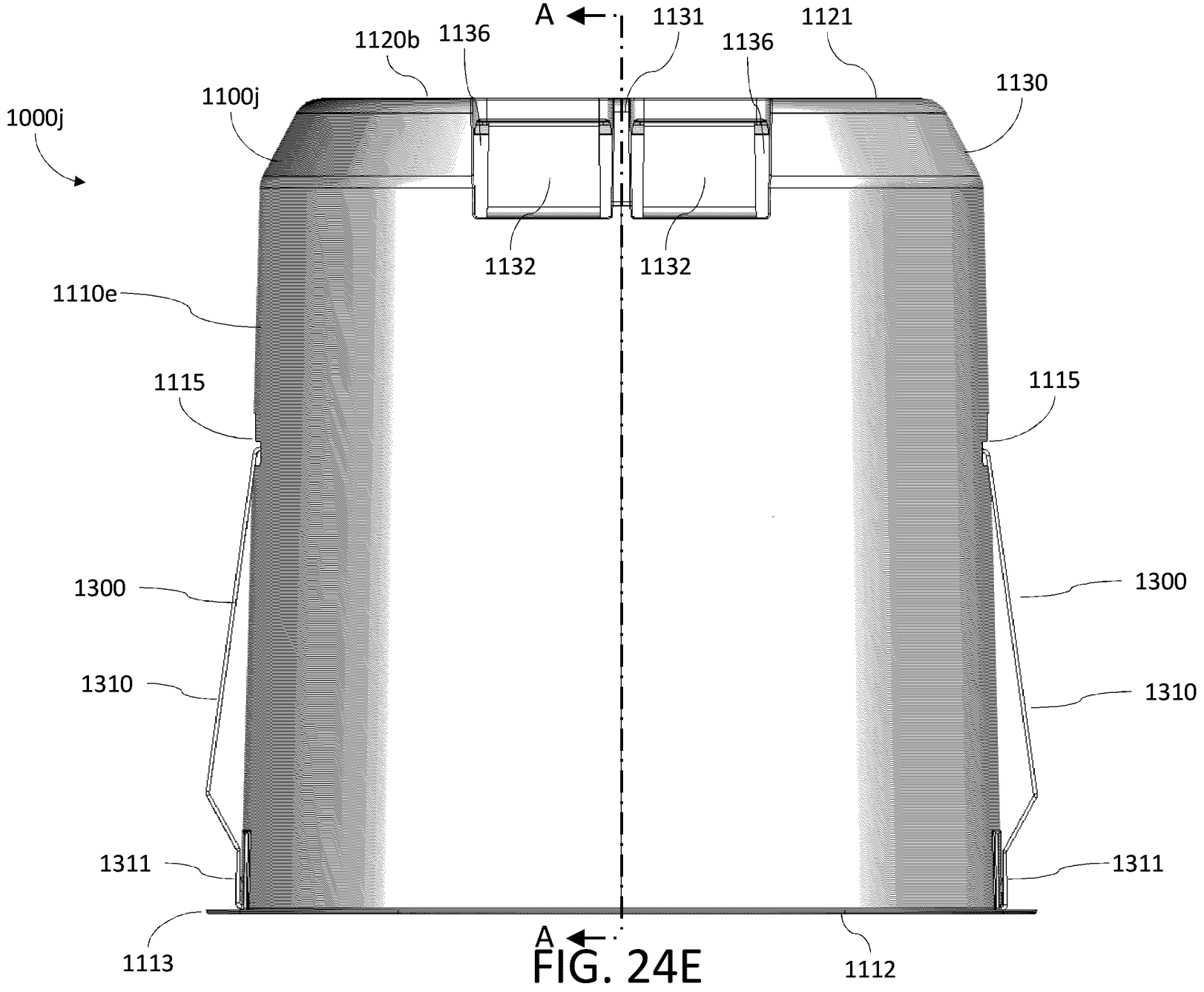



FIG. 24E

Date Reçue/Date Received 2021-07-16

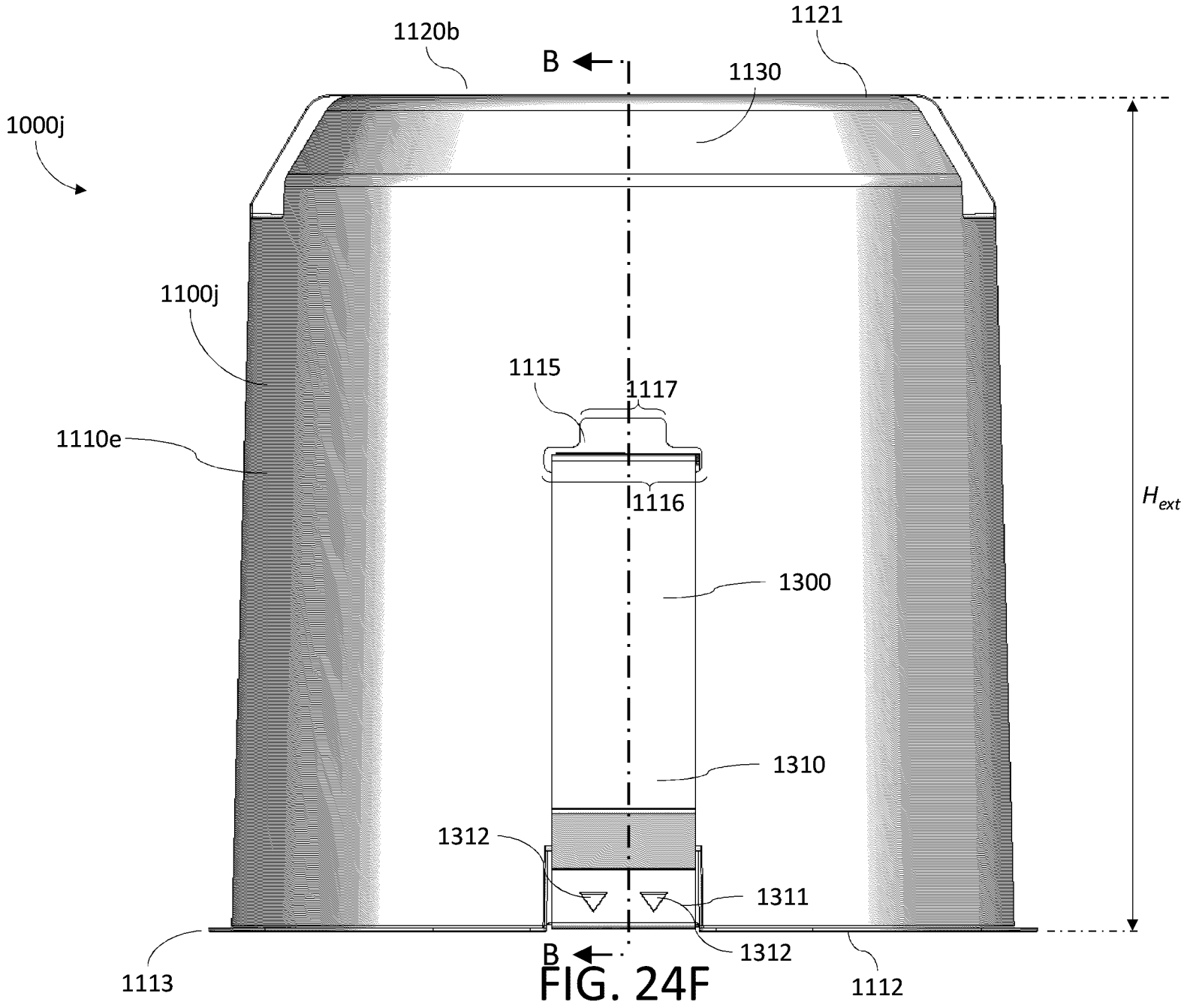



FIG. 24F

Date Reçue/Date Received 2021-07-16

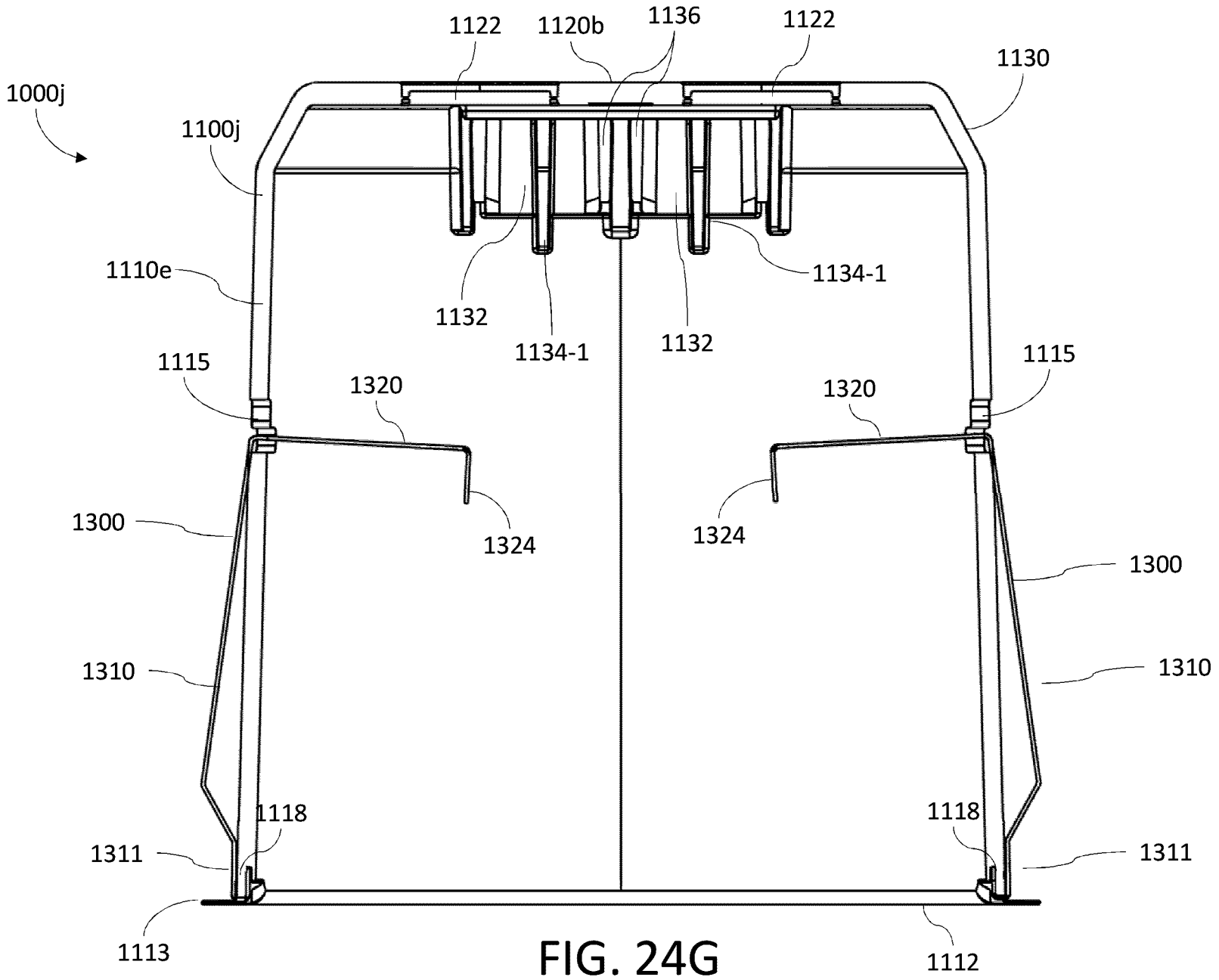



FIG. 24G

Date Reçue/Date Received 2021-07-16

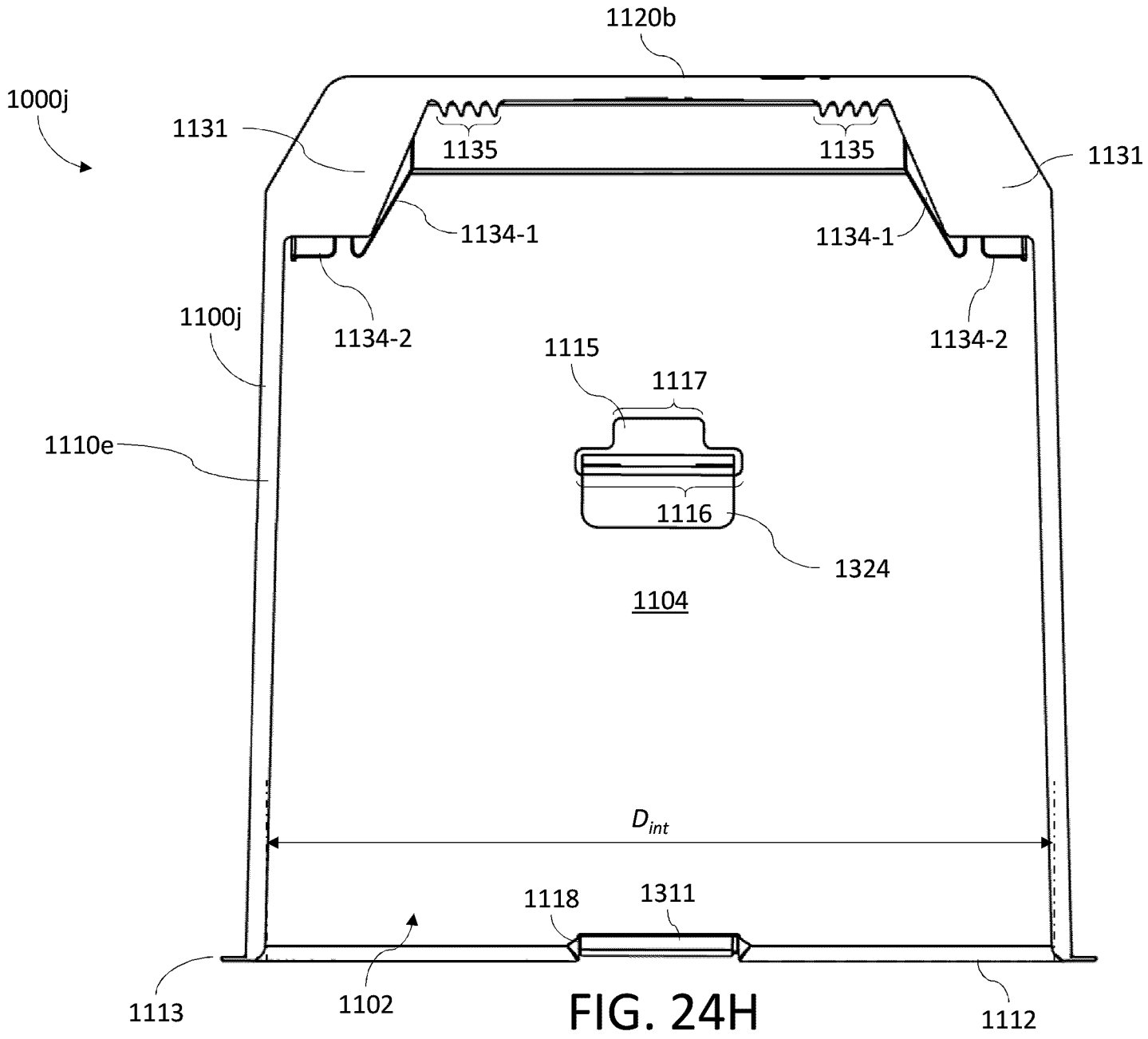



FIG. 24H

Date Reçue/Date Received 2021-07-16

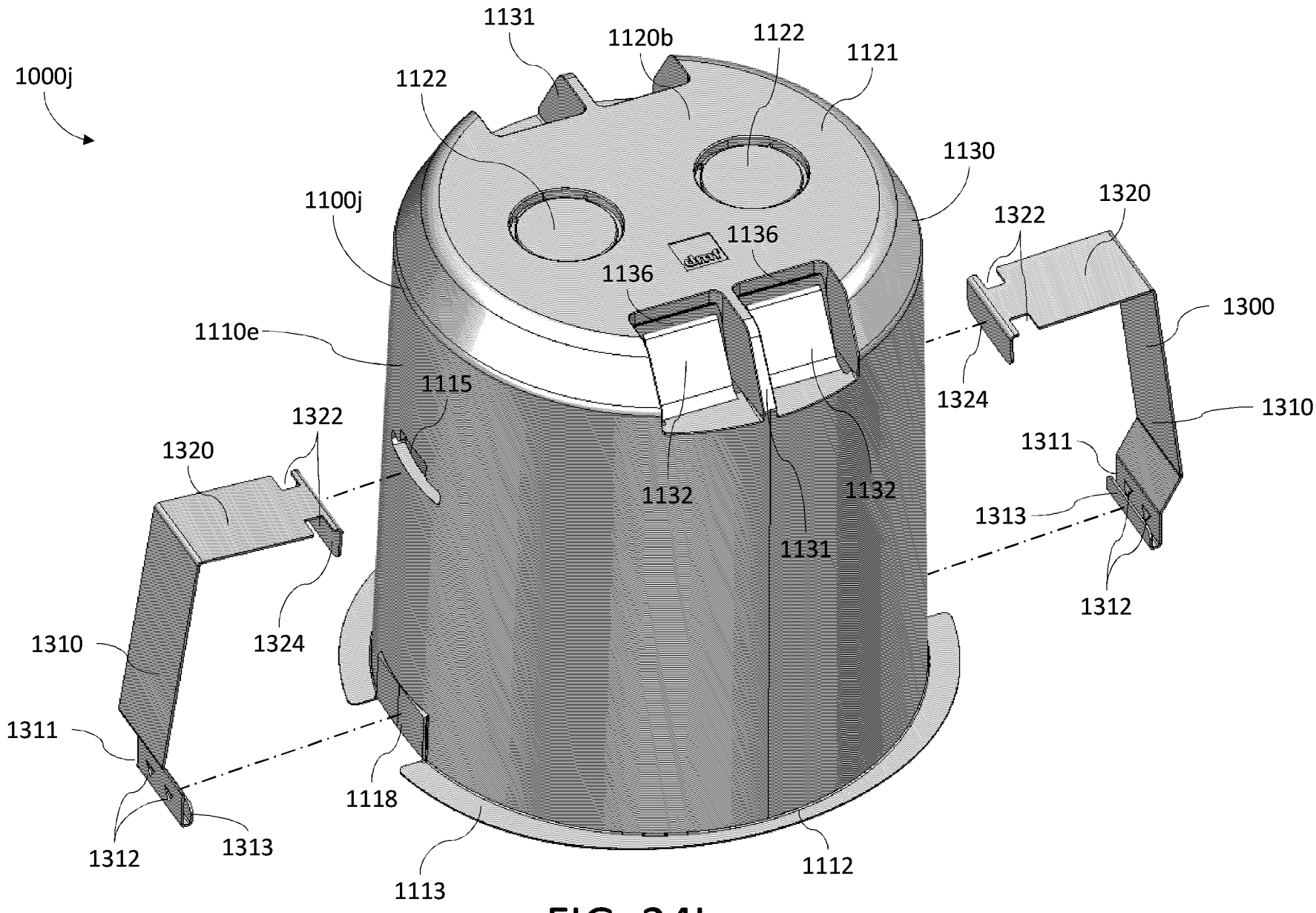
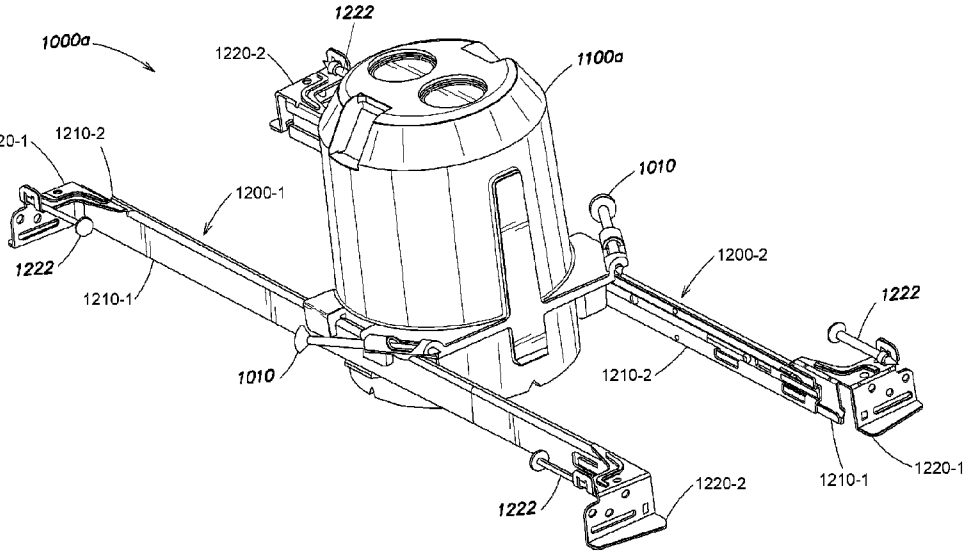



FIG. 24I

Date Reçue/Date Received 2021-07-16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1210-1
1222
1220-2