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Laine et al.

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(54) **RENEWABLE ENERGY GENERATING CLADDING**

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H02S 50/00	(2014.01)
H02S 40/34	(2014.01)
H02S 40/38	(2014.01)

(52) **U.S. Cl.**
CPC ***H02S 20/26*** (2014.12); ***H02S 40/34*** (2014.12); ***H02S 40/36*** (2014.12); ***H02S 40/38*** (2014.12); ***H02S 50/00*** (2013.01)

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CPC H02S 20/26
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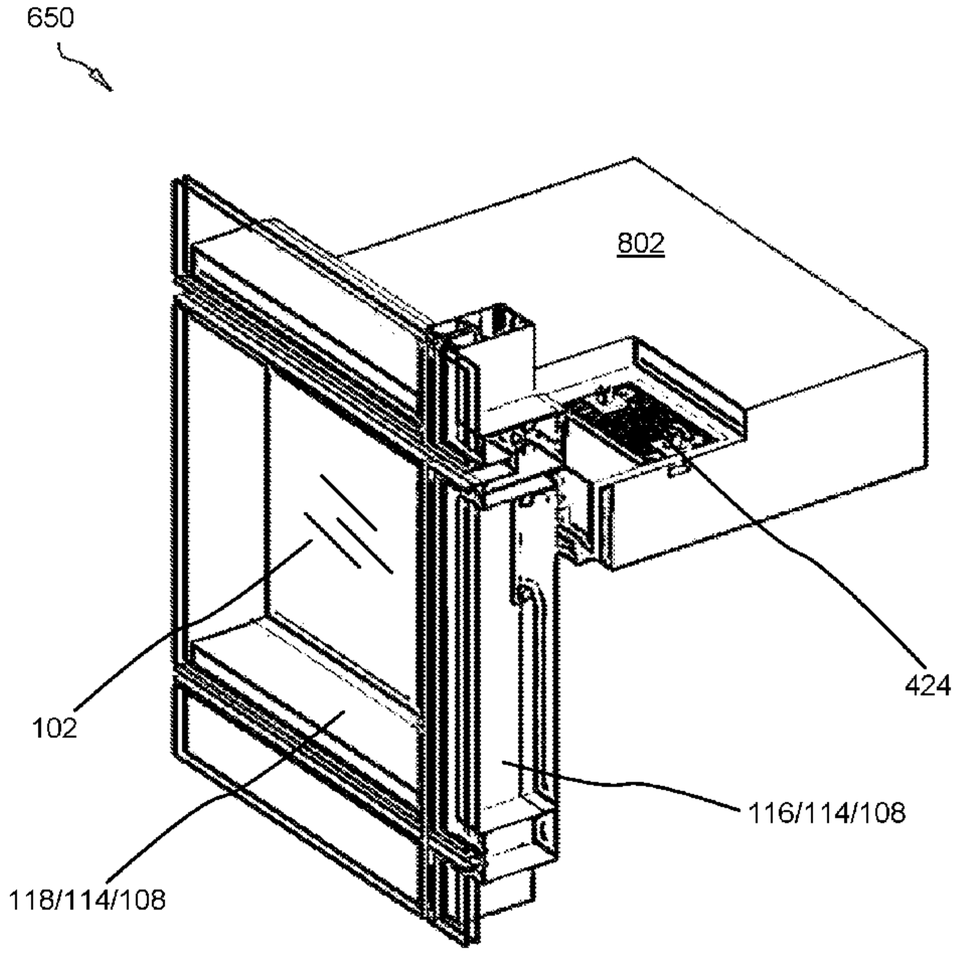
(57) **ABSTRACT**

The invention relates to renewable energy generation and, more particularly, to a cladding system that generates energy from renewable sources. The cladding system comprises, inter alia, a single and/or plurality of renewable energy generating units, such as solar panels, mounted on or integrated into a building's exterior cladding. The renewable energy generating unit(s) are connected to an energy storage system and/or the building's electrical grid, so that the energy generated by the unit(s) can be used to power the building or sold back to the Grid. The invention's features and purpose is to generate energy from a renewable source and allow usage of this energy to either power building resources (e.g. lighting, mechanicals, common areas etc.) and/or to sell the energy to the city grid.

13 Claims, 10 Drawing Sheets



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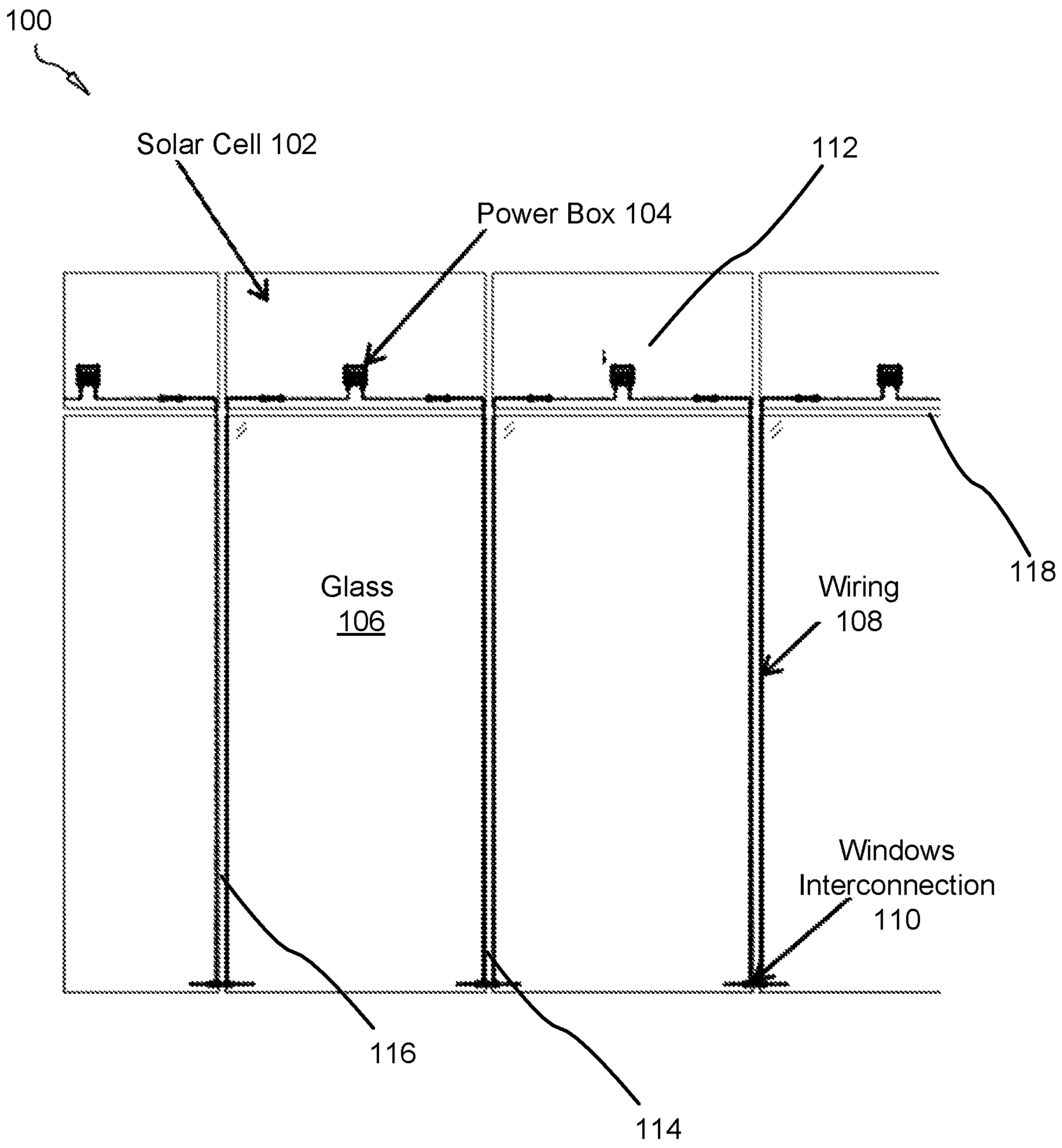
100
Solar Cell 102
Power Box 104
112
Glass
106
Wiring
108
118
Windows
Interconnection
110
116
114

FIG. 1

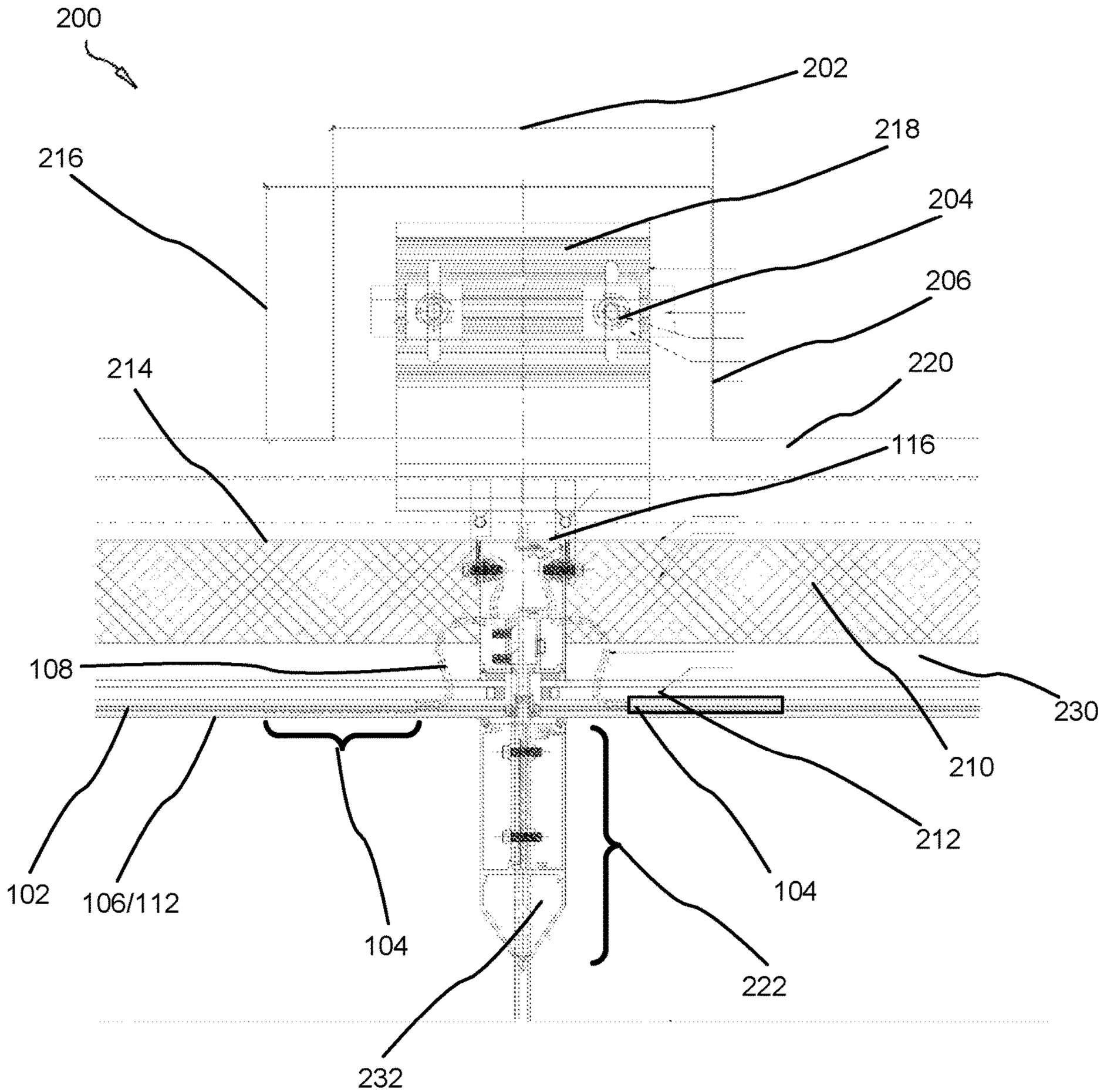
200
202
218
216
204
206
214
220
116
108
230
210
212
102
106/112
104
104
222
232

FIG. 2

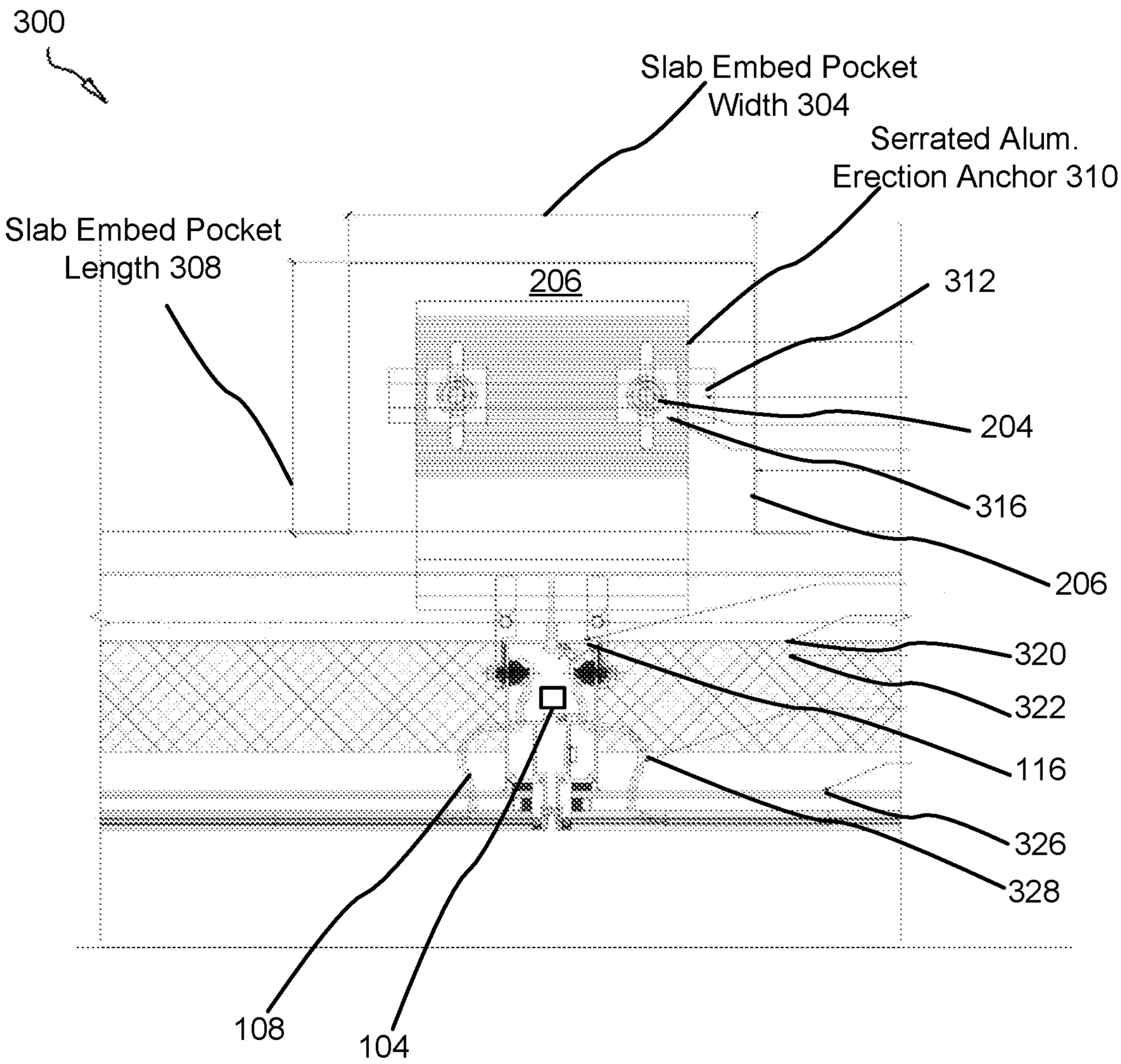
300
Slab Embed Pocket
Width 304
Serrated Alum.
Erection Anchor 310
Slab Embed Pocket
Length 308
206
312
204
316
206
320
322
116
326
328
108
104

FIG. 3A

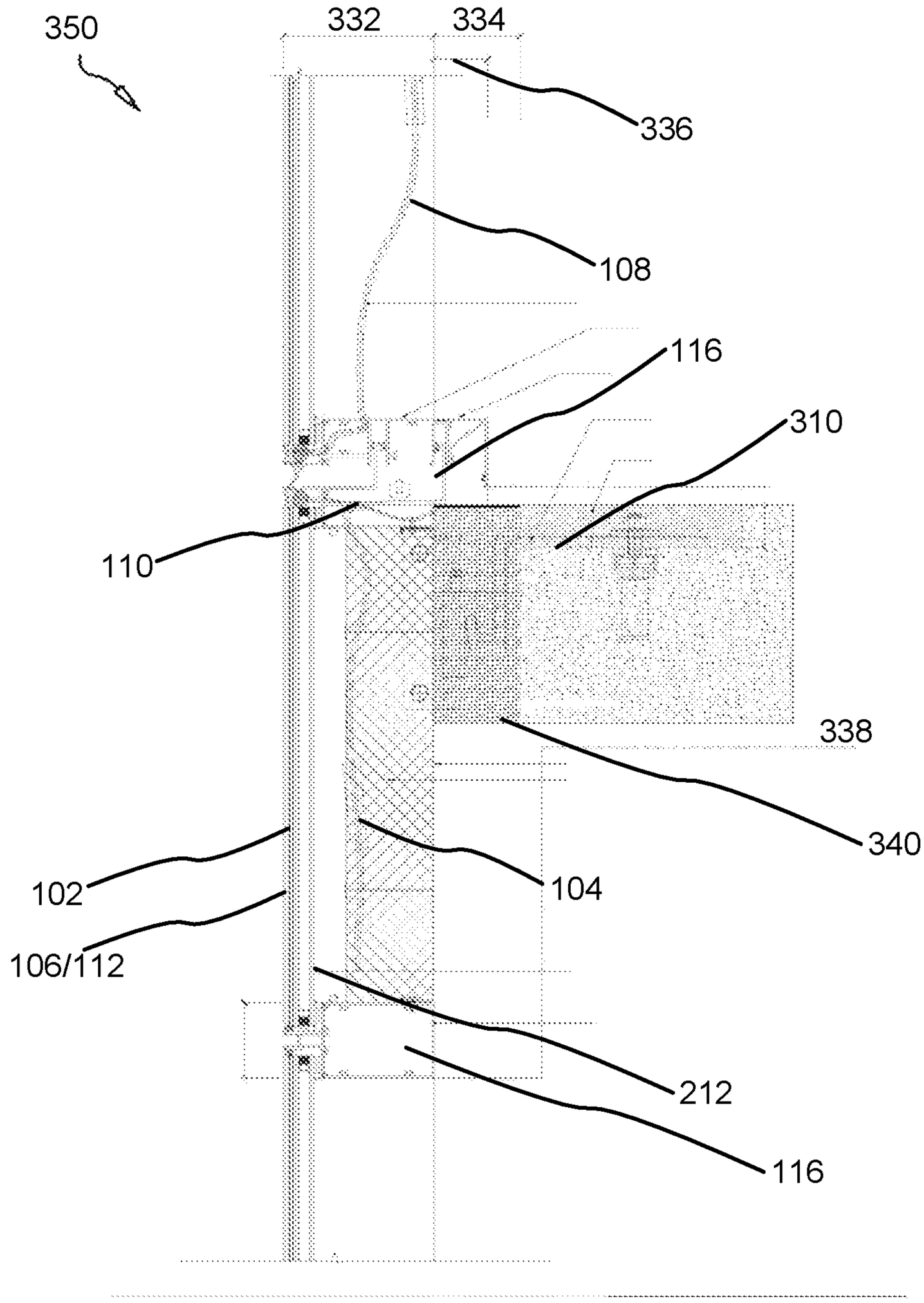

FIG. 3B

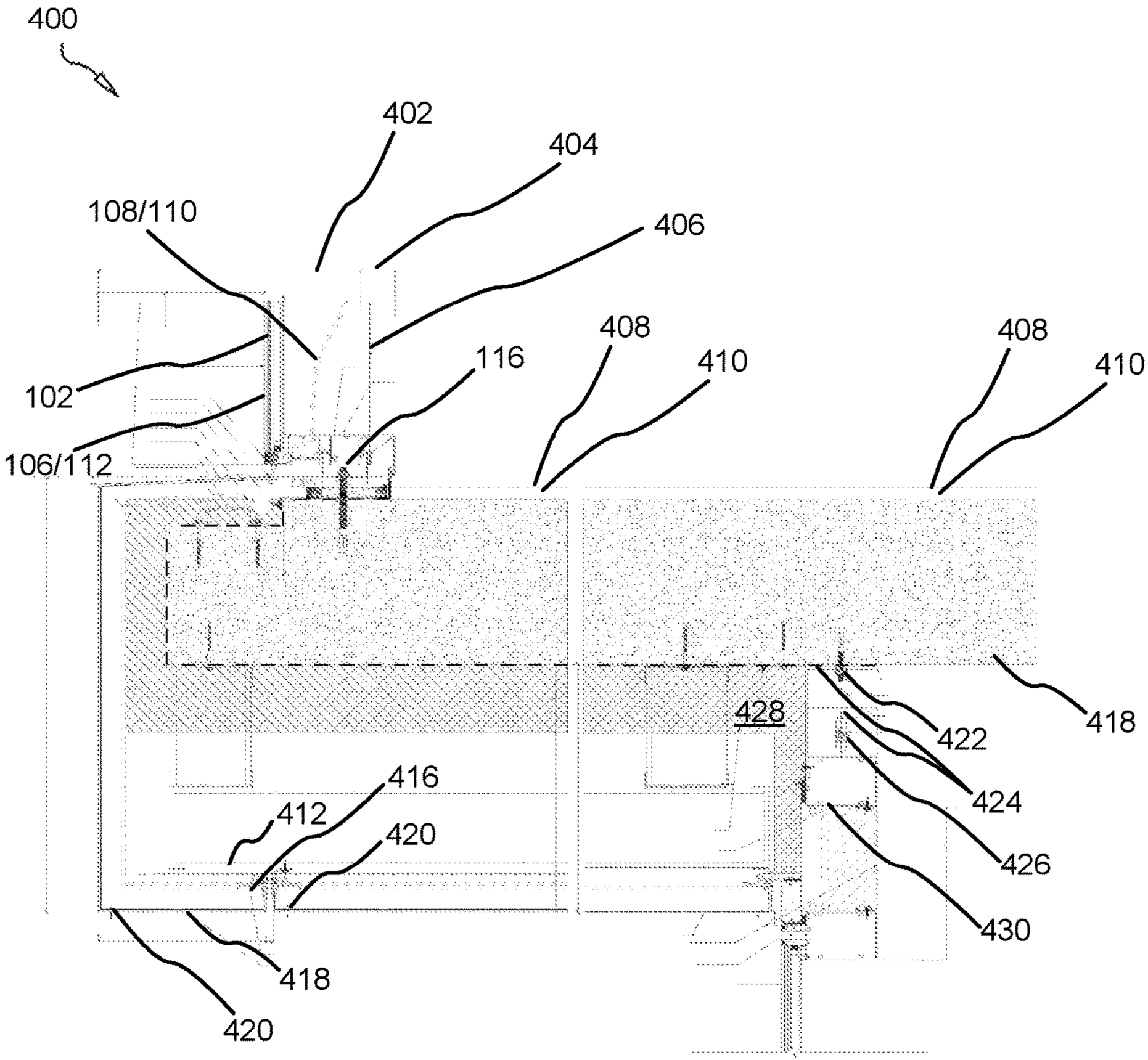
400
402
404
406
108/110
102
106/112
116
408
410
408
410
428
418
422
424
426
430
416
412
420
418
420

FIG. 4

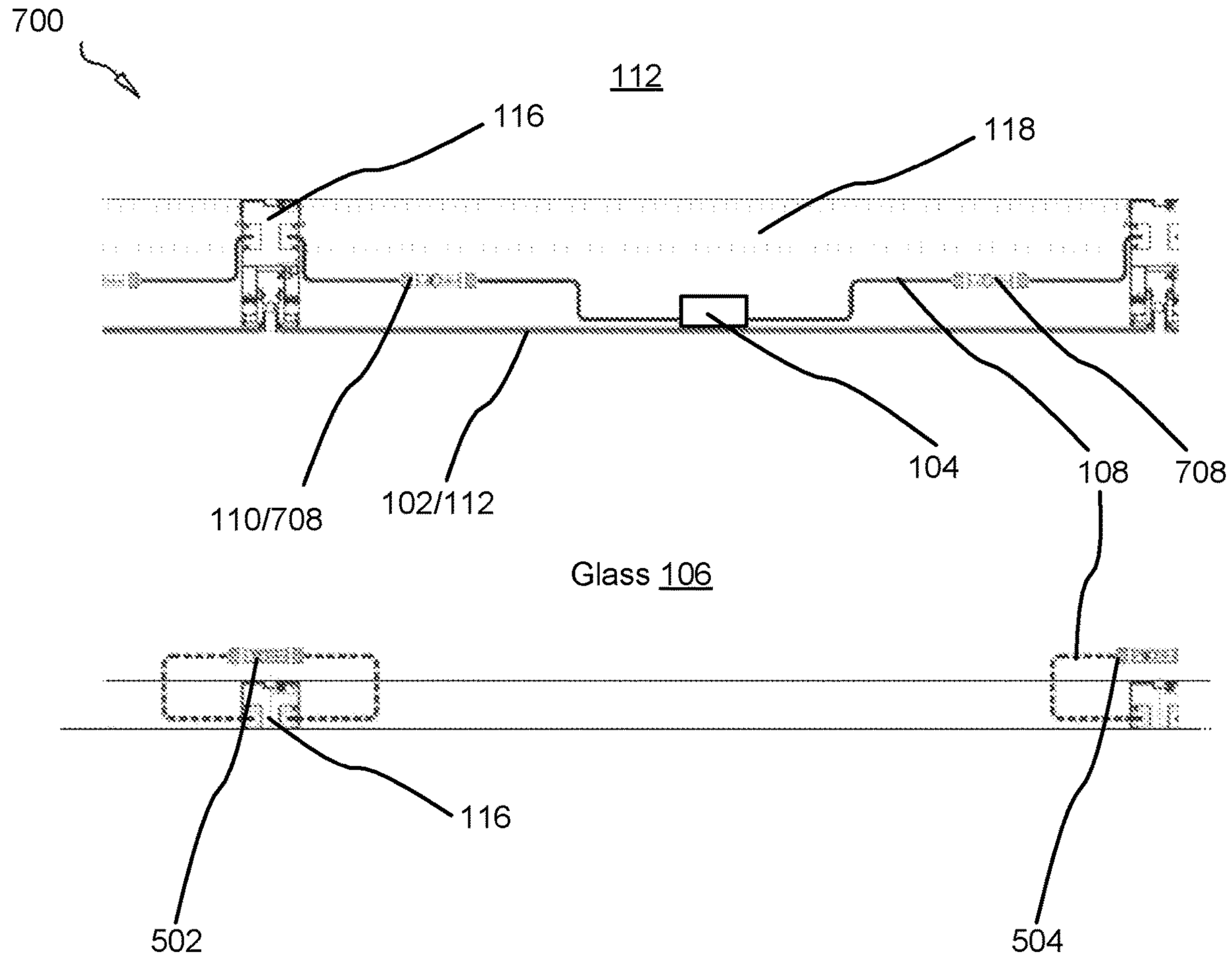
700
112
116
118
110/708
102/112
104
108
708
Glass 106
116
502
504

FIG. 5

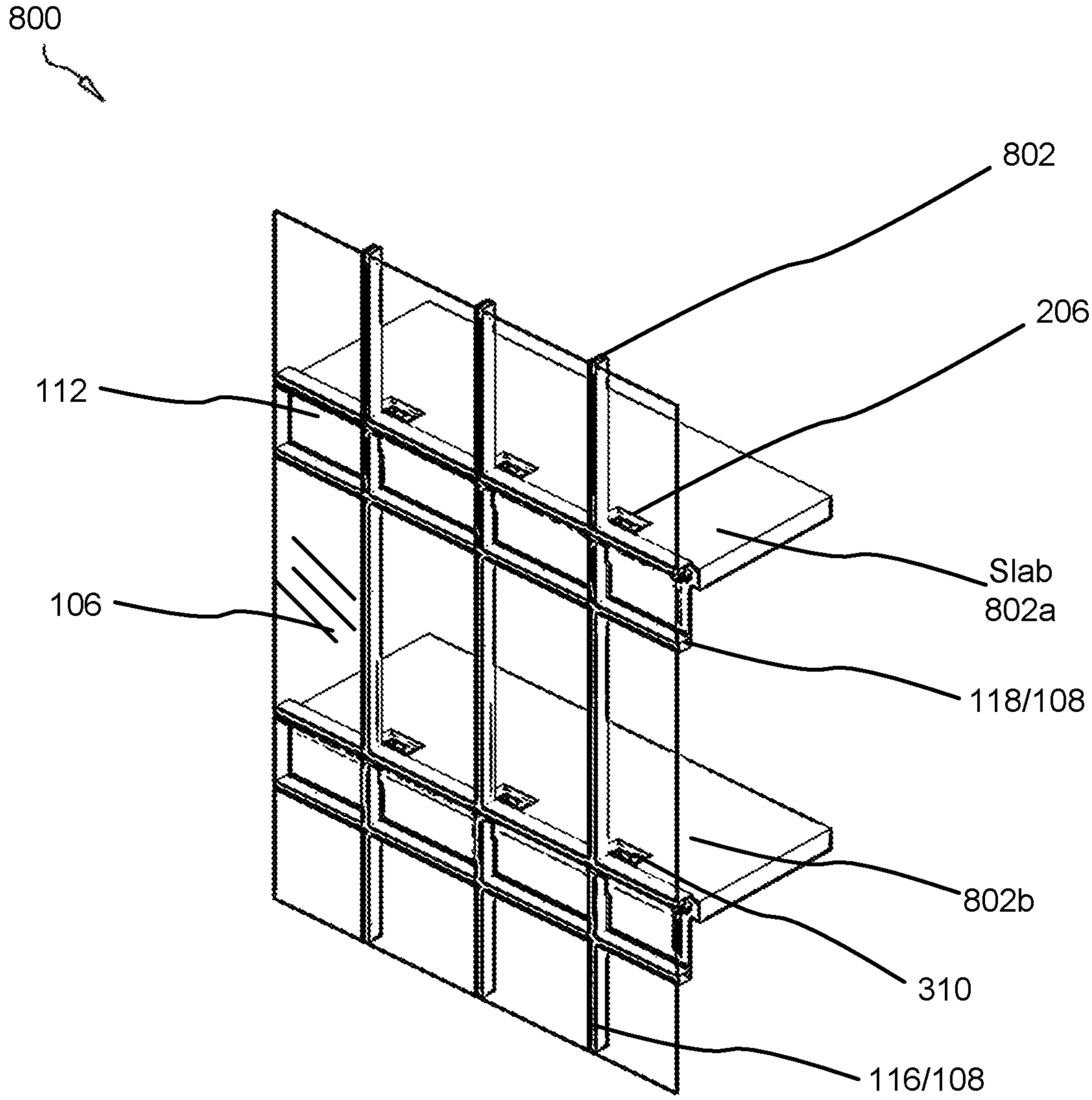

FIG. 6A

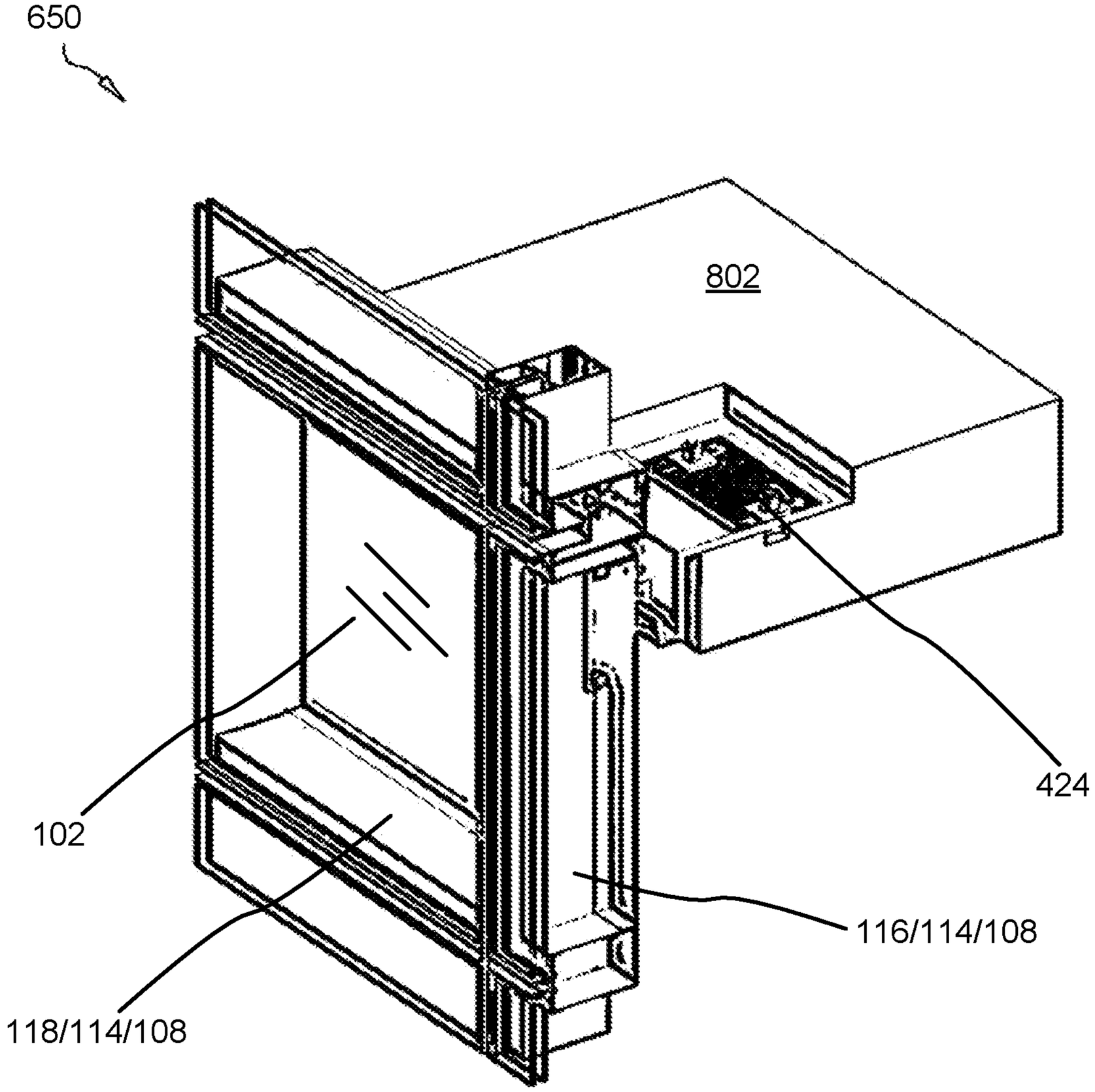

FIG. 6B

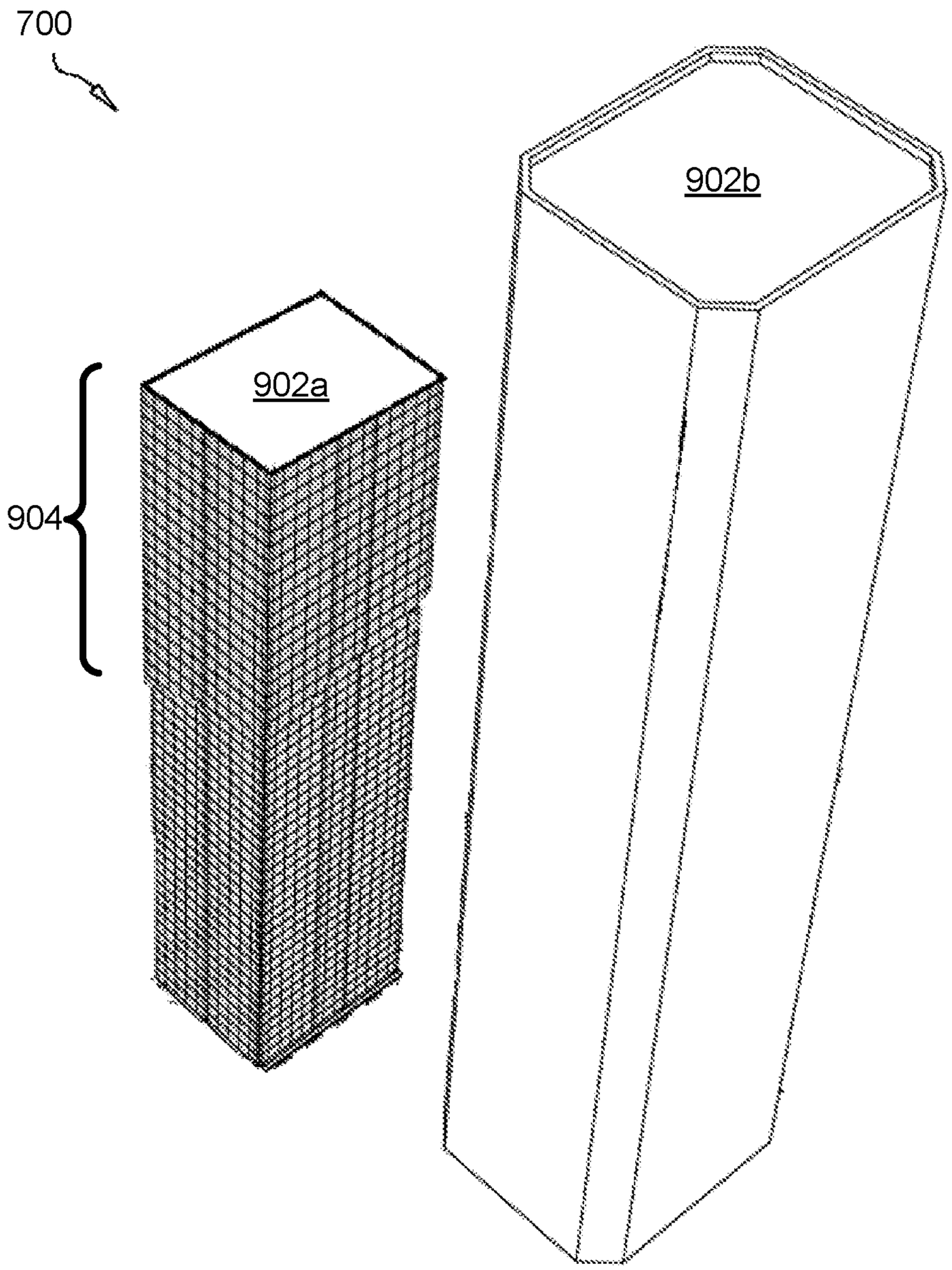

FIG. 7

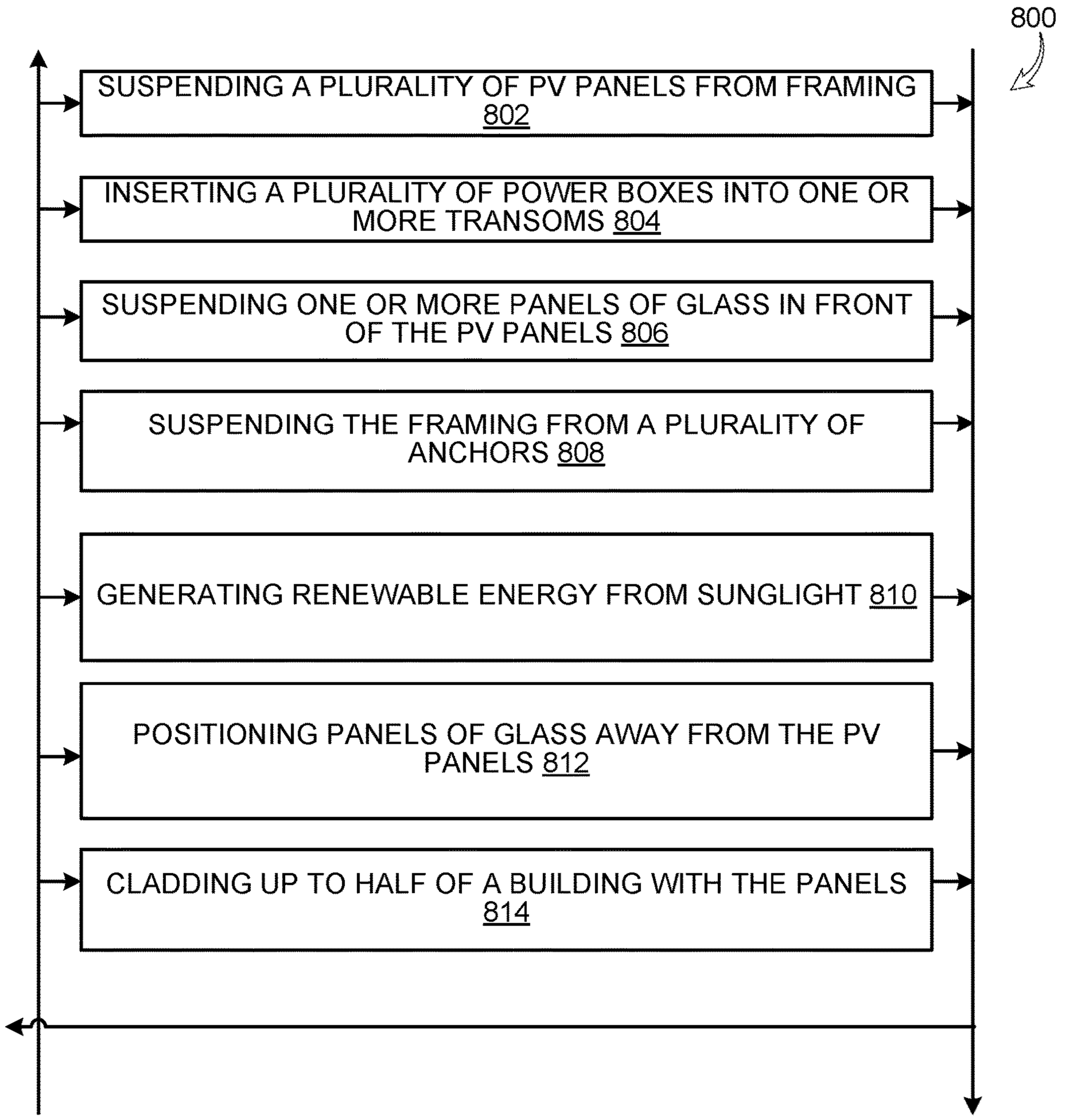
800
SUSPENDING A PLURALITY OF PV PANELS FROM FRAMING 802
INSERTING A PLURALITY OF POWER BOXES INTO ONE OR MORE TRANSOMS 804
SUSPENDING ONE OR MORE PANELS OF GLASS IN FRONT OF THE PV PANELS 806
SUSPENDING THE FRAMING FROM A PLURALITY OF ANCHORS 808
GENERATING RENEWABLE ENERGY FROM SUNGLIGHT 810
POSITIONING PANELS OF GLASS AWAY FROM THE PV PANELS 812
CLADDING UP TO HALF OF A BUILDING WITH THE PANELS 814

FIG. 8

RENEWABLE ENERGY GENERATING CLADDING

TECHNICAL FIELD

The present invention relates to useful technological embodiments of renewable energy and more particularly relates to various types cladding for a variety of useful, efficient novel purposes.

BACKGROUND

Heretofore, there have only been renewable energy sources plastered atop the cladding of roofs and edifices. This invention relates to renewable energy generation and, more particularly, to a cladding system that generates energy from renewable sources.

The integration of photovoltaic (or PV) devices and systems into commercial edifices has generally been confined to conventional roof-top based systems which have limited photovoltaic capacity and which have very small roof surface area relative to other external surface areas such as walls. As such, conventional PV systems cannot cover enough surface area with conventional technology to power either the building much less supply power to an external power grid. The roofs of commercial buildings are often dedicated to other devices, such as rooftop air conditioning units, helicopter landing pads, and the like. Additionally, other buildings may hide or shade roof-top surface area in large metropolitan areas.

Most attempts to remedy these problems, such as improved PV strut systems, have not provided solutions sufficient to be commercially viable. As PV devices become more sightly and lighter, new uses of PV system become feasible, however obstacles remain in arraying PV devices together, installing, sealing and mounting PV systems. It would be desirable to incorporate vertical façades into vertical surface areas of the building assemblies and there is a need in the art for the same.

SUMMARY

The invention relates to renewable energy generation and, more particularly, to a cladding system that generates energy from renewable sources. The cladding system comprises, inter alia, a single and/or plurality of renewable energy generating units, such as solar panels, mounted on or integrated into a building's exterior cladding. The renewable energy generating unit(s) are connected to an energy storage system and/or the building's electrical grid, so that the energy generated by the unit(s) can be used to power the building or sold back to the grid.

The system features an energy transforming module, a component which uses a renewable energy source to mechanically, electrically, chemically or biologically transform that source into energy that can be harvested. In many embodiments, the solar cells are the module. The emitting sun excites the cells where electrons break free in order to produce an electrical charge. Each solar cell is interconnected. The solar cells can be installed in a multitude of spaces. They can be installed on a small portion of the system or the entire system depending on the design.

In several embodiments, solar cells are installed on the spandrel section of the window. This positioning allows to maximize the design for solar cells to harness a maximum amount of energy while also permitting a clear view to people looking through the vision glass.

Many embodiments feature an Energy Collector and Distributor; the energy produced is collected and distributed by an electrical device. In many embodiments, his device is a power box. The power box collects the energy produced by the solar cells and transmits that energy through the wiring. Many embodiments feature a Distribution System: The distribution system is the means by which the energy harvested is distributed as designed and required. In many embodiments, the distribution system is Wiring. The wiring is used to carry and distribute the energy to the required source. Many embodiments feature System Interaction: When multiple cladding systems are installed, they interconnect in a daisy chain or in parallel. This interaction occurs at the windows interconnection.

A renewable energy generating cladding system is provided comprising at least one renewable energy generating unit integrated with a building's exterior cladding, wherein the energy unit is connected to the building's electrical grid, comprising: a renewable energy generating unit; a cladding system circumscribing a building, the cladding system comprising: a forward glass layer between 2 mm and 20 mm thick positioned in front of the renewable energy generating unit, the forward; a power box positioned in front of one of a mullion and a transom positioned behind the renewable energy generating unit; wiring interconnecting a plurality of renewable energy generating units; and an interconnection system.

The renewable energy generating unit may comprises at least one solar panel. A plurality of renewable energy generating units may be connected in one of series and parallel.

The renewable energy generating cladding system of claim **1**, wherein the renewable energy generating unit is integrated into the building's exterior cladding.

The renewable energy generating unit may be integrated into the building's façade by virtue of a mounting system comprising a embed pocket in a slab, mullion, transoms, and an anchor.

The renewable energy generating unit may be mounted on a frame attached to the building's exterior.

The renewable energy generating cladding system may further comprise a monitoring system to track the amount of energy stored and discharged, wherein the monitoring system comprises sensors to measure energy generation and consumption, as well as optionally-executed algorithms to optimize the performance and efficiency of the renewable energy generating cladding system.

In various embodiments, the renewable energy generating cladding system further comprises safety features of discharge transfer and overload surge protection.

The renewable energy generating cladding system of claim **1**, wherein the renewable energy generating units are resistant to weather, environmental conditions, high shifting winds, hail and extreme temperatures.

The renewable energy generating cladding system of claim **1**, wherein the renewable energy generating unit system is modular, and therefore interchangeable, replaceable, replicable and expandable.

The renewable energy generating cladding system of claim **1**, further comprising an optional remote-control monitoring and communication system, said system optionally connected to a cloud-based platform that provides real-time data on energy generation, consumption, and performance of the system.

The renewable energy generating cladding system of claim **1**, wherein the system provides a return on investment

within a reasonable timeframe, therefore eligible for government incentives, rebates, energy credits and corollary financial benefits.

A renewable energy generating cladding system comprising at least one renewable energy generating unit integrated with a building's exterior cladding, wherein the energy unit is connected to the building's electrical grid, comprising:

a plurality of transparent photovoltaic cells;

a cladding system, the cladding system comprising:

a forward glass layer positioned in front of one or more of the plurality of photovoltaic cells;

a power box positioned within of one of a mullion and a transom suspending the forward glass layer;

an aluminum anchor recessed into an embed pocket of a cement slab, the aluminum anchor affixed to framing comprising mullions and transoms;

wiring interconnecting a plurality of renewable energy generating units, the wiring running longitudinally and positioning between photovoltaic cells;

a plurality of windows interconnections adapted to connect the wiring.

The renewable energy generating cladding system of claim **13**, further comprising a fin positioning forward of the cladding system, the fin defining a hollow interior recess, wherein the fin comprises a power box and windows interconnection for connecting wiring from the plurality of transparent photovoltaic cells.

The renewable energy generating cladding system of claim **13**, wherein the system provides a return on investment within a reasonable timeframe, therefore eligible for government incentives, rebates, energy credits and corollary financial benefits.

A renewable energy generating cladding system comprising at least one renewable energy generating unit integrated with a building's exterior cladding, wherein the energy unit is connected to the building's electrical grid, comprising:

a renewable energy generating unit;

a cladding system circumscribing a top half of a building, the cladding system comprising:

a forward glass layer between 2 mm and 20 mm thick positioned in front of the renewable energy generating unit, wherein a recess is defined between the renewable energy generating unit and the forward glass layer of between 1 and 5 mm thick;

a power box positioned in front of one of a mullion and a transom positioned behind the renewable energy generating unit;

an aluminum anchor recessed into an embed pocket of a cement slab;

wiring interconnecting a plurality of renewable energy generating units, the wiring positioning within the recess.

Many embodiments feature Power Storage Devices. These devices are used to store the energy harvested and are capable of distributing the energy when needed and commanded by a control module. The control module or system is optional, and can be used to monitor the health of the system and identify any breakage or loss of performance and indicate its source to help and ease maintenance. The control module is also used to distribute the energy harvested according to defined parameters to the required energy use devices.

The window system embodiment comprises the following components: ONE: Framing: The framing is usually made of aluminum but can also be made out of steel. PVC, wood and other materials, inside of this frame is where the wiring and interconnections are housed. Each frame is made of various profiles called mullions and transoms. Each profile has a male and female interconnection side. TWO: Vision glass: Vision glass is the portion of glass that is used in a building from which we see clearly through. THREE: Spandrel glass is glass that is heavily tinted and opaque typically used to block view from the outside to the inside.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** depicts an embodiment of the renewable energy cladding system's primary components and interconnections when designed and used in the invention's window system embodiment, consistent with various embodiments. FIG. **1** features the window system embodiment's Spandrel Area and Vision Bottom Area, consistent with various embodiments. FIG. **1** further features the embodiment's wiring, power box, window mullion, insulation, windows interconnection, solar cell, spandrel glass and vision glass, consistent with various embodiments.

FIG. **2** is a structural technical drawing of the system's Spandrel Vision Glass embodiment, consistent with various embodiments.

FIG. **3**A depicts the system's structural technical drawing of Spandrel Plan and Section Stack Joint, consistent with various embodiments, featuring system wiring and PV Glass Interlayer.

FIG. **3**B depicts the system's structural technical drawing of Spandrel Plan and Section Stack Joint, consistent with various embodiments, featuring system wiring and PV Glass Interlayer.

FIG. **4** depicts the system's structural technical drawing o CW Spandrel Glass, consistent with various embodiments.

FIG. **5** illustrates the invention's window system embodiment, illustrating the Spandrel Area and Vision Bottom Area, consistent with various embodiments. FIG. **7** features the embodiment's wiring, power box, PV Glass Interlayer. FIG. **7** further illustrates the positioning and design of the windows interconnection.

FIG. **6**A depicts external perspective views of the system's windows embodiment, featuring the system's positioning of CW Spandrel Glass.

FIG. **6**B depicts external perspective views of the system's windows embodiment, featuring the system's positioning of CW Spandrel Glass.

FIG. **7** illustrates an environmental perspective view of renewable energy generating cladding in accordance with present invention.

FIG. **8** illustrates a flow chart of the steps of a method in accordance with present invention.

DEFINITIONS

Photovoltaic glass ("PV Glass"): PV Glass incorporates transparent semiconductor-based photovoltaic cells, which are also known as solar cells. PV Glass utilizes solar cells to convert solar energy into electricity. In the present invention, PV Glass is installed as, into or onto, areas of, inter alia, a building to produce power for an entire building or structure.

IGU: Insulated glass units ("IGUs") prevent heat loss through glass facades, partitions, doors and windows.

PV Glass Interlayer: The interlayer in the glass composition consisting of PV solar cells.

Junction Box: An electrical enclosure where an electrical connection is made between 2 components.

Spandrel Glazing: Glass with feature preventing view from outdoor to indoor.

[Aluminum] Transmission Mullion: Component of the window frame

PV Glass Wire: Electrical wiring used for power distribution to transmit electricity from renewable energy source or other source to a building outlet.

Embedded Channel: Channel system within the frame used to hold the system wiring interconnection system.

Spandrel Glass: Spandrel Glass: spandrel glass is, inter alia a vision application designed to be somewhat opaque in order to help obscure the spaces between the floors of a building, including insulation, vents, wires, slab ends and mechanical equipment.

Vision Glazing: Clear vision glass allowing through viewing from all sides. Windows Interconnection: system interaction points, often housed in the system's framing, linked in daisy chain or in parallel, optionally connected to a municipal electrical grid and/or to power storage devices.

DETAILED DESCRIPTION OF THE DRAWINGS

The renewable energy generating cladding system includes a single and/or plurality of renewable energy generating unit(s), which may be solar panels, or any other suitable renewable energy generating device. The unit(s) are mounted on or integrated into the building's exterior cladding, such as walls, or windows.

In one embodiment, the renewable energy generating units are mounted inside a frame that is attached to the building's exterior. The frame may be made of any suitable material, such as metal, plastic, or composite materials. The renewable energy generating units may be mounted on the frame using any suitable mounting system, such as clamps, brackets, or adhesive.

In another embodiment, the renewable energy generating units are integrated into the building's exterior cladding. For example, solar panels may be integrated into the building's walls, while wind turbines may be integrated into the building's windows.

The renewable energy generating units are connected to an energy storage system and/or the building's electrical grid, so that the energy generated by the units can be used to power the building or sold back to the grid. The energy storage system may include batteries, capacitors, or any other suitable energy storage or distributing device.

In some embodiments, the renewable energy generating cladding system may also include a control system that monitors and controls the operation of the renewable energy generating units and the energy storage system. The control system may be connected to the building's electrical system or may be a standalone system.

For clarity, renewable energy generating cladding includes all different types of exterior layer or skin of a building that helps to protect the interior from the elements and/or also contributing to its overall aesthetic appearance partially or fully fitted with materials capable of generating renewable energy including but not limited to all types of:

Brick cladding
Stone cladding
Metal cladding
Glass cladding
Wood cladding
Composite cladding
Concrete cladding
Terracotta cladding
GFRC cladding
Stucco cladding
Window systems

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

FIG. **1** depicts an embodiment of the renewable energy cladding system's **100** primary components and interconnections when designed and used in a window system. In FIG. **1**, solar energy is the renewable energy source which the system harnesses and distributes using renewable energy generating units.

FIG. **1** illustrates an energy transforming module, the component that uses a renewable energy source to mechanically, electrically, chemically or biologically transform that source into energy that can be harvested. In FIG. **1**, the solar cells **102** are the module. As shown in FIG. **1**, solar cells **102** are installed only on a portion of the system (not plastered over the whole system). In FIG. **1**, the solar cells **102** are installed on the spandrel section **112** of the window. This positioning allows the solar cells **102** to harness maximum available energy while permitting a clear view through the vision glass **106**.

FIG. **1**'s window system comprises the following further seminal components. One component shown is the framing **114**; the framing **114** is herein made of aluminum but can also be made out of steel, PVC, wood and other materials. Inside this frame **114** is where the wiring **108** and interconnections are housed. Each frame **114** is made of various profiles/components called mullions **116** and transoms **118**. Each profile has a male and female interconnection side.

Another FIG. **1** component shown is the embodiment's vision glass **106**; vision glass **106** is the portion of glass used in the building that allows an occupant to clearly see out. FIG. **1** features spandrel glass **112**, glass that is heavily tinted and opaque, typically used to block view from the outside to the inside.

FIG. **1** also features the system's embodiment's energy collector and distributor. The energy produced is collected and distributed by an electrical device. This device in FIG. **1** is the power box **104**. The power box **104** collects the energy produced by the solar cells **102** and transmits that energy through the wiring **108**.

The power box **104** is always hidden by being positioned right in front of the transom **118** or just underneath the transom **118**. In still further embodiments, the power box is positioned in front of the mullion **116** or alongside the mullion **116**.

FIG. **1** also illustrates the invention's embodiment's distribution system, the means by which the energy harvested is distributed as designed and required. In FIG. **1**, the distribution system is the wiring **108**. The wiring **108** is used to carry and distribute the energy to the required source/destination.

FIG. **1** also illustrates the invention's embodiment's System Interaction when multiple cladding systems are installed they interconnect in a daisy chain or in parallel. In FIG. **1**, the interaction is accomplished at the windows interconnection. (A second and final interconnection is the interconnection to the municipal electrical grid and/or to power storage devices, not shown in FIG. **1**).

FIG. **1** further illustrates the system's embodiment's Power Storage Devices. These devices are used to store the energy harvested and are capable of distributing the energy when needed and commanded by a control module.

FIG. **1** further illustrates the system's Control Module. The control module or system is optional. The module can be used to monitor the health of the system and identify any

breakage or loss of performance and indicate its source to help and ease maintenance. The control module is also used to distribute the energy harvested according to defined parameters to the required energy use devices.

FIG. **2** is a structural technical drawing of, inter alia, the system's spandrel vision glass embodiment **200**, consistent with various embodiments. FIG. **2** features the system wiring, the system's glass composition as used in various embodiments, and PV Glass Interlayer. The Figure also features a channel for interconnection and a vertical mullion for structure. FIG. **2** also illustrates the function and positioning of the system's typical glass composition with PV Glass Interlayer.

The system **200** comprises a pocket width **202**, a pocket height **216**, an aluminum erection anchor **218**, a steel t-bolt **204**, a steel embed pocket **206**, vertical mullion **118**, semi rigid insulation **210**, a glass interlayer **212**, and wiring **108**. The system comprises a painted aluminum interior sill cover **220** and a fin **222**.

The fin **222** comprises a metal alloy or polymeric feature which juts forward of the glass **106**. The fix **222** may cover gaps between cladding **200**. In various embodiments, one or more of the power boxes **104** and the windows interconnection **110** may be housed within the fin **222**. The fin **222** may taper or be frustoconical in shape. The fin **222** may define a hollow interior recess **232** into which a power box **104**, the windows interconnection **110**, and a plurality of wiring **108** may be housed.

Semi-rigid insulation **210** may position behind the glass **106** and PV glass **102** between mullion **116**. In various embodiments, the semi-rigid insulation **210** is as thick as the mullion **116**. A recess **230** be defined between the insulation **210** and the back pan of the cladding.

In various embodiments, the power box **104** is recessed into one or more of the glass interlayer **212**, the solar panel **102**, and the glass **106**. The power box **104** may position behind one or more of the glass **106** and the PV glass **102**.

FIG. **3**A depicts the system's structural technical drawing of Spandrel Plan and Section Stack Joint, consistent with various embodiments. FIG. **3**A features wiring **108** comprising PV glass wire **328** interconnected the PV glass and the junction box; spandrel IGU with PV glass interlayer **326**; aluminum vertical mullion **116**; semi-rigid insulation; a galvanized back pan **320**; a galvanized steel embed pocket **206**; a serrated washer plate **316**; a t-bolt **204**; a steel embed channel **312**; a serrated aluminum erection anchor **310**; and a slab embed pocket length **308**.

FIG. **3**B depicts the system's **350** structural technical drawing of Spandrel Plan and Section Stack Joint (i.e., renewable energy generating cladding), consistent with various embodiments. FIG. **3**B features a system depth **332**, a slab edge gap **334**, a sill cover **336**, wiring **108**, glass **106**, a photovoltaic cell **102**, a power box **104**, a windows interconnection **110**, a glass interlayer **212**, a mullion **116**, a finish floor **338**, and a fire safing **340**.

FIG. **4** depicts an environmental perspective view of Spandrel Plan and Section Stack Joint, consistent with various embodiments. FIG. **4** features the system wiring **108**, the system's glass composition as used in various embodiments including a solar panel **102** disposed behind, and PV Glass Interlayer, and typical insulation.

The system **400** further comprises a weep hole **420**, a pre-finished aluminum composite panel **418**, stud framing **412**, an aluminum clip **416**, a finish floor **408**, a subfloor **410**, five-inch thick insulation **428**, aluminum horizontal mullion **430**, an anchor screw **422**, a bolt and nut **426**, and an anchor plate **424**.

The semi-rigid insulation may be four inches thick or vary in thickness from inch to eight inches. The wash plate **316** may be fabricated from aluminum and may be serrated.

FIG. **5** depicts a renewable energy generating cladding **500** in accordance with the present invention. The cladding **500** comprises a mullion **116**, a spandrel section **112**, a power box **104**, wiring **108**, glass **106**, a windows interconnection **110**, and a solar panel **102**.

The windows interconnection **110**, in various embodiments, comprises a threaded cylindrical body **502** adapted to mate with two or more threaded connectors **504**.

In various embodiments, the glass **106**, in various embodiments, comprises, or is adhered to or abuts, one or more photovoltaic cells **102**. The glass **106** may be is placed in front of the photovoltaic cell **102** such that the photovoltaic cells **106** is spaced behind the glass **102**. The glass **106** may comprise silica glass and/or acrylic and may be adhered to the photovoltaic cell **102** or in front or a plurality of photovoltaic cells **102**.

In various embodiments, a small recess of 1-2 mm is defined between the glass **106** and the PV glass **102**, such that the PV glass **102** and the glass **106** are spaced apart slightly. In various embodiments, the glass **106** is arcuate, concave or convex to some degree such that the glass **106** acts as a concentrator focusing light on photoactive layers of the PV glass **102**. In some embodiments, only a portion of the glass **106** is curved forming a lens in front of photoactive areas of the glass **102**. The glass **106** may be coated with anti-reflected coating.

The glass **106** may be formed from a plurality of silica-based chemically-tempered or heat-tempered glass sheets or annealed silica glass or nylon, which may be cut to a predimensioned form or formed within a mold or tool, and dyed to form a certain color, such as with cobalt to form blue. In various embodiments, the glass **106** layered in front of the photovoltaic cell is thin to allow maximum light and UV light to penetrate, being from 1 mm to 10 mm. In other embodiments, the glass **106** comprises a simple flexible, laminated substrate. A laminated substrate may dispose between the glass **106** and the PV glass **102**.

In various embodiments, the wiring **108** traversing either the glass **106** and/or the PV glass/cell **102** internally. The wiring may traverse internal channels formed when the glass **106** is fabricated using means known to those of skill in the art or may be traverse a small recess between the PV glass **102** and the glass **106**. The photoactive layers may be integrated into the glass **102**

FIGS. **6**A-**6**B illustrate the invention's window system **600**-**650** embodiment, illustrating the Spandrel Area and Vision Bottom Area, consistent with various embodiments. The system **600** comprises a forward glass **106** pane disposed in front of transparent PV glass **102**. The slabs **802***a*-*b*, which form part of a building structure and which may be fabricated from concrete, define an embed pocket **206** into which the an anchor **310** and/or plate **424** and/or bolt and nut **426** inserts. In various embodiments, the embed pocket **206** and the anchor **310** may be rectangular from an upper perspective and may be from six inches to 16 inches wide and from 5 inches to 15 inches deep.

The framing **114** is suspended from the anchor **310**, including hollow mullion **116** and transom **118**. The mullion **116** and the transom **118** form a hollow interior recess **802** through which the wiring **108** may traverse. In various embodiments, the power box **104** is also housed within the hollow interior recess **108**. In some embodiments, a plurality of power boxes **104** are spaced together horizontally within

a transom **118** or vertically within mullion **116** to provide more convenient repair access to multiple power boxes **104**.

The PV glass **102** may be fabricated on a glass substrate with the electrical connection created at fabrication (i.e., monolithic integration).

The power box **104** may comprises bypass diodes, wiring, and other components necessary to prevent power from feeding back to the PV glass **102**. In some embodiments, the power boxes **104** comprises inverters. In other embodiments, the power boxes **104** feed power to inverters in separate areas of the building.

FIG. **7** illustrates an environmental perspective view of renewable energy generating cladding **700** in accordance with present invention.

The cladding **700**, in the shown embodiment, may be affixed to a building **902**.

In some embodiments, only the upper half, third, fourth or fifth of a building integrates into its construction the renewable energy generating cladding **700** as in various embodiments, only this portion of the building is sufficiently exposed to sunlight. Additionally, with tall buildings such a skyscrapers, temperatures are colder at the top of the building than the bottom near a ground surface, resulting in increased efficiency of the system **100**, **700**.

FIG. **8** illustrates a flow chart of the steps of a method in accordance with present invention.

In various embodiments, a plurality of PV cells/frames may be suspending **802** from the mullions **116** and/or the transoms **118**. The power boxes **104** may be positioned **804** or inserted into the hollow recesses defined by the transoms **118** and/or the mullions **116**.

Glass **106** may be suspending **806** in front of the PV glass **102** from the framing **114**. The framing **114** may be suspended **808** from anchors and renewable energy generated **810** from sunlight illuminating the building **902**.

In various embodiments, the glass **102** is spaced away from the PV glass **106** by 1 to 20 mm.

In other embodiments, the plurality of transparent photovoltaic cells are interconnected using the window connections **110**, which may be housed within fins **222** or behind the glass **106**.

Specifications Generally

In the Summary above and in this Detailed Description, and the Claims below, and in the accompanying drawings, reference is made to particular features of various embodiments of the invention. It is to be understood that the disclosure of embodiments of the invention in this specification includes all possible combinations of such particular features. For example, where a particular feature is disclosed in the context of a particular aspect or embodiment of the invention, or a particular claim, that feature can also be used—to the extent possible—in combination with and/or in the context of other particular aspects and embodiments of the invention, and in the invention generally.

While multiple embodiments are disclosed, still other embodiments of the present invention will become apparent to those skilled in the art from this detailed description. The invention is capable of myriad modifications in various obvious aspects, all without departing from the spirit and scope of the present invention. Accordingly, the drawings and descriptions are to be regarded as illustrative in nature and not restrictive.

It should be noted that the features illustrated in the drawings are not necessarily drawn to scale, and features of one embodiment may be employed with other embodiments as the skilled artisan would recognize, even if not explicitly stated herein. Descriptions of well-known components and processing techniques may be omitted so as to not unnecessarily obscure the embodiments.

In the present disclosure, various features may be described as being optional, for example, through the use of the verb "may;", or, through the use of any of the phrases: "in some embodiments," "in some implementations," "in some designs," "in various embodiments," "in various implementations,", "in various designs," "in an illustrative example," or "for example;" or, through the use of parentheses. For the sake of brevity and legibility, the present disclosure does not explicitly recite each and every permutation that may be obtained by choosing from the set of optional features. However, the present disclosure is to be interpreted as explicitly disclosing all such permutations. For example, a system described as having three optional features may be embodied in seven different ways, namely with just one of the three possible features, with any two of the three possible features or with all three of the three possible features.

In various embodiments, elements described herein as coupled or connected may have an effectual relationship realizable by a direct connection or indirectly with one or more other intervening elements.

In the present disclosure, the term "any" may be understood as designating any number of the respective elements, i.e. as designating one, at least one, at least two, each or all of the respective elements. Similarly, the term "any" may be understood as designating any collection(s) of the respective elements, i.e. as designating one or more collections of the respective elements, a collection comprising one, at least one, at least two, each or all of the respective elements. The respective collections need not comprise the same number of elements.

While various embodiments of the present invention have been disclosed and described in detail herein, it will be apparent to those skilled in the art that various changes may be made to the configuration, operation and form of the invention without departing from the spirit and scope thereof. In particular, it is noted that the respective features of embodiments of the invention, even those disclosed solely in combination with other features of embodiments of the invention, may be combined in any configuration excepting those readily apparent to the person skilled in the art as nonsensical. Likewise, use of the singular and plural is solely for the sake of illustration and is not to be interpreted as limiting.

In the present disclosure, all embodiments where "comprising" is used may have as alternatives "consisting essentially of," or "consisting of." In the present disclosure, any method or apparatus embodiment may be devoid of one or more process steps or components. In the present disclosure, embodiments employing negative limitations are expressly disclosed and considered a part of this disclosure.

Certain terminology and derivations thereof may be used in the present disclosure for convenience in reference only and will not be limiting. For example, words such as "upward," "downward," "left," and "right" would refer to directions in the drawings to which reference is made unless otherwise stated. Similarly, words such as "inward" and "outward" would refer to directions toward and away from, respectively, the geometric center of a device or area and designated parts thereof. References in the singular tense include the plural, and vice versa, unless otherwise noted.

The term "comprises" and grammatical equivalents thereof are used herein to mean that other components,

ingredients, steps, among others, are optionally present. For example, an embodiment "comprising" (or "which comprises") components A, B and C can consist of (i.e., contain only) components A, B and C, or can contain not only components A, B, and C but also contain one or more other components.

Where reference is made herein to a method comprising two or more defined steps, the defined steps can be carried out in any order or simultaneously (except where the context excludes that possibility), and the method can include one or more other steps which are carried out before any of the defined steps, between two of the defined steps, or after all the defined steps (except where the context excludes that possibility).

The term "at least" followed by a number is used herein to denote the start of a range beginning with that number (which may be a range having an upper limit or no upper limit, depending on the variable being defined). For example, "at least 1" means 1 or more than 1. The term "at most" followed by a number (which may be a range having 1 or 0 as its lower limit, or a range having no lower limit, depending upon the variable being defined). For example, "at most 4" means 4 or less than 4, and "at most 40% means 40% or less than 40%. When, in this specification, a range is given as "(a first number) to (a second number)" or "(a first number)-(a second number)," this means a range whose limit is the second number. For example, 25 to 100 mm means a range whose lower limit is 25 mm and upper limit is 100 mm.

Many suitable methods and corresponding materials to make each of the individual parts of embodiment apparatus are known in the art. According to an embodiment of the present invention, one or more of the parts may be formed by machining, 3D printing (also known as "additive" manufacturing), CNC machined parts (also known as "subtractive" manufacturing), and injection molding, as will be apparent to a person of ordinary skill in the art. Metals, wood, thermoplastic and thermosetting polymers, resins and elastomers as may be described herein-above may be used. Many suitable materials are known and available and can be selected and mixed depending on desired strength and flexibility, preferred manufacturing method and particular use, as will be apparent to a person of ordinary skill in the art.

Any element in a claim herein that does not explicitly state "means for" performing a specified function, or "step for" performing a specific function, is not to be interpreted as a "means" or "step" clause as specified in 35 U.S.C. § 112 (f). Specifically, any use of "step of" in the claims herein is not intended to invoke the provisions of 35 U.S.C. § 112 (f). Elements recited in means-plus-function format are intended to be construed in accordance with 35 U.S.C. § 112 (f).

Recitation in a claim of the term "first" with respect to a feature or element does not necessarily imply the existence of a second or additional such feature or element.

The phrases "connected to," "coupled to" and "in communication with" refer to any form of interaction between two or more entities, including mechanical, electrical, magnetic, electromagnetic, fluid, and thermal interaction. Two components may be functionally coupled to each other even though they are not in direct contact with each other. The term "abutting" refers to items that are in direct physical contact with each other, although the items may not necessarily be attached together.

The word "exemplary" is used herein to mean "serving as an example, instance, or illustration." Any embodiment described herein as "exemplary" is not necessarily to be construed as preferred or advantageous over other embodiments. While the various aspects of the embodiments are presented in drawings, the drawings are not necessarily drawn to scale unless specifically indicated.

Reference throughout this specification to "an embodiment" or "the embodiment" means that a particular feature, structure or characteristic described in connection with that embodiment is included in at least one embodiment. Thus, the quoted phrases, or variations thereof, as recited throughout this specification are not necessarily all referring to the same embodiment.

Similarly, it should be appreciated that in the above description of embodiments, various features are sometimes grouped together in a single embodiment, Figure, or description thereof for the purpose of streamlining the disclosure. This method of disclosure, however, is not to be interpreted as reflecting an intention that any claim in this or any application claiming priority to this application require more features than those expressly recited in that claim. Rather, as the following claims reflect, inventive aspects lie in a combination of fewer than all features of any single foregoing disclosed embodiment. Thus, the claims following this Detailed Description are hereby expressly incorporated into this Detailed Description, with each claim standing on its own as a separate embodiment. This disclosure includes all permutations of the independent claims with their dependent claims.

A number of implementations have been described. Nevertheless, it will be understood that various modifications may be made. For example, advantageous results may be achieved if the steps of the disclosed techniques were performed in a different sequence, or if components of the disclosed systems were combined in a different manner, or if the components were supplemented with other components. Accordingly, other implementations are contemplated within the scope of the following claims.

The invention claimed is:

1. A renewable energy generating cladding system comprising at least one renewable energy generating unit integrated with a building's exterior cladding, wherein the energy unit is connected to the building's electrical grid, comprising:

a renewable energy generating unit;

a cladding system, the cladding system comprising:

a forward glass layer between 2 mm and 20 mm thick positioned in front of the renewable energy generating unit, wherein a recess is defined between the renewable energy generating unit and the forward glass layer of between 1 and 5 mm thick;

a power box positioned behind the renewable energy generating unit;

wiring interconnecting a plurality of renewable energy generating units, the wiring positioning within the recess.

2. The renewable energy generating cladding system of claim **1**, wherein the renewable energy generating unit comprises at least one solar panel.

3. The renewable energy generating cladding system of claim **1**, wherein a plurality of renewable energy generating units are connected in one of series and parallel.

4. The renewable energy generating cladding system of claim **1**, wherein the renewable energy generating unit is integrated into the building's exterior cladding.

5. The renewable energy generating cladding system of claim **1**, wherein the renewable energy generating unit is

integrated into the building's façade by virtue of a mounting system comprising a embed pocket in a slab, mullion, transoms, and an anchor.

6. The renewable energy generating cladding system of claim **1**, wherein the renewable energy generating unit is mounted on a frame attached to the building's exterior.

7. The renewable energy generating cladding system of claim **1**, further comprising a monitoring system to track the amount of energy stored and discharged, wherein the monitoring system comprises sensors to measure energy generation and consumption, as well as optionally-executed algorithms to optimize the performance and efficiency of the renewable energy generating cladding system.

8. The renewable energy generating cladding system of claim **1**, further comprising safety features of discharge transfer and overload surge protection.

9. The renewable energy generating cladding system of claim **1**, wherein the renewable energy generating units are resistant to weather, environmental conditions, high shifting winds, hail and extreme temperatures.

10. The renewable energy generating cladding system of claim **1**, wherein the renewable energy generating unit system is modular, and therefore interchangeable, replaceable, replicable and expandable.

11. The renewable energy generating cladding system of claim **1**, further comprising an optional remote-control monitoring and communication system, said system optionally connected to a cloud-based platform that provides real-time data on energy generation, consumption, and performance of the system.

12. The renewable energy generating cladding system of claim **1**, wherein the system provides a return on investment within a reasonable timeframe, therefore eligible for government incentives, rebates, energy credits and corollary financial benefits.

13. The renewable energy generating cladding system of claim **1**, further comprising a fin positioning forward of the cladding system, the fin defining a hollow interior recess, wherein the fin comprises a power box and windows interconnection for connecting wiring from the plurality of transparent photovoltaic cells.

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